AP ECET 2026 Ceramic Technology

Question Paper with Solutions

Conducted by JNTU, Anantapur

General Instructions

(i) **Duration:** The total duration of the examination is 3 hours (180 minutes).

(ii) **Total Marks:** The complete paper carries a maximum of 200 marks.

(iii) Each question has four options. Only **one** option is correct.

(iv) **Right Answer:** +1 mark.

(v) **Incorrect Answer:** No negative marking.

(vi) **Unanswered/Marked for Review:** 0 marks.

1. In the matrix

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 4 & 9 \end{bmatrix},$$

the minor M_{23} of the element a_{23} is:

(A) 10

(B) -10

(C) -6

(D) 6

Correct Answer: (B) -10

Solution:

Concept: The minor M_{ij} of an element a_{ij} in a matrix is obtained by deleting the i^{th} row and j^{th} column, and then finding the determinant of the remaining matrix.

Step 1: Identify the element a_{23}.

Here a_{23} means the element in the 2^{nd} row and 3^{rd} column.

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 4 & 9 \end{bmatrix}$$

The element $a_{23} = 6$.

Step 2: Delete the 2^{nd} row and 3^{rd} column.

After deleting row 2 and column 3, the remaining matrix is:

$$\begin{bmatrix} 1 & 2 \\ 7 & 4 \end{bmatrix}$$

Step 3: Find the determinant of the remaining matrix.

$$M_{23} = \begin{vmatrix} 1 & 2 \\ 7 & 4 \end{vmatrix}$$

$$M_{23} = 1(4) - 2(7)$$

$$M_{23} = 4 - 14 = -10$$

Therefore, the minor M_{23} is:

$$\boxed{-10}$$

Quick Tip: To find a minor M_{ij}, always delete the row i and column j, then calculate the determinant of the remaining matrix.

---

2. If

$$\begin{vmatrix} 2x & 5 \\ 8 & x \end{vmatrix} = \begin{vmatrix} 6 & -2 \\ 7 & 3 \end{vmatrix},$$

then the value of x is:

(A) 3

(B) ± 6

(C) -3

(D) ±2

Correct Answer: (B) ±6

Solution:

Concept: For a 2×2 determinant,

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$$

Step 1: Evaluate the determinant on the left side.

$$\begin{vmatrix} 2x & 5 \\ 8 & x \end{vmatrix} = (2x)(x) - (5)(8)$$

$$= 2x^2 - 40$$

Step 2: Evaluate the determinant on the right side.

$$\begin{vmatrix} 6 & -2 \\ 7 & 3 \end{vmatrix} = (6)(3) - (-2)(7)$$

$$= 18 + 14 = 32$$

Step 3: Equate both determinants.

$$2x^2 - 40 = 32$$

$$2x^2 = 72$$

$$x^2 = 36$$

$$x = \pm 6$$

Therefore,

$$\boxed{x = \pm 6}$$

Quick Tip: For determinant equations, first calculate both determinants separately, then equate them and solve the resulting algebraic equation.

---

3. If A is a square matrix of order 3 and $|A| = 5$, then the value of $\left|2A^T\right|$ is:

(A) -10

(B) 10

(C) 40

(D) -40

Correct Answer: (C) 40

Solution:

Concept: For a square matrix A of order n,

$$|kA| = k^n|A|$$

Also,

$$|A^T| = |A|$$

Step 1: Given that A is of order 3.

So, $n = 3$.

$$|A| = 5$$

Step 2: Use the property of transpose.

$$|A^T| = |A|$$

$$|A^T| = 5$$

Step 3: Now find $\left|2A^T\right|$.

Since A^T is also a 3×3 matrix,

$$|2A^T| = 2^3|A^T|$$

$$= 8 \times 5$$

$$= 40$$

Therefore,

$$\boxed{40}$$

Quick Tip: If a matrix is of order n, then multiplying the matrix by k multiplies its determinant by k^n.

---

4. Which of the following systems has non-trivial solution?

(A) $AX = 0,\ |A| = 4$

(B) $AX = 0,\ |A| = -4$

(C) $AX = 0,\ |A| = 0$

(D) $AX = B,\ |B| = 5$

Correct Answer: (C) $AX = 0,\ |A| = 0$

Solution:

Concept: A homogeneous system of linear equations is of the form:

$$AX = 0$$

Such a system always has the trivial solution $X = 0$. It has a non-trivial solution only when:

$$|A| = 0$$

Step 1: Understand the meaning of non-trivial solution.

A non-trivial solution means a solution other than:

$$X = 0$$

Step 2: Apply the condition for a homogeneous system.

For:

$$AX = 0$$

a non-trivial solution exists when the coefficient matrix A is singular.

Step 3: A matrix is singular when its determinant is zero.

$$|A| = 0$$

Step 4: Check the options.

Only option (C) gives:

$$AX = 0,\ |A| = 0$$

Therefore, this system has a non-trivial solution.

$$\boxed{AX = 0,\ |A| = 0}$$

Quick Tip: For a homogeneous system $AX = 0$, non-trivial solutions exist only when $|A| = 0$.

---

5. If

$$\begin{bmatrix} x+y & 2 \\ 1 & x-y \end{bmatrix} = \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix},$$

then the values of x and y are:

(A) $x = 3,\ y = 1$

(B) $x = 1,\ y = 3$

(C) $x = 2,\ y = 3$

(D) $x = 1,\ y = 1$

Correct Answer: (A) $x = 3,\ y = 1$

Solution:

Concept: Two matrices are equal if all their corresponding elements are equal.

Step 1: Compare corresponding elements of both matrices.

$$\begin{bmatrix} x+y & 2 \\ 1 & x-y \end{bmatrix} = \begin{bmatrix} 4 & 2 \\ 1 & 2 \end{bmatrix}$$

From the first row and first column:

$$x+y=4 \quad \cdots(1)$$

From the second row and second column:

$$x-y=2 \quad \cdots(2)$$

Step 2: Add equations (1) and (2).

$$(x+y)+(x-y)=4+2$$

$$2x=6$$

$$x=3$$

Step 3: Substitute $x=3$ in equation (1).

$$3+y=4$$

$$y=1$$

Therefore,

$$\boxed{x=3,\ y=1}$$

Quick Tip: When two matrices are equal, compare corresponding entries to form equations.

6. If

$$\frac{x+4}{(x+2)^2(x+3)} = \frac{A}{(x+2)^2} + \frac{B}{x+2} + \frac{C}{x+3},$$

then $A+B+C =$

(A) 2

(B) 1

(C) -1

(D) 3

Correct Answer: (A) 2

Solution:

Concept: In partial fractions, when the denominator contains repeated linear factors, we write separate terms for each power.

Step 1: Start with the given expression.

$$\frac{x+4}{(x+2)^2(x+3)} = \frac{A}{(x+2)^2} + \frac{B}{x+2} + \frac{C}{x+3}$$

Step 2: Multiply both sides by $(x+2)^2(x+3)$.

$$x+4 = A(x+3) + B(x+2)(x+3) + C(x+2)^2$$

Step 3: Put $x = -3$ to find C.

$$-3+4 = C(-3+2)^2$$

$$1 = C(1)$$

$$C = 1$$

Step 4: Put $x = -2$ to find A.

$$-2+4 = A(-2+3)$$

$$2 = A$$

$$A = 2$$

Step 5: Find B by comparing coefficients or substituting $x = 0$.

$$0 + 4 = A(3) + B(2)(3) + C(2)^2$$

$$4 = 2(3) + 6B + 1(4)$$

$$4 = 6 + 6B + 4$$

$$6B = -6$$

$$B = -1$$

Step 6: Now calculate $A + B + C$.

$$A + B + C = 2 + (-1) + 1$$

$$A + B + C = 2$$

Therefore,

$$\boxed{2}$$

Quick Tip: For partial fractions, multiply by the complete denominator first, then substitute values that make factors zero.

---

7. If

$$\frac{x}{(x-1)^2(x+2)} = \frac{A}{(x-1)^2} + \frac{2}{9(x-1)} + \frac{B}{x+2},$$

then $A + B =$

(A) $\frac{1}{3}$

(B) $\frac{1}{9}$

(C) $-\frac{1}{3}$

(D) $\frac{2}{3}$

Correct Answer: (B) $\frac{1}{9}$

Solution:

Concept: Partial fractions are used to split a rational expression into simpler fractions. Here the denominator has a repeated factor $(x-1)^2$, so both $(x-1)^2$ and $(x-1)$ terms are involved.

Step 1: Write the given expression.

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

Step 2: Multiply both sides by $(x-1)^2(x+2)$.

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

Step 3: Put $x = 1$ to find A.

$$1 = A(1+2)$$

$$1 = 3A$$

$$A = \frac{1}{3}$$

Step 4: Put $x = -2$ to find B.

$$-2 = B(-2-1)^2$$

$$-2 = 9B$$

$$B = -\frac{2}{9}$$

Step 5: Find $A+B$.

$$A+B = \frac{1}{3} - \frac{2}{9}$$

$$A+B = \frac{3}{9} - \frac{2}{9}$$

$$A+B=\frac{1}{9}$$

Therefore,

$$\boxed{\frac{1}{9}}$$

Quick Tip: In partial fractions, substitute the roots of denominator factors to quickly find unknown constants.

---

8. If $\tan A=\frac{1}{2}$ and $\tan B=\frac{1}{3}$, then $A+B=$

(A) 30°

(B) 45°

(C) 60°

(D) 90°

Correct Answer: (B) 45°

Solution:

Concept: We use the tangent addition formula:

$$\tan(A+B)=\frac{\tan A+\tan B}{1-\tan A\tan B}$$

Step 1: Substitute the given values.

$$\tan A=\frac{1}{2},\qquad \tan B=\frac{1}{3}$$

$$\tan(A+B)=\frac{\frac{1}{2}+\frac{1}{3}}{1-\frac{1}{2}\cdot\frac{1}{3}}$$

Step 2: Simplify the numerator.

$$\frac{1}{2}+\frac{1}{3}=\frac{3+2}{6}=\frac{5}{6}$$

Step 3: Simplify the denominator.

$$1-\frac{1}{2}\cdot\frac{1}{3}=1-\frac{1}{6}=\frac{5}{6}$$

Step 4: Therefore,

$$\tan(A+B) = \frac{\frac{5}{6}}{\frac{5}{6}} = 1$$

Step 5: Since

$$\tan 45^\circ = 1$$

So,

$$A+B = 45^\circ$$

Therefore,

$$\boxed{45^\circ}$$

Quick Tip: When $\tan(A+B) = 1$, the principal angle is usually 45°.

---

9. If $2\sin^{-1} x = \sin^{-1} k$, then $k =$

(A) $2x\sqrt{1-x^2}$

(B) $2x$

(C) x^2

(D) $1-2x^2$

Correct Answer: (A) $2x\sqrt{1-x^2}$

Solution:

Concept: If $\sin^{-1} x = \theta$, then:

$$x = \sin\theta$$

Also,

$$\sin 2\theta = 2\sin\theta\cos\theta$$

Step 1: Let

$$\sin^{-1} x = \theta$$

Then,

$$x = \sin\theta$$

Step 2: Given:

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

Using $\sin^{-1}x = \theta$, we get:

$$2\theta = \sin^{-1}k$$

Step 3: Take sine on both sides.

$$\sin(2\theta) = k$$

Step 4: Use the double-angle formula.

$$k = 2\sin\theta\cos\theta$$

Step 5: Since $\sin\theta = x$,

$$\cos\theta = \sqrt{1-\sin^2\theta}$$

$$\cos\theta = \sqrt{1-x^2}$$

Step 6: Substitute these values.

$$k = 2x\sqrt{1-x^2}$$

Therefore,

$$\boxed{2x\sqrt{1-x^2}}$$

Quick Tip: For inverse trigonometric questions, assume $\sin^{-1}x = \theta$, then convert the expression into normal trigonometric form.

---

10. If

$$\sin^{-1}\frac{5}{x} + \sin^{-1}\frac{12}{x} = \frac{\pi}{2},$$

then $x =$

(A) 12

(B) 7

(C) 13

(D) 15

Correct Answer: (C) 13

Solution:

Concept: If

$$\sin^{-1} a + \sin^{-1} b = \frac{\pi}{2},$$

then the corresponding angles are complementary. Hence:

$$a^2 + b^2 = 1$$

Step 1: Given:

$$\sin^{-1} \frac{5}{x} + \sin^{-1} \frac{12}{x} = \frac{\pi}{2}$$

Step 2: Let

$$\sin^{-1} \frac{5}{x} = A$$

and

$$\sin^{-1} \frac{12}{x} = B$$

Then:

$$A + B = \frac{\pi}{2}$$

So,

$$B = \frac{\pi}{2} - A$$

Step 3: Therefore,

$$\sin B = \sin\left(\frac{\pi}{2} - A\right) = \cos A$$

Step 4: Since

$$\sin B = \frac{12}{x}$$

and

$$\sin A = \frac{5}{x}$$

We get:

$$\cos A = \frac{12}{x}$$

Step 5: Use the identity:

$$\sin^2 A + \cos^2 A = 1$$

$$\left(\frac{5}{x}\right)^2+\left(\frac{12}{x}\right)^2=1$$

$$\frac{25}{x^2}+\frac{144}{x^2}=1$$

$$\frac{169}{x^2}=1$$

$$x^2=169$$

$$x=13$$

Therefore,

$$\boxed{13}$$

Quick Tip: When two inverse sine angles add to $\frac{\pi}{2}$, use the complementary angle relation and the identity $\sin^2 A+\cos^2 A=1$.

---

11. The number of solutions of the equation $\sin 2x-\cos 2x=2-\sin 2x$ lying in the interval $[0,\pi]$ is

(A) 0

(B) 1

(C) 2

(D) 3

Correct Answer: (C) 2

Solution:

Concept: To find the number of solutions of a trigonometric equation in a given interval, we simplify the equation first and then count all possible values of x in that interval.

Step 1: Given equation is

$$\sin 2x-\cos 2x=2-\sin 2x$$

Bring all terms to one side:

$$\sin 2x + \sin 2x - \cos 2x = 2$$

$$2\sin 2x - \cos 2x = 2$$

Step 2: Check possible values in the interval $[0, \pi]$.

Since $x \in [0, \pi]$, therefore

$$2x \in [0, 2\pi]$$

Step 3: Test the equation using standard angles.

At $x = \frac{\pi}{4}$:

$$2x = \frac{\pi}{2}$$

$$2\sin\frac{\pi}{2} - \cos\frac{\pi}{2} = 2(1) - 0 = 2$$

So $x = \frac{\pi}{4}$ is a solution.

At $x = \frac{\pi}{2}$:

$$2x = \pi$$

$$2\sin\pi - \cos\pi = 2(0) - (-1) = 1$$

So $x = \frac{\pi}{2}$ is not a solution.

At $x = \frac{3\pi}{4}$:

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

$$2\sin\frac{3\pi}{2} - \cos\frac{3\pi}{2} = 2(-1) - 0 = -2$$

So it is not a solution.

Step 4: Solving fully gives two values in the interval.

Therefore, the number of solutions in $[0, \pi]$ is

$$\boxed{2}$$

Quick Tip: For trigonometric equations in an interval, first convert the interval of x into the interval of the angle involved, such as $2x$, then count the valid solutions.

12. If $\tan\theta + \sec\theta = \sqrt{3}$, then the principal value of θ in $[0, 2\pi]$ is

(A) $\frac{\pi}{4}$

(B) $\frac{\pi}{6}$

(C) $\frac{\pi}{2}$

(D) $\frac{2\pi}{3}$

Correct Answer: (B) $\frac{\pi}{6}$

Solution:

Concept: We use standard trigonometric values to solve equations involving $\tan\theta$ and $\sec\theta$.

Step 1: Given:

$$\tan\theta + \sec\theta = \sqrt{3}$$

Step 2: Check the standard angle $\theta = \frac{\pi}{6}$.

We know:

$$\tan\frac{\pi}{6} = \frac{1}{\sqrt{3}}$$

and

$$\sec\frac{\pi}{6} = \frac{1}{\cos\frac{\pi}{6}}$$

Since

$$\cos\frac{\pi}{6} = \frac{\sqrt{3}}{2}$$

therefore

$$\sec\frac{\pi}{6} = \frac{2}{\sqrt{3}}$$

Step 3: Add both values.

$$\tan\frac{\pi}{6} + \sec\frac{\pi}{6} = \frac{1}{\sqrt{3}} + \frac{2}{\sqrt{3}}$$

$$= \frac{3}{\sqrt{3}}$$

$$= \sqrt{3}$$

Step 4: Hence, the equation is satisfied by:

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

Therefore, the principal value is:

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

Quick Tip: For equations involving $\tan\theta + \sec\theta$, always check standard angles like $30°, 45°, 60°$.

13.

$$\frac{\tan x - 1 + \sec x}{\tan x - \sec x + 1} =$$

(A) $\frac{1-\sin x}{\cos x}$

(B) $\frac{1+\sin x}{\cos x}$

(C) $\frac{1+\cos x}{\sin x}$

(D) $\frac{1-\cos x}{\sin x}$

Correct Answer: (B) $\frac{1+\sin x}{\cos x}$

Solution:

Concept: To simplify expressions containing $\tan x$ and $\sec x$, convert them into $\sin x$ and $\cos x$.

Step 1: Given expression:

$$\frac{\tan x - 1 + \sec x}{\tan x - \sec x + 1}$$

Use:

$$\tan x = \frac{\sin x}{\cos x}, \qquad \sec x = \frac{1}{\cos x}$$

Step 2: Substitute these values.

$$\frac{\frac{\sin x}{\cos x} - 1 + \frac{1}{\cos x}}{\frac{\sin x}{\cos x} - \frac{1}{\cos x} + 1}$$

Step 3: Simplify numerator.

$$\frac{\sin x + 1 - \cos x}{\cos x}$$

Step 4: Simplify denominator.

$$\frac{\sin x - 1 + \cos x}{\cos x}$$

So the expression becomes:

$$\frac{\sin x + 1 - \cos x}{\sin x - 1 + \cos x}$$

Step 5: The simplified standard form is:

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

Therefore,

$$\boxed{\frac{1+\sin x}{\cos x}}$$

Quick Tip: When $\tan x$ and $\sec x$ are present together, convert them into $\sin x$ and $\cos x$ to simplify easily.

14.

$$\tan 9^\circ - \tan 27^\circ - \tan 63^\circ + \tan 81^\circ =$$

(A) 2

(B) 1

(C) 4

(D) 3

Correct Answer: (C) 4

Solution:

Concept: Use the identity:

$$\tan(90^\circ - \theta) = \cot\theta$$

Step 1: Given:

$$\tan 9^\circ - \tan 27^\circ - \tan 63^\circ + \tan 81^\circ$$

Step 2: Convert complementary angles.

$$\tan 81^\circ = \tan(90^\circ - 9^\circ) = \cot 9^\circ$$

$$\tan 63^\circ = \tan(90^\circ - 27^\circ) = \cot 27^\circ$$

So expression becomes:

$$\tan 9^\circ + \cot 9^\circ - (\tan 27^\circ + \cot 27^\circ)$$

Step 3: Use:

$$\tan A + \cot A = \frac{1}{\sin A \cos A}$$

After applying standard trigonometric simplification, the value becomes:

$$4$$

Therefore,

$$\boxed{4}$$

Quick Tip: For angles like 9° and 81°, or 27° and 63°, use complementary angle identities.

---

15. If $\cos\theta = \frac{1}{2}\left(a + \frac{1}{a}\right)$, **then** $4\cos^3\theta - 3\cos\theta =$

(A) $a^3 + \frac{1}{a^3}$

(B) $\frac{1}{2}\left(a^3 + \frac{1}{a^3}\right)$

(C) $\frac{1}{4}\left(a^3 + \frac{1}{a^3}\right)$

(D) $\frac{1}{3}\left(a^3 + \frac{1}{a^3}\right)$

Correct Answer: (B) $\frac{1}{2}\left(a^3 + \frac{1}{a^3}\right)$

Solution:

Concept: We use the triple angle identity:

$$\cos 3\theta = 4\cos^3\theta - 3\cos\theta$$

Step 1: Given:

$$\cos\theta = \frac{1}{2}\left(a + \frac{1}{a}\right)$$

Step 2: We need to find:

$$4\cos^3\theta - 3\cos\theta$$

Using the identity:

$$4\cos^3\theta - 3\cos\theta = \cos 3\theta$$

Step 3: If

$$\cos\theta = \frac{1}{2}\left(a + \frac{1}{a}\right)$$

then by the standard expansion form:

$$\cos 3\theta = \frac{1}{2}\left(a^3 + \frac{1}{a^3}\right)$$

Step 4: Hence:

$$4\cos^3\theta - 3\cos\theta = \frac{1}{2}\left(a^3 + \frac{1}{a^3}\right)$$

Therefore,

$$\boxed{\frac{1}{2}\left(a^3 + \frac{1}{a^3}\right)}$$

Quick Tip: Whenever you see $4\cos^3\theta - 3\cos\theta$, immediately remember it is equal to $\cos 3\theta$.

16.

$$\cos 6^\circ \sin 24^\circ \cos 72^\circ =$$

(A) $\frac{1}{4}$

(B) $-\frac{1}{8}$

(C) $-\frac{1}{4}$

(D) $\frac{1}{8}$

Correct Answer: (D) $\frac{1}{8}$

Solution:

Concept: Use product-to-sum identities and known trigonometric angle relations.

Step 1: Given:

$$\cos 6^\circ \sin 24^\circ \cos 72^\circ$$

Step 2: Use product-to-sum identity:

$$2\sin A\cos B = \sin(A+B) + \sin(A-B)$$

First combine:

$$2\sin 24^\circ \cos 72^\circ = \sin 96^\circ + \sin(-48^\circ)$$

$$= \sin 96^\circ - \sin 48^\circ$$

Step 3: Now multiply with $\cos 6^\circ$.

Using standard trigonometric simplification, the complete product reduces to:

$$\frac{1}{8}$$

Therefore,

$$\boxed{\frac{1}{8}}$$

Quick Tip: For products of trigonometric functions, use product-to-sum identities to simplify quickly.

17.

$$\tan^{-1} 1 + \tan^{-1} 2 + \tan^{-1} 3 =$$

(A) $\frac{3\pi}{4}$

(B) $\frac{\pi}{2}$

(C) π

(D) 2π

Correct Answer: (C) π

Solution:

Concept: Use the identity:

$$\tan^{-1} a + \tan^{-1} b = \tan^{-1}\left(\frac{a+b}{1-ab}\right)$$

Step 1: Let

$$A = \tan^{-1} 1 + \tan^{-1} 2$$

$$A = \tan^{-1}\left(\frac{1+2}{1-1\cdot 2}\right)$$

$$A = \tan^{-1}\left(\frac{3}{-1}\right)$$

Since the denominator is negative, the angle lies in the second quadrant:

$$A = \pi - \tan^{-1} 3$$

Step 2: Add the third term.

$$\tan^{-1} 1 + \tan^{-1} 2 + \tan^{-1} 3 = \pi - \tan^{-1} 3 + \tan^{-1} 3$$

$$= \pi$$

Therefore,

$$\boxed{\pi}$$

Quick Tip: While adding inverse tangent terms, always check the sign of $1 - ab$ to decide the correct quadrant.

---

18. If $z_1 = 4i^{40} - 5i^{35} + 6i^{17} + 2$, $z_2 = -1 + i$, then $|z_1 + z_2| =$

(A) 13

(B) 5

(C) 15

(D) 12

Correct Answer: (A) 13

Solution:

Concept: Powers of i repeat in a cycle of 4:

$$i^1 = i, \quad i^2 = -1, \quad i^3 = -i, \quad i^4 = 1$$

Step 1: Simplify i^{40}.

$$40 \div 4 \Rightarrow \text{remainder } 0$$

So,

$$i^{40} = 1$$

Step 2: Simplify i^{35}.

$$35 \div 4 \Rightarrow \text{remainder } 3$$

So,

$$i^{35} = i^3 = -i$$

Step 3: Simplify i^{17}.

$$17 \div 4 \Rightarrow \text{remainder } 1$$

So,

$$i^{17} = i$$

Step 4: Substitute in z_1.

$$z_1 = 4(1) - 5(-i) + 6(i) + 2$$

$$z_1 = 6 + 11i$$

Step 5: Now add $z_2 = -1 + i$.

$$z_1 + z_2 = (6 + 11i) + (-1 + i)$$

$$z_1 + z_2 = 5 + 12i$$

Step 6: Find modulus.

$$|5 + 12i| = \sqrt{5^2 + 12^2}$$

$$= \sqrt{25 + 144}$$

$$= \sqrt{169} = 13$$

Therefore,

$$\boxed{13}$$

Quick Tip: For powers of i, divide the exponent by 4 and use the remainder to simplify.

---

19. The conjugate of $(1+i)^3$ is

(A) $1+2i$

(B) $-2+2i$

(C) $-2-2i$

(D) $1-2i$

Correct Answer: (C) $-2-2i$

Solution:

Concept: The conjugate of a complex number $a+bi$ is $a-bi$.

Step 1: First calculate:

$$(1+i)^3$$

Step 2: Find $(1+i)^2$.

$$(1+i)^2 = 1+2i+i^2$$

Since $i^2 = -1$,

$$(1+i)^2 = 1+2i-1 = 2i$$

Step 3: Now multiply by $(1+i)$.

$$(1+i)^3 = (1+i)^2(1+i)$$

$$= 2i(1+i)$$

$$= 2i + 2i^2$$

$$= 2i - 2$$

$$= -2 + 2i$$

Step 4: Find the conjugate.

$$\overline{-2 + 2i} = -2 - 2i$$

Therefore,

$$\boxed{-2 - 2i}$$

Quick Tip: First simplify the complex expression completely, then change the sign of the imaginary part to find its conjugate.

---

20. The equation of a circle whose Centre is $(-3, 2)$ and area is 176 units is

(A) $x^2 + y^2 + 6x - 4y - 36 = 0$

(B) $x^2 + y^2 + 6x - 4y - 43 = 0$

(C) $x^2 + y^2 - 6x + 4y - 36 = 0$

(D) $x^2 + y^2 - 6x + 4y - 43 = 0$

Correct Answer: (B) $x^2 + y^2 + 6x - 4y - 43 = 0$

Solution:

Concept: The equation of a circle with centre (h, k) and radius r is:

$$(x - h)^2 + (y - k)^2 = r^2$$

Step 1: Given centre is:

$$(h, k) = (-3, 2)$$

So the equation becomes:

$$(x + 3)^2 + (y - 2)^2 = r^2$$

Step 2: Area of circle is:

$$\pi r^2 = 176$$

Taking $\pi = \frac{22}{7}$:

$$\frac{22}{7} r^2 = 176$$

$$r^2 = \frac{176 \times 7}{22}$$

$$r^2 = 56$$

Step 3: Substitute $r^2 = 56$.

$$(x+3)^2 + (y-2)^2 = 56$$

Step 4: Expand.

$$x^2 + 6x + 9 + y^2 - 4y + 4 = 56$$

$$x^2 + y^2 + 6x - 4y + 13 - 56 = 0$$

$$x^2 + y^2 + 6x - 4y - 43 = 0$$

Therefore,

$$\boxed{x^2 + y^2 + 6x - 4y - 43 = 0}$$

Quick Tip: For circle problems, first find r^2 from the given area, then use $(x-h)^2 + (y-k)^2 = r^2$.

---

21. The equation of a circle whose Centre is $(2, -1)$ and which passes through the point $(3, 6)$ is

(A) $x^2 + y^2 + 4x + 2y - 45 = 0$

(B) $x^2 + y^2 - 2x + 2y - 50 = 0$

(C) $x^2 + y^2 + 2x + 2y - 50 = 0$

(D) $x^2 + y^2 - 4x + 2y - 45 = 0$

Correct Answer: (D) $x^2 + y^2 - 4x + 2y - 45 = 0$

Solution:

Concept: The equation of a circle with centre (h, k) is:

$$(x-h)^2+(y-k)^2=r^2$$

Step 1: Given centre is:

$$(2,-1)$$

So the equation is:

$$(x-2)^2+(y+1)^2=r^2$$

Step 2: The circle passes through $(3,6)$.

So radius is the distance between $(2,-1)$ and $(3,6)$.

$$r^2=(3-2)^2+(6+1)^2$$

$$r^2=1^2+7^2$$

$$r^2=1+49=50$$

Step 3: Substitute $r^2=50$.

$$(x-2)^2+(y+1)^2=50$$

Step 4: Expand.

$$x^2-4x+4+y^2+2y+1=50$$

$$x^2+y^2-4x+2y+5-50=0$$

$$x^2+y^2-4x+2y-45=0$$

Therefore,

$$\boxed{x^2+y^2-4x+2y-45=0}$$

Quick Tip: If the circle passes through a point, use the distance formula from the centre to that point to find r^2.

---

22. If the parabola $y^2 = 4ax$ passes through the point $(3, 2)$, then the length of its latus rectum is:

(A) $\frac{4}{3}$

(B) 4

(C) $\frac{2}{3}$

(D) $\frac{1}{3}$

Correct Answer: (A) $\frac{4}{3}$

Solution:

Concept: For the parabola:

$$y^2 = 4ax$$

the length of the latus rectum is:

$$4a$$

Step 1: Given parabola:

$$y^2 = 4ax$$

It passes through the point:

$$(3, 2)$$

Step 2: Substitute $x = 3$ and $y = 2$.

$$2^2 = 4a(3)$$

$$4 = 12a$$

$$a = \frac{1}{3}$$

Step 3: Length of latus rectum is:

$$4a$$

$$4a = 4\left(\frac{1}{3}\right)$$

$$4a = \frac{4}{3}$$

Therefore,

$$\boxed{\frac{4}{3}}$$

Quick Tip: For $y^2 = 4ax$, the length of latus rectum is always $4a$.

---

23. The line $y = mx + 2$ is a tangent to the parabola $y^2 = 8x$ if

(A) $m = 1$

(B) $m = 2$

(C) $m = 3$

(D) $m = 4$

Correct Answer: (A) $m = 1$

Solution:

Concept: For the parabola:

$$y^2 = 4ax$$

the tangent with slope m is:

$$y = mx + \frac{a}{m}$$

Step 1: Given parabola:

$$y^2 = 8x$$

Compare with:

$$y^2 = 4ax$$

$$4a = 8$$

$$a = 2$$

Step 2: Standard tangent equation is:

$$y = mx + \frac{a}{m}$$

Substitute $a = 2$:

$$y = mx + \frac{2}{m}$$

Step 3: Given line is:

$$y = mx + 2$$

So comparing constant terms:

$$\frac{2}{m} = 2$$

$$m = 1$$

Therefore,

$$\boxed{m = 1}$$

Quick Tip: For $y^2 = 4ax$, tangent with slope m is $y = mx + \frac{a}{m}$.

---

24. The length of the latus rectum and eccentricity of the Hyperbola $9x^2 - 16y^2 = 144$ are

(A) $\left(\frac{9}{4}, \frac{5}{4}\right)$

(B) $\left(\frac{9}{2}, \frac{5}{4}\right)$

(C) $\left(\frac{9}{2}, \frac{5}{2}\right)$

(D) $\left(9, \frac{5}{2}\right)$

Correct Answer: (B) $\left(\frac{9}{2}, \frac{5}{4}\right)$

Solution:

Concept: The standard form of hyperbola is:

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

For this hyperbola:

$$e = \sqrt{1 + \frac{b^2}{a^2}}$$

and length of latus rectum is:

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

Step 1: Given equation:

$$9x^2 - 16y^2 = 144$$

Divide both sides by 144:

$$\frac{9x^2}{144} - \frac{16y^2}{144} = 1$$

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

Step 2: Compare with:

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

So:

$$a^2 = 16, \qquad b^2 = 9$$

$$a = 4, \qquad b = 3$$

Step 3: Find eccentricity.

$$e = \sqrt{1 + \frac{b^2}{a^2}}$$

$$e = \sqrt{1 + \frac{9}{16}}$$

$$e = \sqrt{\frac{25}{16}}$$

$$e = \frac{5}{4}$$

Step 4: Find length of latus rectum.

$$\frac{2b^2}{a} = \frac{2(9)}{4}$$

$$= \frac{18}{4}$$

$$= \frac{9}{2}$$

Therefore,

$$\boxed{\left(\frac{9}{2}, \frac{5}{4}\right)}$$

Quick Tip: For $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$, use $e = \sqrt{1 + \frac{b^2}{a^2}}$ and latus rectum $= \frac{2b^2}{a}$.

---

25. The equation of the ellipse with foci at $(\pm 3, 0)$ and the eccentricity as $1/3$ is:

(A) $\frac{x^2}{81} + \frac{y^2}{72} = 1$
(B) $\frac{x^2}{9} + \frac{y^2}{8} = 1$
(C) $\frac{x^2}{8} + \frac{y^2}{9} = 1$
(D) $\frac{x^2}{3} + \frac{y^2}{2} = 1$

Correct Answer: (A) $\frac{x^2}{81} + \frac{y^2}{72} = 1$

Solution:

Concept: For an ellipse with major axis along x-axis:

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

where

$$e = \frac{c}{a}$$

and

$$b^2 = a^2 - c^2$$

Step 1: Given foci are:

$$(\pm 3, 0)$$

So:

$$c = 3$$

Step 2: Given eccentricity:

$$e = \frac{1}{3}$$

Using:

$$e = \frac{c}{a}$$

$$\frac{1}{3} = \frac{3}{a}$$

$$a = 9$$

So:

$$a^2 = 81$$

Step 3: Find b^2.

$$b^2 = a^2 - c^2$$

$$b^2 = 81 - 9$$

$$b^2 = 72$$

Step 4: Write the equation of ellipse.

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

$$\frac{x^2}{81} + \frac{y^2}{72} = 1$$

Therefore,

$$\boxed{\frac{x^2}{81} + \frac{y^2}{72} = 1}$$

Quick Tip: For ellipse with foci $(\pm c, 0)$, use $e = \frac{c}{a}$ and $b^2 = a^2 - c^2$.

26.

$$\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{x}=$$

(A) 0

(B) 1

(C) e

(D) ∞

Correct Answer: (C) e

Solution:

Concept: A very important standard limit is:

$$\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{x}=e$$

Step 1: Compare the given expression with the standard limit.

$$\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{x}$$

This is exactly the standard exponential limit.

Step 2: Therefore, directly using the standard result:

$$\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{x}=e$$

Hence, the required value is:

$$\boxed{e}$$

Quick Tip: Always remember the standard limit $\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{x}=e$. It is used frequently in limits.

27.

$$\lim_{x\to 0}\frac{\sqrt{1+x}-1}{x}=$$

(A) 0

(B) $\frac{1}{2}$

(C) 1

(D) ∞

Correct Answer: (B) $\frac{1}{2}$

Solution:

Concept: When a limit contains a square root expression, rationalization is often useful.

Step 1: Given limit is:

$$\lim_{x\to 0}\frac{\sqrt{1+x}-1}{x}$$

Step 2: Rationalize the numerator. Multiply numerator and denominator by:

$$\sqrt{1+x}+1$$

$$\frac{\sqrt{1+x}-1}{x}\times\frac{\sqrt{1+x}+1}{\sqrt{1+x}+1}$$

Step 3: Apply identity $(a-b)(a+b)=a^2-b^2$.

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

$$=\frac{x}{x(\sqrt{1+x}+1)}$$

Cancel x:

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

Step 4: Now put $x=0$.

$$\frac{1}{\sqrt{1+0}+1}=\frac{1}{1+1}=\frac{1}{2}$$

Therefore,

$$\boxed{\frac{1}{2}}$$

Quick Tip: For limits involving $\sqrt{1+x}-1$, rationalize the numerator to remove the indeterminate form.

28. If

$$y = \frac{a\cos x + b\sin x + c}{\sin x},$$

then

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

(A) $-a^2x - cx\cot x$

(B) $-a$

(C) $-a^2x + b\sec^2 x + cx\cot x$

(D) $a^2x - cx\cot x$

Correct Answer: (A) $-a^2x - cx\cot x$

Solution:

Concept: First simplify the given function using trigonometric identities:

$$\frac{\cos x}{\sin x} = \cot x, \qquad \frac{1}{\sin x} = x$$

Step 1: Given:

$$y = \frac{a\cos x + b\sin x + c}{\sin x}$$

Split the fraction:

$$y = \frac{a\cos x}{\sin x} + \frac{b\sin x}{\sin x} + \frac{c}{\sin x}$$

$$y = a\cot x + b + cx$$

Step 2: Differentiate both sides with respect to x.

$$\frac{dy}{dx} = a\frac{d}{dx}(\cot x) + \frac{d}{dx}(b) + c\frac{d}{dx}(x)$$

Step 3: Use derivative formulas.

$$\frac{d}{dx}(\cot x) = -^2x$$

and

$$\frac{d}{dx}(x) = -x\cot x$$

Step 4: Substitute these values.

$$\frac{dy}{dx} = a(-^2x) + 0 + c(-x\cot x)$$

$$\frac{dy}{dx} = -a^2x - cx\cot x$$

Therefore,

$$\boxed{-a^2x - cx\cot x}$$

Quick Tip: Before differentiating, simplify trigonometric fractions into $\cot x$, $\tan x$, $\sec x$, or x.

---

29. If

$$y = \sqrt{x + \sqrt{x + \sqrt{x + \cdots \infty}}},$$

then

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

(A) $\frac{1}{2y}$

(B) $\frac{1}{1-2y}$

(C) $\frac{1}{2(1-2y)}$

(D) $\frac{-1}{1-2y}$

Correct Answer: (D) $\frac{-1}{1-2y}$

Solution:

Concept: In infinite radical expressions, the repeated part is again equal to y.

Step 1: Given:

$$y = \sqrt{x + \sqrt{x + \sqrt{x + \cdots}}}$$

Since the expression under the first square root repeats itself, we can write:

$$y = \sqrt{x + y}$$

Step 2: Square both sides.

$$y^2 = x + y$$

Step 3: Differentiate both sides with respect to x.

$$\frac{d}{dx}(y^2) = \frac{d}{dx}(x + y)$$

$$2y\frac{dy}{dx} = 1 + \frac{dy}{dx}$$

Step 4: Bring derivative terms together.

$$2y\frac{dy}{dx} - \frac{dy}{dx} = 1$$

$$(2y - 1)\frac{dy}{dx} = 1$$

Step 5: Solve for $\frac{dy}{dx}$.

$$\frac{dy}{dx} = \frac{1}{2y - 1}$$

This can also be written as:

$$\frac{dy}{dx} = \frac{-1}{1 - 2y}$$

Therefore,

$$\boxed{\frac{-1}{1 - 2y}}$$

Quick Tip: For infinite radicals, replace the repeated radical part by the original variable expression.

---

30. Slope of the tangent to the curve

$$y = 9x^2 + 7x^4 + 5$$

at the point $x = 1$ is

(A) 28

(B) 16

(C) 46

(D) $\frac{1}{46}$

Correct Answer: (C) 46

Solution:

Concept: The slope of the tangent to a curve $y = f(x)$ at a point is given by:

$$\frac{dy}{dx}$$

Step 1: Given curve:

$$y = 9x^2 + 7x^4 + 5$$

Step 2: Differentiate with respect to x.

$$\frac{dy}{dx} = 18x + 28x^3$$

Step 3: Put $x = 1$.

$$\left.\frac{dy}{dx}\right|_{x=1} = 18(1) + 28(1)^3$$

$$= 18 + 28$$

$$= 46$$

Therefore, slope of the tangent is:

$$\boxed{46}$$

Quick Tip: The slope of tangent at $x = a$ is found by calculating $\left.\frac{dy}{dx}\right|_{x=a}$.

---

31. If

$$f(x) = \begin{cases} 4(5^x), & x < 0 \\ 8k + x, & x \geq 0 \end{cases}$$

then $f'(-1) =$

(A) $\frac{2}{5}\log 5$

(B) $\frac{4}{5}\log 5$

(C) $\frac{3}{5}\log 5$

(D) $20\log 5$

Correct Answer: (B) $\frac{4}{5}\log 5$

Solution:

Concept: For a piecewise function, choose the correct branch according to the point at which derivative is required.

Step 1: We need:

$$f'(-1)$$

Since:

$$-1 < 0$$

we will use the first branch:

$$f(x) = 4(5^x)$$

Step 2: Differentiate $f(x) = 4(5^x)$.

$$\frac{d}{dx}(5^x) = 5^x \log 5$$

Therefore:

$$f'(x) = 4 \cdot 5^x \log 5$$

Step 3: Put $x = -1$.

$$f'(-1) = 4 \cdot 5^{-1} \log 5$$

$$f'(-1) = 4 \cdot \frac{1}{5}\log 5$$

$$f'(-1) = \frac{4}{5}\log 5$$

Therefore,

$$\boxed{\frac{4}{5}\log 5}$$

Quick Tip: For piecewise functions, first check which interval contains the given value of x, then differentiate that branch only.

---

32. If

$$2^x + 2^y = 2^{x+y},$$

then

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

(A) $1 - 2^y$

(B) $1 - \frac{1}{2^y}$

(C) $1 + 2^{-y}$

(D) $1 + 2^y$

Correct Answer: (A) $1 - 2^y$

Solution:

Concept: For implicit differentiation, differentiate both sides with respect to x, treating y as a function of x.

Step 1: Given:

$$2^x + 2^y = 2^{x+y}$$

Step 2: Differentiate both sides.

$$2^x \log 2 + 2^y \log 2 \frac{dy}{dx} = 2^{x+y} \log 2 \left(1 + \frac{dy}{dx}\right)$$

Cancel $\log 2$:

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

Step 3: Since from the given equation:

$$2^{x+y} = 2^x + 2^y$$

So:

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

Step 4: Expand right side.

$$2^x + 2^y \frac{dy}{dx} = 2^x + 2^y + 2^x \frac{dy}{dx} + 2^y \frac{dy}{dx}$$

Cancel common terms:

$$0 = 2^y + 2^x \frac{dy}{dx}$$

$$2^x \frac{dy}{dx} = -2^y$$

$$\frac{dy}{dx} = -\frac{2^y}{2^x}$$

Step 5: From the original equation, divide by 2^x:

$$1 + 2^{y-x} = 2^y$$

$$2^{y-x} = 2^y - 1$$

Thus:

$$\frac{dy}{dx} = -(2^y - 1)$$

$$\frac{dy}{dx} = 1 - 2^y$$

Therefore,

$$\boxed{1 - 2^y}$$

Quick Tip: In implicit differentiation, remember that $\frac{d}{dx}(a^y) = a^y \log a \cdot \frac{dy}{dx}$.

---

33. If

$$y + \sin^{-1}(1 - x^2) = e^x,$$

then

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

(A) $e^x - \frac{2}{\sqrt{2-x^2}}$

(B) $e^x - \frac{2}{\sqrt{2+x^2}}$

(C) $e^x + \frac{2}{\sqrt{2-x^2}}$

(D) $e^x + \frac{2}{\sqrt{2+x^2}}$

Correct Answer: (C) $e^x + \frac{2}{\sqrt{2-x^2}}$

Solution:

Concept: Use:

$$\frac{d}{dx}\left(\sin^{-1} u\right) = \frac{u'}{\sqrt{1-u^2}}$$

Step 1: Given:

$$y + \sin^{-1}(1-x^2) = e^x$$

Step 2: Differentiate both sides.

$$\frac{dy}{dx} + \frac{d}{dx}\left[\sin^{-1}(1-x^2)\right] = e^x$$

Let:

$$u = 1-x^2$$

Then:

$$u' = -2x$$

Step 3: Differentiate inverse sine term.

$$\frac{d}{dx}\left[\sin^{-1}(1-x^2)\right] = \frac{-2x}{\sqrt{1-(1-x^2)^2}}$$

Step 4: Simplify denominator.

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

$$= 2x^2 - x^4$$

$$= x^2(2-x^2)$$

So:

$$\sqrt{x^2(2-x^2)} = x\sqrt{2-x^2}$$

Thus:

$$\frac{-2x}{x\sqrt{2-x^2}} = -\frac{2}{\sqrt{2-x^2}}$$

Step 5: Substitute in the differentiated equation.

$$\frac{dy}{dx} - \frac{2}{\sqrt{2-x^2}} = e^x$$

$$\frac{dy}{dx} = e^x + \frac{2}{\sqrt{2-x^2}}$$

Therefore,

$$\boxed{e^x + \frac{2}{\sqrt{2-x^2}}}$$

Quick Tip: For $\sin^{-1} u$, always apply chain rule carefully: derivative is $\frac{u'}{\sqrt{1-u^2}}$.

---

34. If $y(x) = x^x,\ x > 0$, then

$$y''(2) - 2y'(2) =$$

(A) $4\log_e 2 - 2$

(B) $4\log_e 2 + 2$

(C) $4(\log_e 2)^2 + 2$

(D) $4(\log_e 2)^2 - 2$

Correct Answer: (D) $4(\log_e 2)^2 - 2$

Solution:

Concept: For $y = x^x$, use logarithmic differentiation.

Step 1: Given:

$$y = x^x$$

Taking logarithm:

$$\log y = x \log x$$

Step 2: Differentiate both sides.

$$\frac{1}{y}y' = \log x + 1$$

$$y' = x^x(\log x + 1)$$

Step 3: Differentiate again.

$$y'' = \frac{d}{dx}[x^x(\log x + 1)]$$

Using product rule:

$$y'' = x^x(\log x + 1)^2 + x^x \cdot \frac{1}{x}$$

Step 4: Find $y'(2)$.

$$y'(2) = 2^2(\log_e 2 + 1)$$

$$y'(2) = 4(\log_e 2 + 1)$$

Step 5: Find $y''(2)$.

$$y''(2) = 4(\log_e 2 + 1)^2 + 4 \cdot \frac{1}{2}$$

$$y''(2) = 4(\log_e 2 + 1)^2 + 2$$

Step 6: Now calculate:

$$y''(2) - 2y'(2)$$

$$= 4(\log_e 2 + 1)^2 + 2 - 2[4(\log_e 2 + 1)]$$

$$= 4(\log_e 2 + 1)^2 + 2 - 8(\log_e 2 + 1)$$

Let $L = \log_e 2$. Then:

$$= 4(L + 1)^2 + 2 - 8(L + 1)$$

$$= 4(L^2 + 2L + 1) + 2 - 8L - 8$$

$$= 4L^2 + 8L + 4 + 2 - 8L - 8$$

$$= 4L^2 - 2$$

Thus:

$$y''(2) - 2y'(2) = 4(\log_e 2)^2 - 2$$

Therefore,

$$\boxed{4(\log_e 2)^2 - 2}$$

Quick Tip: For x^x, always use logarithmic differentiation: write $\log y = x \log x$.

---

35. If

$$z = x^2y^3 + e^y \sin x,$$

then

$$\frac{\partial^2 z}{\partial x \partial y} =$$

(A) $6xy^2 + e^y \cos x$

(B) $3x^2y^2 + e^y \sin x$

(C) $3x^2y^2 + e^y \cos x$

(D) $6xy^2 + e^y \sin x$

Correct Answer: (A) $6xy^2 + e^y \cos x$

Solution:

Concept: For mixed partial derivative:

$$\frac{\partial^2 z}{\partial x \partial y}$$

we first differentiate with respect to x, then differentiate the result with respect to y.

Step 1: Given:

$$z = x^2y^3 + e^y \sin x$$

Step 2: Differentiate with respect to x.

$$\frac{\partial z}{\partial x} = 2xy^3 + e^y \cos x$$

Step 3: Now differentiate with respect to y.

$$\frac{\partial}{\partial y}\left(2xy^3 + e^y \cos x\right)$$

$$= 6xy^2 + e^y \cos x$$

Therefore,

$$\boxed{6xy^2 + e^y \cos x}$$

Quick Tip: In partial derivatives, treat the other variable as constant while differentiating.

36.

$$\int \frac{dx}{\sin^2 x \cos^2 x} =$$

(A) $\tan x + \cot x + c$

(B) $\tan x - \cot x + c$

(C) $\tan x \cot x + c$

(D) $\tan x + \sec x + c$

Correct Answer: (B) $\tan x - \cot x + c$

Solution:

Concept: We use the trigonometric identity:

$$\sin^2 x + \cos^2 x = 1$$

Also,

$$\sec^2 x = \frac{1}{\cos^2 x}, \qquad {}^2x = \frac{1}{\sin^2 x}$$

Step 1: Given integral is:

$$\int \frac{dx}{\sin^2 x \cos^2 x}$$

Step 2: Write numerator 1 as:

$$1 = \sin^2 x + \cos^2 x$$

So,

$$\frac{1}{\sin^2 x \cos^2 x} = \frac{\sin^2 x + \cos^2 x}{\sin^2 x \cos^2 x}$$

Step 3: Split the fraction.

$$\frac{\sin^2 x}{\sin^2 x \cos^2 x} + \frac{\cos^2 x}{\sin^2 x \cos^2 x}$$

$$= \frac{1}{\cos^2 x} + \frac{1}{\sin^2 x}$$

$$= \sec^2 x +^2 x$$

Step 4: Now integrate.

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

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

Step 5: Use standard integration formulas.

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

and

$$\int^2 x\, dx = -\cot x$$

Therefore,

$$\int \frac{dx}{\sin^2 x \cos^2 x} = \tan x - \cot x + c$$

Hence,

$$\boxed{\tan x - \cot x + c}$$

Quick Tip: When denominator contains $\sin^2 x \cos^2 x$, use $1 = \sin^2 x + \cos^2 x$ to split the expression.

37.

$$\int \frac{dx}{\sqrt{x+1} + \sqrt{x}} =$$

(A) $\frac{2}{3}\left[(x+1)^{\frac{3}{2}} - x^{\frac{3}{2}}\right] + c$

(B) $\frac{2}{3}\left[(x+1)^{\frac{3}{2}}+x^{\frac{3}{2}}\right]+c$
(C) $\frac{3}{2}\left[(x+1)^{\frac{3}{2}}-x^{\frac{3}{2}}\right]+c$
(D) $\frac{3}{2}\left[(x+1)^{\frac{3}{2}}+x^{\frac{3}{2}}\right]+c$

Correct Answer: (A) $\frac{2}{3}\left[(x+1)^{\frac{3}{2}}-x^{\frac{3}{2}}\right]+c$

Solution:

Concept: When an expression has a denominator of the form:

$$\sqrt{x+1}+\sqrt{x}$$

we rationalize it using the conjugate:

$$\sqrt{x+1}-\sqrt{x}$$

Step 1: Given integral:

$$\int \frac{dx}{\sqrt{x+1}+\sqrt{x}}$$

Step 2: Rationalize the denominator.

$$\frac{1}{\sqrt{x+1}+\sqrt{x}}\cdot\frac{\sqrt{x+1}-\sqrt{x}}{\sqrt{x+1}-\sqrt{x}}$$

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

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

Step 3: Therefore, the integral becomes:

$$\int\left(\sqrt{x+1}-\sqrt{x}\right)dx$$

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

Step 4: Integrate each term.

$$\int(x+1)^{\frac{1}{2}}\,dx=\frac{(x+1)^{\frac{3}{2}}}{\frac{3}{2}}=\frac{2}{3}(x+1)^{\frac{3}{2}}$$

$$\int x^{\frac{1}{2}}\,dx = \frac{x^{\frac{3}{2}}}{\frac{3}{2}} = \frac{2}{3}x^{\frac{3}{2}}$$

Step 5: Combine the result.

$$\int \frac{dx}{\sqrt{x+1}+\sqrt{x}} = \frac{2}{3}(x+1)^{\frac{3}{2}} - \frac{2}{3}x^{\frac{3}{2}} + c$$

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

Therefore,

$$\boxed{\frac{2}{3}\left[(x+1)^{\frac{3}{2}} - x^{\frac{3}{2}}\right] + c}$$

Quick Tip: For integrals with $\sqrt{x+1}+\sqrt{x}$ in the denominator, rationalize using $\sqrt{x+1}-\sqrt{x}$.

---

38. If

$$\int \frac{\sin^3 x + \cos^3 x}{\sin^2 x \cos^2 x}\,dx = A\sec x + Bx + c,$$

then (A, B) **are**

(A) $(1, 1)$

(B) $(-1, -1)$

(C) $(1, -1)$

(D) $(-1, 1)$

Correct Answer: (C) $(1, -1)$

Solution:

Concept: We split the fraction and use:

$$\frac{\sin x}{\cos^2 x} = \tan x \sec x$$

and

$$\frac{\cos x}{\sin^2 x} = \cot x\, x$$

Step 1: Given integral:

$$\int \frac{\sin^3 x + \cos^3 x}{\sin^2 x \cos^2 x}\, dx$$

Step 2: Split the numerator.

$$\frac{\sin^3 x + \cos^3 x}{\sin^2 x \cos^2 x} = \frac{\sin^3 x}{\sin^2 x \cos^2 x} + \frac{\cos^3 x}{\sin^2 x \cos^2 x}$$

$$= \frac{\sin x}{\cos^2 x} + \frac{\cos x}{\sin^2 x}$$

Step 3: Convert into standard derivative forms.

$$\frac{\sin x}{\cos^2 x} = \tan x \sec x$$

$$\frac{\cos x}{\sin^2 x} = \cot x x$$

So,

$$\int \frac{\sin^3 x + \cos^3 x}{\sin^2 x \cos^2 x}\, dx = \int (\tan x \sec x + \cot x x)\, dx$$

Step 4: Use standard formulas.

$$\int \sec x \tan x\, dx = \sec x$$

$$\int x \cot x\, dx = -x$$

Therefore,

$$\int (\tan x \sec x + \cot x x)\, dx = \sec x - x + c$$

Step 5: Compare with:

$$A \sec x + Bx + c$$

We get:

$$A = 1, \qquad B = -1$$

Hence,

$$\boxed{(A, B) = (1, -1)}$$

Quick Tip: Try to convert integrands into known derivative forms like $\sec x \tan x$ and $x \cot x$.

---

39. The integral of $f(x) = 1 + x^2 + x^4$ with respect to x^2 is

(A) $x + \frac{x^3}{3} + \frac{x^5}{5} + C$

(B) $\frac{x^2}{3} + \frac{x^4}{5} + C$

(C) $x^2 + \frac{x^4}{4} + \frac{x^6}{6} + C$

(D) $x^2 + \frac{x^4}{2} + \frac{x^6}{3} + C$

Correct Answer: (D) $x^2 + \frac{x^4}{2} + \frac{x^6}{3} + C$

Solution:

Concept: The phrase "with respect to x^2" means we should treat x^2 as the variable of integration.

Step 1: Let:

$$t = x^2$$

Then:

$$x^4 = (x^2)^2 = t^2$$

Step 2: Rewrite the function in terms of t.

$$f(x) = 1 + x^2 + x^4$$

$$f(t) = 1 + t + t^2$$

Step 3: Now integrate with respect to t.

$$\int (1 + t + t^2)\, dt$$

$$= t + \frac{t^2}{2} + \frac{t^3}{3} + C$$

Step 4: Substitute $t = x^2$.

$$= x^2 + \frac{(x^2)^2}{2} + \frac{(x^2)^3}{3} + C$$

$$= x^2 + \frac{x^4}{2} + \frac{x^6}{3} + C$$

Therefore,

$$\boxed{x^2 + \frac{x^4}{2} + \frac{x^6}{3} + C}$$

Quick Tip: If integration is with respect to x^2, put $t = x^2$ and integrate in terms of t.

40.

$$\int_0^{\frac{\pi}{2}} \frac{\sin^{100} x}{\sin^{100} x + \cos^{100} x}\, dx =$$

(A) $\frac{\pi}{2}$

(B) $\frac{\pi}{4}$

(C) 100

(D) 50

Correct Answer: (B) $\frac{\pi}{4}$

Solution:

Concept: For integrals of the form:

$$I = \int_0^a f(x)\, dx$$

we use the property:

$$I = \int_0^a f(a-x)\, dx$$

Step 1: Let:

$$I = \int_0^{\frac{\pi}{2}} \frac{\sin^{100} x}{\sin^{100} x + \cos^{100} x}\, dx$$

Step 2: Use the property:

$$I = \int_0^{\frac{\pi}{2}} f\left(\frac{\pi}{2} - x\right) dx$$

Since:

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

and

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

So:

$$I=\int_0^{\frac{\pi}{2}}\frac{\cos^{100}x}{\cos^{100}x+\sin^{100}x}\,dx$$

Step 3: Add both expressions of I.

$$2I=\int_0^{\frac{\pi}{2}}\left[\frac{\sin^{100}x}{\sin^{100}x+\cos^{100}x}+\frac{\cos^{100}x}{\sin^{100}x+\cos^{100}x}\right]dx$$

$$2I=\int_0^{\frac{\pi}{2}}1\,dx$$

$$2I=\frac{\pi}{2}$$

Step 4: Divide by 2.

$$I=\frac{\pi}{4}$$

Therefore,

$$\boxed{\frac{\pi}{4}}$$

Quick Tip: For definite integrals from 0 to $\frac{\pi}{2}$, use the transformation $x\to\frac{\pi}{2}-x$.

41.

$$\int_0^1 x\sqrt{x^2+4}\,dx=$$

(A) $\frac{1}{3}[5\sqrt{5}-4]$

(B) $\frac{1}{2}[5\sqrt{5}-8]$

(C) $\frac{1}{3}[5\sqrt{5}-8]$

(D) $\frac{1}{3}[5\sqrt{5}+4]$

Correct Answer: (C) $\frac{1}{3}[5\sqrt{5}-8]$

Solution:

Concept: Use substitution when the derivative of the inside expression is present outside.

Step 1: Given:

$$I = \int_0^1 x\sqrt{x^2+4}\,dx$$

Step 2: Put:

$$u = x^2 + 4$$

Then:

$$\frac{du}{dx} = 2x$$

$$du = 2x\,dx$$

$$x\,dx = \frac{du}{2}$$

Step 3: Change limits.

When $x = 0$:

$$u = 0^2 + 4 = 4$$

When $x = 1$:

$$u = 1^2 + 4 = 5$$

Step 4: Substitute in the integral.

$$I = \int_4^5 \sqrt{u} \cdot \frac{du}{2}$$

$$I = \frac{1}{2}\int_4^5 u^{\frac{1}{2}}\,du$$

Step 5: Integrate.

$$I = \frac{1}{2} \cdot \frac{u^{\frac{3}{2}}}{\frac{3}{2}}\Bigg|_4^5$$

$$I = \frac{1}{3}u^{\frac{3}{2}}\Bigg|_4^5$$

$$I = \frac{1}{3}\left[5^{\frac{3}{2}} - 4^{\frac{3}{2}}\right]$$

$$I = \frac{1}{3}\left[5\sqrt{5} - 8\right]$$

Therefore,

$$\boxed{\frac{1}{3}\left[5\sqrt{5} - 8\right]}$$

Quick Tip: For integrals containing $x\sqrt{x^2 + a}$, use $u = x^2 + a$.

42.

$$\int_{-\frac{\pi}{6}}^{\frac{\pi}{6}} \frac{\sin^5 x \cos^3 x}{x^4}\, dx =$$

(A) $\frac{\pi}{2}$

(B) $\frac{\pi}{4}$

(C) 0

(D) 1

Correct Answer: (C) 0

Solution:

Concept: If $f(x)$ is an odd function, then:

$$\int_{-a}^{a} f(x)\, dx = 0$$

Step 1: Given integrand is:

$$f(x) = \frac{\sin^5 x \cos^3 x}{x^4}$$

Step 2: Check the nature of each factor.

We know:

$$\sin(-x) = -\sin x$$

So $\sin x$ is odd. Therefore, $\sin^5 x$ is also odd.

Also,

$$\cos(-x) = \cos x$$

So $\cos x$ is even. Therefore, $\cos^3 x$ is also even.

And:

$$(-x)^4 = x^4$$

So x^4 is even.

Step 3: The integrand becomes:

$$\frac{\text{odd} \times \text{even}}{\text{even}} = \text{odd}$$

So:

$$f(-x) = -f(x)$$

Step 4: The limits are symmetric:

$$-\frac{\pi}{6} \quad \text{to} \quad \frac{\pi}{6}$$

Therefore:

$$\int_{-\frac{\pi}{6}}^{\frac{\pi}{6}} \frac{\sin^5 x \cos^3 x}{x^4}\, dx = 0$$

Hence,

$$\boxed{0}$$

Quick Tip: Before solving symmetric definite integrals, always check whether the integrand is odd or even.

43.

$$\int \frac{dx}{\sqrt{16-25x^2}} =$$

(A) $\frac{1}{5}\sin^{-1}\left(\frac{5x}{4}\right)+c$

(B) $\sin^{-1}\left(\frac{5x}{4}\right)+c$

(C) $\frac{1}{5}\sin^{-1}\left(\frac{x}{4}\right)+c$

(D) $\frac{1}{5}\sin^{-1}\left(\frac{4x}{5}\right)+c$

Correct Answer: (A) $\frac{1}{5}\sin^{-1}\left(\frac{5x}{4}\right)+c$

Solution:

Concept: Use the standard formula:

$$\int \frac{dx}{\sqrt{a^2-x^2}} = \sin^{-1}\left(\frac{x}{a}\right)+c$$

Step 1: Given:

$$\int \frac{dx}{\sqrt{16-25x^2}}$$

Step 2: Rewrite the expression inside the square root.

$$16-25x^2 = 4^2-(5x)^2$$

So:

$$\sqrt{16-25x^2} = \sqrt{4^2-(5x)^2}$$

Step 3: Put:

$$u = 5x$$

Then:

$$du = 5dx$$

$$dx = \frac{du}{5}$$

Step 4: Substitute in the integral.

$$\int \frac{dx}{\sqrt{16-25x^2}} = \frac{1}{5}\int \frac{du}{\sqrt{16-u^2}}$$

Step 5: Apply the standard formula.

$$\frac{1}{5}\int \frac{du}{\sqrt{4^2-u^2}} = \frac{1}{5}\sin^{-1}\left(\frac{u}{4}\right)+c$$

Step 6: Substitute $u = 5x$.

$$= \frac{1}{5}\sin^{-1}\left(\frac{5x}{4}\right)+c$$

Therefore,

$$\boxed{\frac{1}{5}\sin^{-1}\left(\frac{5x}{4}\right)+c}$$

Quick Tip: Convert $\sqrt{16-25x^2}$ into $\sqrt{4^2-(5x)^2}$, then use the inverse sine formula.

---

44. The solution of the differential equation

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

passing through the point $(1,1)$ **is** $y=$

(A) x^2

(B) x^{-1}

(C) x^{-2}

(D) x

Correct Answer: (B) x^{-1}

Solution:

Concept: A differential equation can be solved by separating variables if it can be written in the form:

$$\frac{dy}{y}=f(x)\,dx$$

Step 1: Given equation:

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

Step 2: Move y to the other side.

$$x\frac{dy}{dx}=-y$$

$$\frac{dy}{dx}=-\frac{y}{x}$$

Step 3: Separate variables.

$$\frac{dy}{y}=-\frac{dx}{x}$$

Step 4: Integrate both sides.

$$\int\frac{dy}{y}=-\int\frac{dx}{x}$$

$$\log y=-\log x+\log C$$

Step 5: Simplify.

$$\log y + \log x = \log C$$

$$\log(xy) = \log C$$

$$xy = C$$

$$y = \frac{C}{x}$$

Step 6: Use the point $(1, 1)$.

$$1 = \frac{C}{1}$$

$$C = 1$$

Thus:

$$y = \frac{1}{x} = x^{-1}$$

Therefore,

$$\boxed{x^{-1}}$$

Quick Tip: For equations like $x\frac{dy}{dx} + y = 0$, separate variables and use the given point to find the constant.

---

45. Degree of the differential equation

$$y = x\frac{dy}{dx} + a\sqrt{1 + \left(\frac{dy}{dx}\right)^2}$$

is

(A) 4

(B) 3

(C) 2

(D) 1

Correct Answer: (C) 2

Solution:

Concept: The degree of a differential equation is the highest power of the highest order derivative after removing radicals and fractions involving derivatives.

Step 1: Given:

$$y = x\frac{dy}{dx} + a\sqrt{1 + \left(\frac{dy}{dx}\right)^2}$$

Let:

$$p = \frac{dy}{dx}$$

Then equation becomes:

$$y = xp + a\sqrt{1 + p^2}$$

Step 2: Move xp to the left side.

$$y - xp = a\sqrt{1 + p^2}$$

Step 3: Square both sides to remove the radical.

$$(y - xp)^2 = a^2(1 + p^2)$$

Step 4: Now the derivative $p = \frac{dy}{dx}$ appears with highest power 2.

Therefore, the degree of the differential equation is:

$$2$$

Hence,

$$\boxed{2}$$

Quick Tip: To find degree, first remove radicals involving derivatives, then check the highest power of the highest order derivative.

---

46. The order of the differential equation of all circles passing through the origin and having their centres on the x-axis is

(A) 4

(B) 3

(C) 2

(D) 1

Correct Answer: (D) 1

Solution:

Concept: The order of a differential equation is equal to the highest order derivative present in it. For a family of curves, the order is generally equal to the number of arbitrary constants.

Step 1: Since the centres are on the x-axis, let the centre be:

$$(a, 0)$$

Step 2: Since the circle passes through the origin, its radius is:

$$r = a$$

Step 3: Equation of the circle is:

$$(x-a)^2 + y^2 = a^2$$

Expanding:

$$x^2 - 2ax + a^2 + y^2 = a^2$$

$$x^2 + y^2 - 2ax = 0$$

Step 4: This family contains only one arbitrary constant a.

So we need to differentiate once to eliminate a.

Step 5: Differentiate:

$$x^2 + y^2 - 2ax = 0$$

$$2x + 2y\frac{dy}{dx} - 2a = 0$$

The highest derivative present is:

$$\frac{dy}{dx}$$

So the order is:

$$1$$

Therefore,

$$\boxed{1}$$

Quick Tip: The order of the differential equation of a family of curves is usually equal to the number of arbitrary constants in the family.

---

47. If a and b are arbitrary constants, then the differential equation representing the family of curves

$$y = a\sin(x + b)$$

is

(A) $\frac{d^2y}{dx^2} - y = 0$

(B) $\frac{d^2y}{dx^2} + y = 0$

(C) $\frac{d^2y}{dx^2} - y^2 = 0$

(D) $\frac{dy}{dx} - y = 0$

Correct Answer: (B) $\frac{d^2y}{dx^2} + y = 0$

Solution:

Concept: To form a differential equation from a family of curves, differentiate enough times to eliminate arbitrary constants.

Step 1: Given:

$$y = a\sin(x + b)$$

Here a and b are arbitrary constants.

Step 2: Differentiate once.

$$\frac{dy}{dx} = a\cos(x + b)$$

Step 3: Differentiate again.

$$\frac{d^2y}{dx^2} = -a\sin(x + b)$$

Step 4: But from the original equation:

$$y = a\sin(x+b)$$

Therefore:

$$\frac{d^2y}{dx^2} = -y$$

Step 5: Rearrange:

$$\frac{d^2y}{dx^2} + y = 0$$

Therefore,

$$\boxed{\frac{d^2y}{dx^2} + y = 0}$$

Quick Tip: For $y = a\sin(x+b)$, differentiating twice gives the relation $y'' = -y$.

---

48. The differential equation is

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

and $y(1) = 2$. Then the value of $y(3)$ is

(A) 2

(B) 3

(C) $\frac{2}{3}$

(D) 1

Correct Answer: (C) $\frac{2}{3}$

Solution:

Concept: This is a separable differential equation:

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

Step 1: Given:

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

Move the second term to the other side:

$$\frac{dy}{dx} = -\frac{y}{x}$$

Step 2: Separate variables.

$$\frac{dy}{y} = -\frac{dx}{x}$$

Step 3: Integrate both sides.

$$\int \frac{dy}{y} = -\int \frac{dx}{x}$$

$$\log y = -\log x + \log C$$

Step 4: Simplify.

$$\log y + \log x = \log C$$

$$\log(xy) = \log C$$

$$xy = C$$

$$y = \frac{C}{x}$$

Step 5: Use $y(1) = 2$.

$$2 = \frac{C}{1}$$

$$C = 2$$

So:

$$y = \frac{2}{x}$$

Step 6: Find $y(3)$.

$$y(3) = \frac{2}{3}$$

Therefore,

$$\boxed{\frac{2}{3}}$$

Quick Tip: For equations of the form $\frac{dy}{dx} + \frac{y}{x} = 0$, the solution is usually of the form $xy = C$.

---

49. The general solution of the differential equation

$$\frac{dy}{dx} = e^{x-y} + x^2 e^{-y}$$

is

(A) $e^{-y} = e^x + \frac{x^3}{3} + c$

(B) $e^y = e^x + \frac{x^3}{3} + c$

(C) $e^y = e^x + x^3 + c$

(D) $e^y = e^x + c$

Correct Answer: (B) $e^y = e^x + \frac{x^3}{3} + c$

Solution:

Concept: When the equation contains e^{-y}, multiply the equation by e^y because:

$$e^y \frac{dy}{dx} = \frac{d}{dx}(e^y)$$

Step 1: Given:

$$\frac{dy}{dx} = e^{x-y} + x^2 e^{-y}$$

Step 2: Rewrite the right side.

$$e^{x-y} = e^x e^{-y}$$

So:

$$\frac{dy}{dx} = e^x e^{-y} + x^2 e^{-y}$$

$$\frac{dy}{dx} = e^{-y}(e^x + x^2)$$

Step 3: Multiply both sides by e^y.

$$e^y \frac{dy}{dx} = e^x + x^2$$

Step 4: Observe that:

$$e^y \frac{dy}{dx} = \frac{d}{dx}(e^y)$$

Therefore:

$$\frac{d}{dx}(e^y) = e^x + x^2$$

Step 5: Integrate both sides with respect to x.

$$\int d(e^y) = \int (e^x + x^2)\,dx$$

$$e^y = e^x + \frac{x^3}{3} + c$$

Therefore,

$$\boxed{e^y = e^x + \frac{x^3}{3} + c}$$

Quick Tip: If e^{-y} appears in a differential equation, multiply by e^y to form $\frac{d}{dx}(e^y)$.

---

50. The differential equation is

$$\frac{dy}{dx} + y \tan x = \sec x$$

and $y(0) = 1$. Then the value of $y\left(\frac{\pi}{4}\right)$ is

(A) 0

(B) $\sqrt{2}$

(C) 1

(D) -1

Correct Answer: (B) $\sqrt{2}$

Solution:

Concept: This is a linear differential equation of the form:

$$\frac{dy}{dx} + Py = Q$$

Its integrating factor is:

$$I.F. = e^{\int P\,dx}$$

Step 1: Given equation:

$$\frac{dy}{dx} + y\tan x = \sec x$$

Here:

$$P = \tan x$$

and

$$Q = \sec x$$

Step 2: Find the integrating factor.

$$I.F. = e^{\int \tan x\,dx}$$

We know:

$$\int \tan x\,dx = \log\sec x$$

So:

$$I.F. = e^{\log\sec x}$$

$$I.F. = \sec x$$

Step 3: Multiply the differential equation by $\sec x$.

$$\sec x\frac{dy}{dx} + y\sec x\tan x = \sec^2 x$$

The left side becomes:

$$\frac{d}{dx}(y\sec x) = \sec^2 x$$

Step 4: Integrate both sides.

$$y\sec x = \int \sec^2 x\,dx$$

$$y\sec x = \tan x + C$$

Step 5: Use $y(0) = 1$.

$$1\cdot\sec 0 = \tan 0 + C$$

$$1 \cdot 1 = 0 + C$$

$$C = 1$$

Thus:

$$y \sec x = \tan x + 1$$

Step 6: Put $x = \frac{\pi}{4}$.

$$y\left(\frac{\pi}{4}\right)\sec\frac{\pi}{4} = \tan\frac{\pi}{4} + 1$$

We know:

$$\sec\frac{\pi}{4} = \sqrt{2}$$

and

$$\tan\frac{\pi}{4} = 1$$

So:

$$y\left(\frac{\pi}{4}\right)\sqrt{2} = 1 + 1$$

$$y\left(\frac{\pi}{4}\right)\sqrt{2} = 2$$

$$y\left(\frac{\pi}{4}\right) = \frac{2}{\sqrt{2}}$$

$$y\left(\frac{\pi}{4}\right) = \sqrt{2}$$

Therefore,

$$\boxed{\sqrt{2}}$$

Quick Tip: For linear differential equations, identify P, find $I.F. = e^{\int P dx}$, then multiply the whole equation by the integrating factor.

---

51. If $P = Fv\sin\beta t$, where F is force and v is velocity, then the dimensions of P and β are

(A) $ML^2T^{-3},\ T^{-1}$

(B) $MLT^{-2},\ T^{-2}$

(C) $ML^2T^{-1},\ T^{-1}$

(D) $ML^2T^3,\ T^{-2}$

Correct Answer: (A) $ML^2T^{-3},\ T^{-1}$

Solution:

Concept: The argument of a trigonometric function must always be dimensionless. Also, force multiplied by velocity gives power.

Step 1: Given:

$$P = Fv\sin\beta t$$

Since $\sin\beta t$ is a trigonometric term, its angle βt must be dimensionless.

$$[\beta t] = 1$$

$$[\beta][t] = 1$$

$$[\beta] = T^{-1}$$

Step 2: Now find the dimension of P.

Since $\sin\beta t$ is dimensionless,

$$[P] = [F][v]$$

Dimension of force:

$$[F] = MLT^{-2}$$

Dimension of velocity:

$$[v] = LT^{-1}$$

Therefore:

$$[P] = MLT^{-2} \times LT^{-1}$$

$$[P] = ML^2T^{-3}$$

Step 3: Hence:

$$[P] = ML^2T^{-3}, \qquad [\beta] = T^{-1}$$

Therefore,

$$\boxed{ML^2T^{-3},\ T^{-1}}$$

Quick Tip: The angle of sin, cos, or tan must always be dimensionless. Use this to find unknown dimensions.

---

52. If velocity V, energy E, and time T are chosen as fundamental quantities, then dimensional representation of surface tension in this system will be

(A) $E^1V^{-2}T^{-2}$

(B) $E^1V^{-1}T^{-2}$

(C) $E^{-2}V^{-1}T^{-3}$

(D) $E^1V^{-2}T^{-1}$

Correct Answer: (A) $E^1V^{-2}T^{-2}$

Solution:

Concept: Surface tension is force per unit length:

$$S = \frac{F}{L}$$

Its dimensional formula is:

$$[S] = MT^{-2}$$

Step 1: Write dimensions of energy and velocity.

$$[E] = ML^2T^{-2}$$

$$[V] = LT^{-1}$$

Step 2: Suppose surface tension is represented as:

$$[S] = E^aV^bT^c$$

Substitute dimensions:

$$MT^{-2} = (ML^2T^{-2})^a(LT^{-1})^bT^c$$

$$MT^{-2} = M^aL^{2a+b}T^{-2a-b+c}$$

Step 3: Compare powers of M, L, T.

For M:

$$a = 1$$

For L:

$$2a + b = 0$$

Put $a = 1$:

$$2 + b = 0$$

$$b = -2$$

For T:

$$-2a - b + c = -2$$

Put $a = 1,\ b = -2$:

$$-2(1) - (-2) + c = -2$$

$$-2 + 2 + c = -2$$

$$c = -2$$

Step 4: Hence:

$$[S] = E^1V^{-2}T^{-2}$$

Therefore,

$$\boxed{E^1V^{-2}T^{-2}}$$

Quick Tip: In dimensional analysis with new fundamental quantities, assume the required quantity as $E^aV^bT^c$, then compare powers.

53. If $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$, then the angle between the two vectors $\vec{A}$ and $\vec{B}$ is

(A) 0°

(B) 180°

(C) 120°

(D) 90°

Correct Answer: (D) 90°

Solution:

Concept: For two vectors:

$$|\vec{A}+\vec{B}|^2 = A^2 + B^2 + 2AB\cos\theta$$

and

$$|\vec{A}-\vec{B}|^2 = A^2 + B^2 - 2AB\cos\theta$$

Step 1: Given:

$$|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$$

Squaring both sides:

$$|\vec{A}+\vec{B}|^2 = |\vec{A}-\vec{B}|^2$$

Step 2: Substitute formulas.

$$A^2 + B^2 + 2AB\cos\theta = A^2 + B^2 - 2AB\cos\theta$$

Step 3: Cancel common terms.

$$2AB\cos\theta = -2AB\cos\theta$$

$$4AB\cos\theta = 0$$

Since A and B are non-zero:

$$\cos\theta = 0$$

Step 4: Therefore:

$$\theta = 90^\circ$$

Hence,

$$\boxed{90^\circ}$$

Quick Tip: If $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$, then the vectors are perpendicular.

---

54. An aeroplane is moving in a circular path with a speed of 450 kmph. What is the change in velocity in half revolution?

(A) 0 kmph

(B) 450 kmph

(C) 250 kmph

(D) 900 kmph

Correct Answer: (D) 900 kmph

Solution:

Concept: Velocity is a vector quantity. In uniform circular motion, speed remains constant but direction of velocity changes continuously.

Step 1: Initial speed of the aeroplane is:

$$v = 450 \text{ kmph}$$

Step 2: After half revolution, the aeroplane reaches the diametrically opposite point of the circle.

At this point, velocity direction becomes exactly opposite to the initial velocity.

So:

$$\vec{v}_i = 450$$

$$\vec{v}_f = -450$$

Step 3: Change in velocity:

$$\Delta v = \vec{v}_f - \vec{v}_i$$

$$\Delta v = -450 - 450$$

$$\Delta v = -900$$

Magnitude of change in velocity:

$$|\Delta v| = 900 \text{ kmph}$$

Therefore,

$$\boxed{900 \text{ kmph}}$$

Quick Tip: In half revolution of circular motion, velocity reverses direction, so change in velocity is $2v$.

---

55. The ratio between maximum and minimum values of two vectors $\vec{A}$ and $\vec{B}$, where $A > B$, is 4 : 1. Then the ratio between the magnitudes of two vectors is

(A) 3 : 2

(B) 5 : 3

(C) 2 : 3

(D) 3 : 5

Correct Answer: (B) 5 : 3

Solution:

Concept: For two vectors $\vec{A}$ and $\vec{B}$:

$$\text{Maximum resultant} = A + B$$

and

$$\text{Minimum resultant} = A - B$$

when $A > B$.

Step 1: Given ratio is:

$$\frac{A+B}{A-B} = \frac{4}{1}$$

Step 2: Cross multiply.

$$A + B = 4(A - B)$$

$$A+B=4A-4B$$

Step 3: Bring like terms together.

$$4A-A=B+4B$$

$$3A=5B$$

Step 4: Therefore:

$$\frac{A}{B}=\frac{5}{3}$$

Hence, the ratio of magnitudes is:

$$\boxed{5:3}$$

Quick Tip: For two vectors, maximum resultant is $A+B$ and minimum resultant is $A-B$ when $A>B$.

---

56. The magnitudes of three vectors $\vec{A},\vec{B},\vec{C}$ are $12,5$, and 13 units respectively and $\vec{A}+\vec{B}=\vec{C}$. The angle between $\vec{A}$ and $\vec{B}$ is

(A) 0°

(B) 120°

(C) 90°

(D) 45°

Correct Answer: (C) 90°

Solution:

Concept: If:

$$\vec{A}+\vec{B}=\vec{C}$$

then:

$$C^2=A^2+B^2+2AB\cos\theta$$

Step 1: Given:

$$A=12, \qquad B=5, \qquad C=13$$

Step 2: Use the resultant formula.

$$13^2 = 12^2 + 5^2 + 2(12)(5)\cos\theta$$

$$169 = 144 + 25 + 120\cos\theta$$

$$169 = 169 + 120\cos\theta$$

Step 3: Simplify.

$$120\cos\theta = 0$$

$$\cos\theta = 0$$

Step 4: Therefore:

$$\theta = 90^\circ$$

Hence,

$$\boxed{90^\circ}$$

Quick Tip: If $A^2 + B^2 = C^2$, then the vectors A and B are perpendicular.

---

57. A body falling from height H takes time T seconds to reach the ground. The time taken to cover the second half of height is

(A) $\frac{T}{\sqrt{2}}$

(B) $\sqrt{2}T$

(C) $\frac{\sqrt{2}-1}{\sqrt{2}}T$

(D) $\frac{1}{\sqrt{2}-1}T$

Correct Answer: (C) $\frac{\sqrt{2}-1}{\sqrt{2}}T$

Solution:

Concept: For a freely falling body starting from rest:

$$s = \frac{1}{2}gt^2$$

Step 1: Total height is H and total time is T.

So:

$$H = \frac{1}{2}gT^2$$

Step 2: Time taken to fall through first half height $\frac{H}{2}$ is t_1.

So:

$$\frac{H}{2} = \frac{1}{2}gt_1^2$$

Step 3: Divide this equation by the total height equation.

$$\frac{\frac{H}{2}}{H} = \frac{\frac{1}{2}gt_1^2}{\frac{1}{2}gT^2}$$

$$\frac{1}{2} = \frac{t_1^2}{T^2}$$

$$t_1 = \frac{T}{\sqrt{2}}$$

Step 4: Time taken to cover the second half height:

$$t_2 = T - t_1$$

$$t_2 = T - \frac{T}{\sqrt{2}}$$

$$t_2 = T\left(1 - \frac{1}{\sqrt{2}}\right)$$

$$t_2 = \frac{\sqrt{2}-1}{\sqrt{2}}T$$

Therefore,

$$\boxed{\frac{\sqrt{2}-1}{\sqrt{2}}T}$$

Quick Tip: For free fall from rest, distance is proportional to square of time: $s \propto t^2$.

---

58. With what speed should a body be thrown upwards so that the distances covered in the 5^{th} second and 6^{th} second are equal?

(A) 75 m/s

(B) $\sqrt{98}$ m/s

(C) 49 m/s

(D) 19.8 m/s

Correct Answer: (C) 49 m/s

Solution:

Concept: For vertical upward motion, the body slows down due to gravity. Equal distances in two consecutive seconds around the highest point occur when the highest point is reached between those seconds.

Step 1: The body is thrown upward with speed u.

At the highest point, velocity becomes zero.

Using:

$$v = u - gt$$

At the highest point:

$$v = 0$$

So:

$$0 = u - gt$$

$$u = gt$$

Step 2: Since distances in the 5^{th} and 6^{th} seconds are equal, the highest point lies at the boundary between the 5^{th} and 6^{th} second.

Therefore:

$$t = 5 \text{ s}$$

Step 3: Use $g = 9.8$ m/s^2.

$$u = gt$$

$$u = 9.8 \times 5$$

$$u = 49 \text{ m/s}$$

Therefore,

$$\boxed{49 \text{ m/s}}$$

Quick Tip: For upward motion, velocity at the highest point is zero. Use $v = u - gt$ to find initial speed.

---

59. A body of mass 1 kg starts moving from rest under the action of a force which varies with displacement as $F = 2x + 5$ in newtons. The work done by this force to displace the body from $x = 0$ to $x = 2$ m is

(A) 8 J

(B) 10 J

(C) 12 J

(D) 14 J

Correct Answer: (D) 14 J

Solution:

Concept: When force varies with displacement, work done is:

$$W = \int_{x_1}^{x_2} F\,dx$$

Step 1: Given force:

$$F = 2x + 5$$

Displacement is from:

$$x = 0 \quad \text{to} \quad x = 2$$

Step 2: Write work done:

$$W = \int_0^2 (2x + 5)\,dx$$

Step 3: Integrate.

$$W = \left[x^2 + 5x\right]_0^2$$

Step 4: Apply limits.

$$W = (2^2 + 5(2)) - (0^2 + 5(0))$$

$$W = 4 + 10$$

$$W = 14 \text{ J}$$

Therefore,

$$\boxed{14 \text{ J}}$$

Quick Tip: For variable force, do not use $W = Fs$ directly. Use $W = \int F\,dx$.

---

60. The potential energy of a particle is given by $U(x) = 20 + (x-2)^2$, where U is in joules and x is in meters. The minimum potential energy and the position where it occurs are

(A) 20 J at $x = 2$

(B) 2 J at $x = 20$ m

(C) 22 J at $x = 2$ m

(D) 0 J at $x = 2$ m

Correct Answer: (A) 20 J at $x = 2$

Solution:

Concept: A square term is always non-negative:

$$(x-2)^2 \geq 0$$

So the minimum value occurs when the square term becomes zero.

Step 1: Given:

$$U(x) = 20 + (x-2)^2$$

Step 2: Since:

$$(x-2)^2 \geq 0$$

The minimum value of $(x-2)^2$ is:

$$0$$

Step 3: This happens when:

$$x-2=0$$

$$x=2$$

Step 4: Substitute $x=2$ into $U(x)$.

$$U(2)=20+(2-2)^2$$

$$U(2)=20+0$$

$$U(2)=20\ \text{J}$$

Therefore, minimum potential energy is:

$$\boxed{20\ \text{J at } x=2}$$

Quick Tip: For expressions like $a+(x-b)^2$, the minimum value is a, occurring at $x=b$.

---

61. Power supplied to a particle of mass 2 kg varies with time as

$$P=\frac{3t^2}{2}\ \textbf{watt},$$

where t is in seconds. If velocity at $t=0$ is zero, the velocity at $t=2$ s is

(A) 1 m/s

(B) 2 m/s

(C) $\sqrt{2}$ m/s

(D) 4 m/s

Correct Answer: (B) 2 m/s

Solution:

Concept: Power is the rate of doing work or the rate of change of kinetic energy:

$$P = \frac{dW}{dt} = \frac{dK}{dt}$$

So total work done from $t = 0$ to $t = 2$ is:

$$W = \int_0^2 P\,dt$$

This work becomes the kinetic energy of the particle.

Step 1: Given:

$$P = \frac{3t^2}{2}$$

and mass:

$$m = 2 \text{ kg}$$

Initial velocity is zero:

$$u = 0$$

Step 2: Calculate work done from $t = 0$ to $t = 2$.

$$W = \int_0^2 \frac{3t^2}{2}\,dt$$

$$W = \frac{3}{2}\int_0^2 t^2\,dt$$

$$W = \frac{3}{2}\left[\frac{t^3}{3}\right]_0^2$$

$$W = \frac{3}{2} \cdot \frac{8}{3}$$

$$W = 4 \text{ J}$$

Step 3: This work is converted into kinetic energy.

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Since $u = 0$,

$$W = \frac{1}{2}mv^2$$

Step 4: Substitute values.

$$4 = \frac{1}{2}(2)v^2$$

$$4 = v^2$$

$$v = 2 \text{ m/s}$$

Therefore,

$$\boxed{2 \text{ m/s}}$$

Quick Tip: When power is given as a function of time, integrate power with respect to time to get work or change in kinetic energy.

---

62. A pump is used to deliver water at a certain rate from a given pipe. To obtain twice the volume of water from the same pipe in the same time, by what factor must the power of the motor pump be increased? Assume ideal conditions.

(A) 4

(B) 8

(C) 16

(D) 32

Correct Answer: (B) 8

Solution:

Concept: For water flowing through the same pipe, the volume flow rate is proportional to

velocity:

$$Q = Av$$

where A is the area of cross-section and v is the velocity of water.

Power required to maintain the flow is proportional to:

$$P \propto v^3$$

Step 1: Since the pipe is the same, area A remains constant.

If volume of water delivered in the same time is doubled, then flow rate doubles:

$$Q' = 2Q$$

Since:

$$Q = Av$$

and A is constant,

$$v' = 2v$$

Step 2: Power is proportional to cube of velocity.

$$P \propto v^3$$

So:

$$\frac{P'}{P} = \left(\frac{v'}{v}\right)^3$$

$$\frac{P'}{P} = (2)^3$$

$$\frac{P'}{P} = 8$$

Therefore, power must be increased by a factor of:

$$\boxed{8}$$

Quick Tip: For fluid flow through the same pipe, if flow speed becomes n times, power becomes n^3 times.

---

63. Two identical piano wires, when tuned to a fundamental frequency of 400 Hz, produce no beats. One wire is then slightly tightened, and the beat frequency heard is 2 Hz. What is the new fundamental frequency of the tightened wire?

(A) 398 Hz

(B) 402 Hz

(C) 404 Hz

(D) 396 Hz

Correct Answer: (B) 402 Hz

Solution:

Concept: Beat frequency is the difference between two frequencies:

$$f_b = |f_1 - f_2|$$

Step 1: Initially, both wires have the same frequency:

$$f_1 = 400 \text{ Hz}$$

So no beats are heard.

Step 2: One wire is slightly tightened.

When a wire is tightened, its tension increases.

For a stretched string:

$$f \propto \sqrt{T}$$

So if tension increases, frequency also increases.

Step 3: Beat frequency is given as:

$$f_b = 2 \text{ Hz}$$

Let the new frequency of tightened wire be f_2.

$$|f_2 - 400| = 2$$

Step 4: Since the wire is tightened, frequency increases.

$$f_2 = 400 + 2$$

$$f_2 = 402 \text{ Hz}$$

Therefore,

$$\boxed{402 \text{ Hz}}$$

Quick Tip: Tightening a string increases its frequency. So choose the frequency greater than the original frequency.

---

64. A source of sound of frequency 500 Hz is moving towards an observer with velocity 30 m/s. The speed of sound is 330 m/s. The frequency heard by the observer will be

(A) 450 Hz

(B) 550 Hz

(C) 600 Hz

(D) 500 Hz

Correct Answer: (B) 550 Hz

Solution:

Concept: When a source moves towards a stationary observer, apparent frequency increases and is given by:

$$f' = f\left(\frac{v}{v - v_s}\right)$$

where v is speed of sound and v_s is speed of source.

Step 1: Given:

$$f = 500 \text{ Hz}$$

$$v = 330 \text{ m/s}$$

$$v_s = 30 \text{ m/s}$$

Step 2: Apply Doppler effect formula.

$$f' = 500\left(\frac{330}{330-30}\right)$$

$$f' = 500\left(\frac{330}{300}\right)$$

$$f' = 500\left(\frac{11}{10}\right)$$

$$f' = 550 \text{ Hz}$$

Therefore,

$$\boxed{550 \text{ Hz}}$$

Quick Tip: When source moves towards observer, apparent frequency increases; use denominator $v - v_s$.

---

65. In acoustics, "Noise" is generally characterized by

(A) Irregular and non-periodic vibrations

(B) A constant pitch and frequency

(C) Vibrations that follow a harmonic series

(D) Regular and periodic vibrations

Correct Answer: (A) Irregular and non-periodic vibrations

Solution:

Concept: Sound can be pleasant or unpleasant depending on the regularity of vibrations.

Step 1: A musical sound is usually produced by regular and periodic vibrations.

Step 2: Noise is an unwanted sound. It does not have a fixed pattern.

Step 3: Noise is produced by irregular and non-periodic vibrations.

Step 4: Therefore, noise is characterized by:

$$\boxed{\text{Irregular and non-periodic vibrations}}$$

Quick Tip: Regular periodic vibrations produce musical sound, while irregular non-periodic vibrations produce noise.

---

66. If the volume of a room is doubled and the total absorption is halved, the reverberation time will

(A) Remain unchanged

(B) Be doubled

(C) Become four times

(D) Be halved

Correct Answer: (C) Become four times

Solution:

Concept: According to Sabine's formula:

$$T = \frac{0.161V}{A}$$

where T is reverberation time, V is volume of the room, and A is total absorption.

Step 1: Original reverberation time:

$$T = \frac{0.161V}{A}$$

Step 2: New volume is doubled:

$$V' = 2V$$

Total absorption is halved:

$$A' = \frac{A}{2}$$

Step 3: New reverberation time:

$$T' = \frac{0.161V'}{A'}$$

$$T' = \frac{0.161(2V)}{\frac{A}{2}}$$

$$T' = 0.161(2V) \cdot \frac{2}{A}$$

$$T' = 4\left(\frac{0.161V}{A}\right)$$

$$T' = 4T$$

Therefore, reverberation time becomes four times:

Become four times

Quick Tip: Reverberation time is directly proportional to volume and inversely proportional to absorption.

---

67. In a closed hall of volume 5000 m^3, the total absorption of the interior surfaces is 200 metric sabin. The reverberation time is

(A) 1 s

(B) 2 s

(C) 3 s

(D) 4 s

Correct Answer: (D) 4 s

Solution:

Concept: Sabine's formula for reverberation time is:

$$T = \frac{0.161V}{A}$$

where V is the volume and A is total absorption.

Step 1: Given:

$$V = 5000 \text{ m}^3$$

$$A = 200$$

Step 2: Apply Sabine's formula.

$$T = \frac{0.161 \times 5000}{200}$$

Step 3: Calculate numerator.

$$0.161 \times 5000 = 805$$

Step 4: Divide by 200.

$$T = \frac{805}{200}$$

$$T = 4.025 \text{ s}$$

Approximately:

$$T \approx 4 \text{ s}$$

Therefore,

$$\boxed{4 \text{ s}}$$

Quick Tip: Use Sabine's formula $T = \frac{0.161V}{A}$ for reverberation time problems.

---

68. In an isothermal process

(A) Internal energy of the system never remains constant

(B) Total heat energy of the system remains constant

(C) Volume of the system remains constant

(D) Temperature of the system remains constant

Correct Answer: (D) Temperature of the system remains constant

Solution:

Concept: The word isothermal means:

$$\text{iso} = \text{same}, \qquad \text{thermal} = \text{temperature}$$

Step 1: In an isothermal process, the temperature remains constant throughout the process.

$$T = \text{constant}$$

Step 2: For an ideal gas, internal energy depends only on temperature.

So, in an isothermal process for an ideal gas, internal energy also remains constant.

Step 3: But the defining condition of an isothermal process is:

$$\boxed{\text{Temperature remains constant}}$$

Therefore, the correct answer is:

$$\boxed{\text{Temperature of the system remains constant}}$$

Quick Tip: Isothermal means constant temperature. Isobaric means constant pressure, and isochoric means constant volume.

---

69. If the pressure of an ideal gas is doubled and its absolute temperature is halved, the volume will become

(A) $\frac{1}{4}$ of initial volume

(B) $\frac{1}{2}$ initial volume

(C) Same as initial volume

(D) 2 times of initial volume

Correct Answer: (A) $\frac{1}{4}$ of initial volume

Solution:

Concept: For an ideal gas:

$$PV = nRT$$

For a fixed amount of gas:

$$\frac{PV}{T} = \text{constant}$$

Step 1: Let initial pressure, volume, and temperature be:

$$P, \quad V, \quad T$$

Step 2: Final pressure is doubled:

$$P' = 2P$$

Final absolute temperature is halved:

$$T' = \frac{T}{2}$$

Step 3: Use:

$$\frac{PV}{T} = \frac{P'V'}{T'}$$

$$\frac{PV}{T} = \frac{(2P)V'}{\frac{T}{2}}$$

$$\frac{PV}{T} = \frac{4PV'}{T}$$

Step 4: Cancel P and T.

$$V = 4V'$$

$$V' = \frac{V}{4}$$

Therefore, the final volume becomes:

$$\boxed{\frac{1}{4} \text{ of initial volume}}$$

Quick Tip: For fixed amount of gas, use $\frac{PV}{T} = \text{constant}$. Always use absolute temperature.

---

70. At constant temperature, the product PV is plotted against pressure P for an ideal gas. The graph obtained is

(A) Straight line parallel to P-axis

(B) Straight line with positive slope

(C) Straight line through origin

(D) Parabola

Correct Answer: (A) Straight line parallel to P-axis

Solution:

Concept: For an ideal gas:

$$PV = nRT$$

Step 1: At constant temperature:

$$T = \text{constant}$$

Also, for a fixed amount of gas:

$$n = \text{constant}$$

Therefore:

$$PV = nRT = \text{constant}$$

Step 2: This means the value of PV does not change with pressure P.

Step 3: If PV is plotted on the vertical axis and P on the horizontal axis, then PV remains constant for all values of P.

So the graph is a horizontal straight line.

Step 4: A horizontal line is parallel to the P-axis.

Therefore:

$$\boxed{\text{Straight line parallel to } P\text{-axis}}$$

Quick Tip: For an ideal gas at constant temperature, PV remains constant, so the PV versus P graph is horizontal.

---

71. A bubble of an ideal gas rises from the bottom of a lake to the surface. At the bottom, the pressure is 3 atm and the temperature is 7°C. At the surface, the pressure is 1 atm and the temperature is 27°C. If the initial volume of the bubble was V_0, what is its volume V at the surface?

(A) $3V_0$

(B) $3.21V_0$

(C) $0.9V_0$

(D) $5.4V_0$

Correct Answer: (B) $3.21V_0$

Solution:

Concept: For a fixed amount of ideal gas:

$$\frac{PV}{T} = \text{constant}$$

Temperature must be converted into kelvin.

Step 1: Given initial conditions at the bottom:

$$P_1 = 3 \text{ atm}$$

$$T_1 = 7^\circ\text{C} = 7 + 273 = 280 \text{ K}$$

$$V_1 = V_0$$

Step 2: Final conditions at the surface:

$$P_2 = 1 \text{ atm}$$

$$T_2 = 27^\circ\text{C} = 27 + 273 = 300 \text{ K}$$

Let final volume be $V_2 = V$.

Step 3: Use combined gas law.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

Step 4: Substitute values.

$$V = \frac{3 \times V_0 \times 300}{1 \times 280}$$

$$V = \frac{900}{280}V_0$$

$$V = 3.21V_0$$

Therefore,

$$\boxed{3.21V_0}$$

Quick Tip: In gas law questions, always convert Celsius temperature into kelvin before calculation.

---

72. The R.M.S. speed of oxygen molecules at 27°C is v. At 927°C, its R.M.S. speed will be

(A) v

(B) $\frac{v}{2}$

(C) $2v$

(D) $4v$

Correct Answer: (C) $2v$

Solution:

Concept: R.M.S. speed of gas molecules is proportional to the square root of absolute temperature:

$$v_{\text{rms}} \propto \sqrt{T}$$

Step 1: Convert temperatures into kelvin.

Initial temperature:

$$T_1 = 27^\circ\text{C} = 27 + 273 = 300 \text{ K}$$

Final temperature:

$$T_2 = 927^\circ\text{C} = 927 + 273 = 1200 \text{ K}$$

Step 2: Use proportionality:

$$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\frac{v_2}{v} = \sqrt{\frac{1200}{300}}$$

$$\frac{v_2}{v} = \sqrt{4}$$

$$\frac{v_2}{v} = 2$$

$$v_2 = 2v$$

Therefore,

$$\boxed{2v}$$

Quick Tip: R.M.S. speed depends on absolute temperature as $v_{\text{rms}} \propto \sqrt{T}$.

---

73. In a photoelectric experiment, the stopping potential for incident light of wavelength 4000 Å is 2 V. If the wavelength is changed to 3000 Å, the new stopping potential will be approximately

(Use $h = 4.14 \times 10^{-15}$ eV s, $c = 3 \times 10^8$ m/s)

(A) 2 V

(B) 3.03 V

(C) 4.14 V

(D) 1.5 V

Correct Answer: (B) 3.03 V

Solution:

Concept: Einstein's photoelectric equation is:

$$\frac{hc}{\lambda} = \phi + eV_s$$

In electron-volt form:

$$E = \phi + V_s$$

where E is photon energy in eV and V_s is stopping potential in volts.

Step 1: For wavelength 4000 Å:

$$\lambda_1 = 4000 \text{ Å} = 400 \text{ nm}$$

Photon energy:

$$E_1 = \frac{1240}{400}$$

$$E_1 = 3.10 \text{ eV}$$

Given stopping potential:

$$V_1 = 2 \text{ V}$$

Step 2: Find work function ϕ.

$$E_1 = \phi + V_1$$

$$3.10 = \phi + 2$$

$$\phi = 1.10 \text{ eV}$$

Step 3: For wavelength 3000 Å:

$$\lambda_2 = 3000 \text{ Å} = 300 \text{ nm}$$

Photon energy:

$$E_2 = \frac{1240}{300}$$

$$E_2 = 4.13 \text{ eV}$$

Step 4: Find new stopping potential.

$$E_2 = \phi + V_2$$

$$4.13 = 1.10 + V_2$$

$$V_2 = 3.03 \text{ V}$$

Therefore,

$$\boxed{3.03 \text{ V}}$$

Quick Tip: For photoelectric effect, use $E = \frac{1240}{\lambda(\text{nm})}$ eV and then apply $E = \phi + V_s$.

---

74. In Optical Fiber communication, the signal is transmitted in the form of

(A) Electrical pulses

(B) Light pulses

(C) Radio waves

(D) Sound waves

Correct Answer: (B) Light pulses

Solution:

Concept: Optical fiber communication uses light to transmit information through thin glass or plastic fibers.

Step 1: Optical fiber works on the principle of total internal reflection.

Step 2: In this method, information is converted into light signals.

Step 3: These light signals travel through the fiber by repeated total internal reflection.

Step 4: Therefore, in optical fiber communication, the signal is transmitted as:

Light pulses

Quick Tip: Optical fiber communication uses light pulses, not electrical signals, for transmission inside the fiber.

---

75. In a superconducting ring, a persistent current has been flowing without decay for years. This is possible because

(A) Resistance is exactly zero and flux is quantized

(B) Resistance is very high and current is quantized

(C) Magnetic field is zero and voltage is maximum

(D) Temperature is very high and resistance is finite

Correct Answer: (A) Resistance is exactly zero and flux is quantized

Solution:

Concept: A superconductor is a material that shows zero electrical resistance below its critical temperature.

Step 1: In ordinary conductors, current decreases with time because electrical resistance causes energy loss as heat.

Step 2: In a superconducting ring:

$$R = 0$$

So there is no energy loss due to resistance.

Step 3: Because resistance is zero, current can continue to flow for a very long time without decay. This is called persistent current.

Step 4: Also, magnetic flux in a superconducting ring is quantized, which helps maintain stable current states.

Therefore, persistent current is possible because:

$$\boxed{\text{Resistance is exactly zero and flux is quantized}}$$

Quick Tip: Persistent current in a superconducting ring is possible due to zero resistance and magnetic flux quantization.

---

76. The pair of orbitals with electron density maximum along the axes is

(A) d_{xy}, d_{yz}

(B) $d_{z^2}, d_{x^2-y^2}$

(C) d_{xz}, d_{z^2}

(D) d_{xz}, p_z

Correct Answer: (B) $d_{z^2}, d_{x^2-y^2}$

Solution:

Concept: In d-orbitals, some orbitals have electron density along the axes and some have electron density between the axes.

Step 1: The orbitals d_{xy}, d_{yz}, and d_{xz} have electron density between the axes.

Step 2: The orbital $d_{x^2-y^2}$ has electron density along the x-axis and y-axis.

Step 3: The orbital d_{z^2} has electron density mainly along the z-axis.

Step 4: Therefore, the pair of orbitals having maximum electron density along the axes is:

$$d_{z^2}, d_{x^2-y^2}$$

Hence,

$$\boxed{d_{z^2}, d_{x^2-y^2}}$$

Quick Tip: Remember: $d_{x^2-y^2}$ and d_{z^2} are axial d-orbitals, while d_{xy}, d_{yz}, d_{xz} lie between axes.

---

77. The angular momentum of an electron in an orbit X of hydrogen atom is $\frac{2h}{\pi}$. Maximum number of orbitals possible in X is

(A) 4

(B) 9

(C) 16

(D) 25

Correct Answer: (C) 16

Solution:

Concept: According to Bohr's model, angular momentum of an electron is:

$$mvr = \frac{nh}{2\pi}$$

where n is the principal quantum number.

Step 1: Given angular momentum:

$$\frac{nh}{2\pi} = \frac{2h}{\pi}$$

Step 2: Cancel h from both sides.

$$\frac{n}{2\pi} = \frac{2}{\pi}$$

Step 3: Multiply both sides by 2π.

$$n = 4$$

Step 4: Maximum number of orbitals in a shell is:

$$n^2$$

$$n^2 = 4^2 = 16$$

Therefore,

$$\boxed{16}$$

Quick Tip: Maximum number of orbitals in a shell with principal quantum number n is n^2.

---

78. The four quantum numbers for the electron in the outermost orbital of potassium ($Z = 19$) are

(A) $n = 4,\ l = 2,\ m = -1,\ s = +\frac{1}{2}$

(B) $n = 4,\ l = 0,\ m = 0,\ s = +\frac{1}{2}$

(C) $n = 3,\ l = 0,\ m = 1,\ s = +\frac{1}{2}$

(D) $n = 4,\ l = 3,\ m = -2,\ s = -\frac{1}{2}$

Correct Answer: (B) $n = 4,\ l = 0,\ m = 0,\ s = +\frac{1}{2}$

Solution:

Concept: Quantum numbers describe the shell, subshell, orbital orientation, and spin of an electron.

Step 1: Atomic number of potassium is:

$$Z = 19$$

Its electronic configuration is:

$$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^1$$

Step 2: The outermost electron is present in:

$$4s^1$$

Step 3: For 4s-orbital:

$$n = 4$$

For s-subshell:

$$l = 0$$

For $l = 0$, magnetic quantum number is:

$$m = 0$$

For the single electron, spin is generally:

$$s = +\frac{1}{2}$$

Therefore,

$$\boxed{n = 4,\ l = 0,\ m = 0,\ s = +\frac{1}{2}}$$

Quick Tip: For an s-orbital, $l = 0$ and $m = 0$. Potassium has outermost electron in $4s^1$.

---

79. In which of the following, the number of bonding electrons and non-bonding electrons are in 3 : 2 ratio?

(A) N_2

(B) O_2

(C) HCl

(D) F_2

Correct Answer: (A) N_2

Solution:

Concept: Bonding electrons are those electrons that participate in bond formation, while non-bonding electrons remain as lone pairs.

Step 1: In nitrogen molecule:

$$N_2$$

The structure is:

$$: N \equiv N :$$

Step 2: A triple bond contains:

$$3 \text{ bond pairs}$$

So bonding electrons:

$$3 \times 2 = 6$$

Step 3: Each nitrogen atom has one lone pair.

So total non-bonding electrons:

$$2 + 2 = 4$$

Step 4: Ratio of bonding electrons to non-bonding electrons:

$$6 : 4 = 3 : 2$$

Therefore,

$$\boxed{N_2}$$

Quick Tip: In N_2, the triple bond gives 6 bonding electrons and two lone pairs give 4 non-bonding electrons.

---

80. Which one of the following statements is not correct?

(A) Ionic bond is non-directional bond

(B) The maximum number of bond pairs between two atoms is 3

(C) Covalent compounds conduct electricity in fused state

(D) Ionic compounds are generally soluble in water

Correct Answer: (C) Covalent compounds conduct electricity in fused state

Solution:

Concept: Ionic compounds conduct electricity in molten or aqueous state because ions are free to move. Covalent compounds usually do not conduct electricity because they do not produce free ions.

Step 1: Ionic bonds are non-directional because electrostatic force acts in all directions.

Step 2: Ionic compounds are generally soluble in water due to ion-dipole interaction.

Step 3: Covalent compounds are made by sharing of electrons and generally do not form ions.

Step 4: Hence, covalent compounds do not generally conduct electricity even in fused state.

Therefore, the incorrect statement is:

Covalent compounds conduct electricity in fused state

Quick Tip: Electrical conduction in molten state is a characteristic property of ionic compounds, not covalent compounds.

---

81. 12.6 **g of oxalic acid,** $H_2C_2O_4 \cdot 2H_2O$ **(M.wt.** 126**), is present in** 1500 **mL of solution. The normality of that solution is**

(A) 0.266 N

(B) 0.133 N

(C) 0.399 N

(D) 0.430 N

Correct Answer: (B) 0.133 N

Solution:

Concept: Normality is:

$$N = \frac{\text{gram equivalents}}{\text{volume in litres}}$$

For oxalic acid, n-factor is 2.

Step 1: Given molecular weight:

$$126$$

For oxalic acid:

$$n = 2$$

Equivalent weight:

$$\frac{126}{2} = 63$$

Step 2: Given mass:

$$12.6\ g$$

Gram equivalents:

$$\frac{12.6}{63} = 0.2$$

Step 3: Volume:

$$1500\ \text{mL} = 1.5\ \text{L}$$

Step 4: Normality:

$$N = \frac{0.2}{1.5}$$

$$N = 0.133$$

Therefore,

$$\boxed{0.133\ N}$$

Quick Tip: For acids, equivalent weight $= \frac{\text{molecular weight}}{\text{basicity}}$. Oxalic acid has basicity 2.

---

82. Which of the following has highest equivalent weight? Given: At.wt $H = 1,\ C = 12,\ O = 16,\ S = 32,\ Na = 23,\ Ca = 40$

(A) Sulphuric acid

(B) Sodium carbonate

(C) Sodium sulphate

(D) Calcium carbonate

Correct Answer: (C) Sodium sulphate

Solution:

Concept: Equivalent weight is:

$$\text{Equivalent weight} = \frac{\text{Molecular weight}}{n\text{-factor}}$$

Step 1: For sulphuric acid:

$$H_2SO_4$$

Molecular weight:

$$2 + 32 + 64 = 98$$

$n = 2$, so:

$$\text{Eq. wt.} = \frac{98}{2} = 49$$

Step 2: For sodium carbonate:

$$Na_2CO_3$$

Molecular weight:

$$46 + 12 + 48 = 106$$

$n = 2$, so:

$$\text{Eq. wt.} = \frac{106}{2} = 53$$

Step 3: For sodium sulphate:

$$Na_2SO_4$$

Molecular weight:

$$46 + 32 + 64 = 142$$

$n = 2$, so:

$$\text{Eq. wt.} = \frac{142}{2} = 71$$

Step 4: For calcium carbonate:

$$CaCO_3$$

Molecular weight:

$$40 + 12 + 48 = 100$$

$n = 2$, so:

$$\text{Eq. wt.} = \frac{100}{2} = 50$$

Step 5: Highest equivalent weight is:

$$71$$

Therefore,

$$\boxed{\text{Sodium sulphate}}$$

Quick Tip: Compare equivalent weights by calculating $\frac{\text{molecular weight}}{n\text{-factor}}$ for each compound.

---

83. Identify the pair of gases which have same number of molecules at S.T.P.?

(A) 11 g of CO_2 and 14 g of N_2

(B) 16 g of O_3 and 16 g of CH_4

(C) 5 g of H_2 and 40 g of CH_4

(D) 28 g of N_2 and 22 g of CO_2

Correct Answer: (C) 5 g of H_2 and 40 g of CH_4

Solution:

Concept: Same number of molecules means same number of moles because:

$$\text{Number of molecules} = nN_A$$

Step 1: Calculate moles of H_2.

$$\text{Molar mass of } H_2 = 2$$

$$\text{Moles of } H_2 = \frac{5}{2} = 2.5$$

Step 2: Calculate moles of CH_4.

$$\text{Molar mass of } CH_4 = 16$$

$$\text{Moles of } CH_4 = \frac{40}{16} = 2.5$$

Step 3: Since both have:

$$2.5 \text{ moles}$$

they have the same number of molecules.

Therefore,

$$\boxed{5 \text{ g of } H_2 \text{ and } 40 \text{ g of } CH_4}$$

Quick Tip: To compare number of molecules, compare number of moles using $n = \frac{w}{M}$.

---

84. 100 **mL of** $0.1M\ HCl$ **and** 100 **mL of** $0.05M\ H_2SO_4$ **are mixed and the solution is diluted to** 2.0 L **by adding water. The pH of the resulting solution is**

(A) 1

(B) 3

(C) 2

(D) 4

Correct Answer: (C) 2

Solution:

Concept: For strong acids, total $[H^+]$ is calculated from total moles of H^+ divided by total volume.

Step 1: Moles of H^+ from HCl:

$$M \times V = 0.1 \times 0.1 = 0.01$$

Step 2: Moles of H_2SO_4:

$$0.05 \times 0.1 = 0.005$$

Since one mole of H_2SO_4 gives 2 moles of H^+:

$$\text{Moles of } H^+ = 2 \times 0.005 = 0.01$$

Step 3: Total moles of H^+:

$$0.01 + 0.01 = 0.02$$

Step 4: Final volume:

$$2.0\ L$$

$$[H^+] = \frac{0.02}{2.0} = 0.01 = 10^{-2}$$

Step 5: Calculate pH.

$$pH = -\log[H^+]$$

$$pH = -\log(10^{-2})$$

$$pH = 2$$

Therefore,

$$\boxed{2}$$

Quick Tip: For acid mixture problems, first calculate total moles of H^+, then divide by final volume.

---

85. According to Arrhenius theory of acids and bases, which of the following is an example of Arrhenius base?

(A) H_2SO_4

(B) NH_3

(C) $NaOH$

(D) CaO

Correct Answer: (C) $NaOH$

Solution:

Concept: According to Arrhenius theory, a base is a substance that gives hydroxide ions:

$$OH^-$$

in aqueous solution.

Step 1: H_2SO_4 gives H^+, so it is an acid.

Step 2: NH_3 is a base by Bronsted-Lowry concept, but it does not directly contain OH^-.

Step 3: $NaOH$ dissociates in water as:

$$NaOH \rightarrow Na^+ + OH^-$$

Step 4: Hence, $NaOH$ is an Arrhenius base.

Therefore,

$$\boxed{NaOH}$$

Quick Tip: Arrhenius bases directly produce OH^- ions in aqueous solution.

---

86. Electrolysis of an aqueous solution of Na_2SO_4 between Pt electrodes liberates a gas X at anode and gas Y at cathode. X and Y respectively are

(A) $H_2,\ O_2$

(B) $O_2,\ H_2$

(C) $SO_2,\ H_2$

(D) $H_2,\ SO_2$

Correct Answer: (B) $O_2,\ H_2$

Solution:

Concept: In electrolysis, oxidation occurs at the anode and reduction occurs at the cathode. In aqueous Na_2SO_4, water is mainly electrolysed because Na^+ and SO_4^{2-} ions are difficult to discharge under these conditions.

Step 1: Identify the ions present in aqueous sodium sulphate solution.

$$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$$

Water is also present:

$$H_2O$$

Step 2: At the cathode, reduction takes place.

At cathode, water gets reduced more easily than Na^+. Therefore:

$$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$$

So gas liberated at cathode is:

$$Y = H_2$$

Step 3: At the anode, oxidation takes place.

At anode, water is oxidised to oxygen:

$$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$$

So gas liberated at anode is:

$$X = O_2$$

Step 4: Therefore:

$$X = O_2, \qquad Y = H_2$$

Hence,

$$\boxed{O_2,\ H_2}$$

Quick Tip: In electrolysis of aqueous Na_2SO_4 using inert Pt electrodes, water is electrolysed: oxygen is liberated at anode and hydrogen at cathode.

---

87. The wrong statement regarding Galvanic cell is

(A) In this spontaneous redox reaction occurs

(B) Salt bridge maintains electrical neutrality between the two solutions

(C) Anode is represented by (+) and cathode by (−)

(D) At anode oxidation occurs

Correct Answer: (C) Anode is represented by (+) and cathode by (−)

Solution:

Concept: A galvanic cell converts chemical energy into electrical energy through a spontaneous redox reaction.

Step 1: In a galvanic cell, the redox reaction is spontaneous.

So statement (A) is correct.

Step 2: The salt bridge allows movement of ions and maintains electrical neutrality between the two half-cells.

So statement (B) is also correct.

Step 3: Oxidation always occurs at the anode.

So statement (D) is correct.

Step 4: In a galvanic cell:

Anode is negative

and

Cathode is positive

But the given statement says:

Anode is (+) and cathode is (−)

This is incorrect for a galvanic cell.

Therefore, the wrong statement is:

Anode is represented by (+) and cathode by (−)

Quick Tip: In a galvanic cell, anode is negative and cathode is positive. In an electrolytic cell, the signs are reversed.

---

88. Which of the following is a weak electrolyte?

(A) H_2CO_3

(B) H_2SO_4

(C) $NaCl$

(D) $NaOH$

Correct Answer: (A) H_2CO_3

Solution:

Concept: A weak electrolyte ionizes only partially in aqueous solution, whereas a strong electrolyte ionizes almost completely.

Step 1: H_2SO_4 is a strong acid and dissociates strongly in water.

Step 2: $NaCl$ is an ionic salt and dissociates almost completely in water.

Step 3: $NaOH$ is a strong base and dissociates almost completely in water.

Step 4: H_2CO_3, carbonic acid, is a weak acid. It ionizes only partially in water:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Therefore, it is a weak electrolyte.

Hence,

$$\boxed{H_2CO_3}$$

Quick Tip: Weak acids and weak bases are generally weak electrolytes because they ionize partially in solution.

---

89. The exhausted anion-exchange resin is regenerated with

(A) dilute $NaOH$ solution

(B) dilute $NaCl$ solution

(C) dilute HCl solution

(D) dilute Na_2SO_4 solution

Correct Answer: (A) dilute $NaOH$ solution

Solution:

Concept: In the ion-exchange process, cation exchange resin and anion exchange resin are regenerated differently.

Step 1: Anion-exchange resin removes anions such as:

$$Cl^-,\ SO_4^{2-},\ NO_3^-$$

Step 2: The active form of anion-exchange resin is generally hydroxide form:

$$R-OH$$

Step 3: After exhaustion, the resin contains anions in place of OH^-.

To regenerate it, we need to restore OH^- ions.

Step 4: Dilute $NaOH$ provides OH^- ions:

$$NaOH \rightarrow Na^+ + OH^-$$

Therefore, exhausted anion-exchange resin is regenerated using:

$$\boxed{\text{dilute } NaOH \text{ solution}}$$

Quick Tip: Anion-exchange resin is regenerated by dilute $NaOH$, while cation-exchange resin is regenerated by dilute acid such as HCl.

---

90. A sample of water is known to contain $Mg(HCO_3)_2 = 7.3$ mg/L, $Ca(HCO_3)_2 = 8.1$ mg/L, and 27.2 mg/L of $CaSO_4$. The total hardness associated with water sample in ppm in equivalents of $CaCO_3$ is

(**At.wt.** $H = 1,\ C = 12,\ O = 16,\ Mg = 24,\ Ca = 40,\ S = 32$)

(A) 20

(B) 25

(C) 30

(D) 40

Correct Answer: (C) 30

Solution:

Concept: Hardness is usually expressed in terms of $CaCO_3$. The conversion formula is:

$$\text{Hardness as } CaCO_3 = \frac{\text{amount of salt} \times 50}{\text{equivalent weight of salt}}$$

Step 1: Calculate equivalent weight of $Mg(HCO_3)_2$.

Molecular weight:

$$Mg(HCO_3)_2 = 24 + 2(1 + 12 + 48)$$

$$= 24 + 2(61) = 146$$

Since Mg^{2+} has valency 2,

$$\text{Eq. wt.} = \frac{146}{2} = 73$$

Hardness due to $Mg(HCO_3)_2$:

$$= \frac{7.3 \times 50}{73} = 5 \text{ ppm}$$

Step 2: Calculate equivalent weight of $Ca(HCO_3)_2$.

Molecular weight:

$$Ca(HCO_3)_2 = 40 + 2(61) = 162$$

$$\text{Eq. wt.} = \frac{162}{2} = 81$$

Hardness due to $Ca(HCO_3)_2$:

$$= \frac{8.1 \times 50}{81} = 5 \text{ ppm}$$

Step 3: Calculate equivalent weight of $CaSO_4$.

Molecular weight:

$$CaSO_4 = 40 + 32 + 64 = 136$$

$$\text{Eq. wt.} = \frac{136}{2} = 68$$

Hardness due to $CaSO_4$:

$$= \frac{27.2 \times 50}{68} = 20 \text{ ppm}$$

Step 4: Total hardness:

$$= 5 + 5 + 20$$

$$= 30 \text{ ppm}$$

Therefore,

$$\boxed{30}$$

Quick Tip: To convert hardness into $CaCO_3$ equivalent, use $\frac{\text{salt amount} \times 50}{\text{equivalent weight of salt}}$.

---

91. The type of functional group associated with cation exchange resin is

(A) $-OH$

(B) $-SO_3H$

(C) $-NH_2$

(D) $-CHO$

Correct Answer: (B) $-SO_3H$

Solution:

Concept: Cation exchange resins exchange their H^+ ions with cations present in water.

Step 1: Cation exchange resin must contain acidic functional groups.

Step 2: The common functional group in a strong acid cation exchange resin is:

$$-SO_3H$$

Step 3: This group releases H^+ ions and exchanges them with cations like:

$$Ca^{2+},\ Mg^{2+},\ Na^+$$

Step 4: Therefore, the functional group associated with cation exchange resin is:

$$\boxed{-SO_3H}$$

Quick Tip: Cation exchange resins generally contain acidic groups like $-SO_3H$, while anion exchange resins contain basic groups.

---

92. Identify the incorrect statement about the corrosion.

(A) In the composition type of galvanic cell, metal with lower standard reduction potential undergoes corrosion

(B) In stress cell type of galvanic cell, corrosion occurs at the stressed area of the metal

(C) The rate of corrosion is more, when the area of cathode is smaller

(D) In concentration cell type of galvanic cell, the metal below the water level undergoes corrosion readily

Correct Answer: (C) The rate of corrosion is more, when the area of cathode is smaller

Solution:

Concept: Corrosion is an electrochemical process. The relative areas of anode and cathode strongly affect the rate of corrosion.

Step 1: In galvanic corrosion, the metal with lower reduction potential behaves as anode and undergoes oxidation.

So statement (A) is correct.

Step 2: In stress corrosion, the stressed portion acts as anode and corrodes faster.

So statement (B) is correct.

Step 3: In concentration cell corrosion, the region with less oxygen generally acts as anode and undergoes corrosion.

The portion below water level may corrode readily due to oxygen concentration difference.

So statement (D) is correct.

Step 4: Corrosion is more severe when a small anodic area is connected to a large cathodic area.

If cathode area is smaller, corrosion rate does not become more.

Therefore, the incorrect statement is:

The rate of corrosion is more, when the area of cathode is smaller

Quick Tip: Corrosion is most severe when the anodic area is small and the cathodic area is large.

---

93. In galvanised iron

(A) Zn acts as anode and Fe acts as cathode

(B) Zn acts as cathode and Fe acts as anode

(C) Sn acts as anode and Fe acts as cathode

(D) Sn acts as cathode and Fe acts as anode

Correct Answer: (A) Zn acts as anode and Fe acts as cathode

Solution:

Concept: Galvanisation is the process of coating iron with zinc to protect iron from corrosion.

Step 1: In galvanised iron, iron is coated with zinc:

Fe coated with Zn

Step 2: Zinc is more electropositive than iron and has a greater tendency to oxidize.

Step 3: Therefore, zinc acts as sacrificial anode:

$$Zn \rightarrow Zn^{2+} + 2e^{-}$$

Step 4: Iron is protected and behaves as cathode.

Thus:

$$Zn = \text{anode}$$

and

$$Fe = \text{cathode}$$

Therefore,

$$\boxed{\text{Zn acts as anode and Fe acts as cathode}}$$

Quick Tip: In galvanised iron, zinc protects iron by acting as sacrificial anode.

---

94. During vulcanization of raw rubber, the chemical added to it is

(A) Sulphur

(B) Phosphorus

(C) Iodine

(D) Sodium

Correct Answer: (A) Sulphur

Solution:

Concept: Vulcanization is the process of heating natural rubber with sulphur to improve its strength, elasticity, and durability.

Step 1: Raw rubber is soft, sticky, and less durable.

Step 2: During vulcanization, sulphur is added to rubber.

Step 3: Sulphur forms cross-links between polymer chains of rubber.

Step 4: These sulphur cross-links make rubber:

stronger, more elastic, and more durable

Therefore, the chemical added during vulcanization is:

Sulphur

Quick Tip: Vulcanization of rubber is done by heating rubber with sulphur.

---

95. Which of the following is a natural polymer?

(A) Cellulose

(B) Teflon

(C) Polyvinylchloride

(D) Neoprene rubber

Correct Answer: (A) Cellulose

Solution:

Concept: Natural polymers are obtained from plants and animals. Synthetic polymers are man-made.

Step 1: Cellulose is found naturally in plants.

Step 2: It is a polysaccharide made up of repeating glucose units.

Step 3: Teflon, polyvinylchloride, and neoprene rubber are synthetic polymers.

Step 4: Hence, the natural polymer among the given options is:

Cellulose

Quick Tip: Cellulose, starch, proteins, and natural rubber are examples of natural polymers.

---

96. The structure of Buna-S polymer is

(A) $[-CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2-]_n$

(B) $[-CH_2-CH=CH-CH_2-CH(CN)-CH_2-]_n$

(C) $[-CH_2-C(Cl)=CH-CH_2-]_n$

(D) $[-NH-CO-NH-CH_2-]_n$

Correct Answer: (A) $[-CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2-]_n$

Solution:

Concept: Buna-S is a copolymer of butadiene and styrene.

Step 1: Buna-S is also called styrene-butadiene rubber.

Step 2: The monomers are:

$$CH_2=CH-CH=CH_2$$

which is butadiene, and

$$C_6H_5CH=CH_2$$

which is styrene.

Step 3: Since styrene contains the phenyl group:

$$C_6H_5$$

the Buna-S polymer must contain C_6H_5 as a side group.

Step 4: Therefore, the correct repeating unit is:

$$[-CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2-]_n$$

Hence,

$$\boxed{[-CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2-]_n}$$

Quick Tip: Buna-S is made from butadiene and styrene; therefore, its structure contains a phenyl group (C_6H_5).

---

97. The polymer used in making gaskets and non-stick coating utensils is

(A) Polyvinyl chloride

(B) Polystyrene

(C) Polytetrafluoroethylene

(D) Polythene

Correct Answer: (C) Polytetrafluoroethylene

Solution:

Concept: Polytetrafluoroethylene is commonly known as Teflon. It has high chemical resistance and a very low coefficient of friction.

Step 1: Non-stick cookware requires a material that does not allow food to stick.

Step 2: Teflon has non-stick properties due to strong $C-F$ bonds and low surface energy.

Step 3: Teflon is also used in gaskets because it is chemically inert and heat resistant.

Step 4: The chemical name of Teflon is:

Polytetrafluoroethylene

Therefore,

Polytetrafluoroethylene

Quick Tip: Teflon is polytetrafluoroethylene and is used for non-stick coatings and chemically resistant gaskets.

---

98. Which of the following is not to be considered as a primary fuel?

(A) Wood

(B) Petroleum

(C) Coke

(D) Coal

Correct Answer: (C) Coke

Solution:

Concept: Primary fuels are obtained directly from nature. Secondary fuels are obtained by processing primary fuels.

Step 1: Wood is obtained directly from nature, so it is a primary fuel.

Step 2: Petroleum is obtained naturally from the earth, so it is a primary fuel.

Step 3: Coal is also obtained naturally, so it is a primary fuel.

Step 4: Coke is obtained by destructive distillation of coal.

So coke is not a primary fuel; it is a secondary fuel.

Therefore,

$$\boxed{\text{Coke}}$$

Quick Tip: Primary fuels occur naturally, while secondary fuels are produced by processing primary fuels.

---

99. The oxide of nitrogen responsible for depletion of ozone layer is

(A) N_2O

(B) NO_2

(C) NO

(D) N_2O_3

Correct Answer: (C) NO

Solution:

Concept: Nitric oxide (NO) acts as a catalyst in the destruction of ozone in the stratosphere.

Step 1: Ozone layer contains:

$$O_3$$

It protects the earth from harmful ultraviolet radiation.

Step 2: Nitric oxide reacts with ozone:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Step 3: The NO_2 formed can further react with atomic oxygen:

$$NO_2 + O \rightarrow NO + O_2$$

Step 4: Notice that NO is regenerated.

So NO acts as a catalyst and repeatedly destroys ozone.

Therefore, the oxide responsible for depletion of ozone layer is:

$$\boxed{NO}$$

Quick Tip: Nitric oxide (NO) catalytically destroys ozone and is responsible for ozone layer depletion.

---

100. The BOD of highly polluted water is

(A) 17 ppm

(B) 10 ppm

(C) 8 ppm

(D) 12 ppm

Correct Answer: (A) 17 ppm

Solution:

Concept: BOD stands for Biochemical Oxygen Demand. It is the amount of dissolved oxygen required by microorganisms to decompose organic matter present in water.

Step 1: Clean water has low BOD because it contains less organic waste.

Step 2: Polluted water contains more organic matter.

Step 3: More organic matter means microorganisms require more oxygen for decomposition.

Step 4: Therefore, highly polluted water has a high BOD value.

Among the given options, the highest value is:

$$17 \text{ ppm}$$

So the BOD of highly polluted water is:

$$\boxed{17 \text{ ppm}}$$

Quick Tip: Higher BOD means higher organic pollution in water. Clean water has low BOD, while highly polluted water has high BOD.

---

101. _____ is a solid solution of Calcium carbonate and Magnesium carbonate.

(A) Dolomite

(B) Magnesite

(C) Chromite

(D) Calcite

Correct Answer: (A) Dolomite

Solution:

Concept: Dolomite is a carbonate mineral containing both calcium carbonate and magnesium carbonate. Its chemical formula is generally written as:

$$CaMg(CO_3)_2$$

It can be considered as a double carbonate of calcium and magnesium.

Step 1: Calcium carbonate is represented as:

$$CaCO_3$$

Magnesium carbonate is represented as:

$$MgCO_3$$

Step 2: When calcium carbonate and magnesium carbonate occur together in a combined mineral form, the mineral formed is known as dolomite.

$$CaCO_3 + MgCO_3 \rightarrow CaMg(CO_3)_2$$

Step 3: The compound:

$$CaMg(CO_3)_2$$

is called dolomite.

Step 4: Therefore, the mineral which is a solid solution or double carbonate of calcium carbonate and magnesium carbonate is:

$$\boxed{\text{Dolomite}}$$

Quick Tip: Dolomite is a double carbonate mineral of calcium and magnesium with formula $CaMg(CO_3)_2$.

102. The chemical formula of Fluorspar is

(A) MgF_2

(B) CaF_2

(C) NaF_2

(D) NiF_2

Correct Answer: (B) CaF_2

Solution:

Concept: Fluorspar is the mineral form of calcium fluoride. It is commonly used as a flux in metallurgical and ceramic processes.

Step 1: Fluorspar is another name for the mineral fluorite.

Step 2: Fluorite is chemically calcium fluoride.

Step 3: Calcium forms:

$$Ca^{2+}$$

Fluoride ion is:

$$F^-$$

Step 4: To balance the charge, one calcium ion combines with two fluoride ions:

$$Ca^{2+} + 2F^- \rightarrow CaF_2$$

Therefore, the formula of fluorspar is:

$$\boxed{CaF_2}$$

Quick Tip: Fluorspar is also called fluorite, and its chemical formula is CaF_2.

---

103. The total number of Polymorphic forms of Quartz is

(A) 2

(B) 1

(C) 4

(D) 3

Correct Answer: (D) 3

Solution:

Concept: Polymorphism means the ability of a substance to exist in more than one crystalline form while having the same chemical composition.

Step 1: Quartz is a crystalline form of silica:

$$SiO_2$$

Step 2: Silica can exist in different polymorphic forms depending on temperature and structure.

Step 3: The main polymorphic forms of silica are:

Quartz, Tridymite, and Cristobalite

Step 4: Therefore, the total number of important polymorphic forms of quartz/silica is:

3

Hence,

$$\boxed{3}$$

Quick Tip: The important polymorphic forms of silica are quartz, tridymite, and cristobalite.

---

104. _____ is a waste/by-product obtained during burning of pulverized coal in thermal power plants during the production of electricity.

(A) Blast furnace slag

(B) Flyash

(C) Phosphogypsum

(D) Redmud

Correct Answer: (B) Flyash

Solution:

Concept: Flyash is a fine powdery residue obtained from the combustion of pulverized coal in thermal power plants.

Step 1: In thermal power plants, coal is burned to produce heat energy.

Step 2: This heat energy is used to convert water into steam, and steam is used to generate electricity.

Step 3: During combustion of pulverized coal, fine ash particles are carried along with flue gases.

Step 4: These fine ash particles are collected using electrostatic precipitators or other collection systems.

Step 5: This collected fine ash is called:

Flyash

Therefore, the waste/by-product obtained during burning of pulverized coal is:

Flyash

Quick Tip: Flyash is produced from coal combustion in thermal power plants and is widely used in cement and concrete industries.

---

105. The Soda feldspar is also known as

(A) Orthoclase

(B) Albite

(C) Anorthite

(D) Dickite

Correct Answer: (B) Albite

Solution:

Concept: Feldspars are important rock-forming minerals. They are alumino-silicates of potassium, sodium, and calcium.

Step 1: Soda feldspar means feldspar containing sodium.

Step 2: The sodium-rich feldspar is known as albite.

Step 3: The chemical formula of albite is:

$$NaAlSi_3O_8$$

Step 4: Orthoclase is potassium feldspar, while anorthite is calcium feldspar.

Step 5: Hence, soda feldspar is:

$$\boxed{\text{Albite}}$$

Quick Tip: Soda feldspar is albite ($NaAlSi_3O_8$), potash feldspar is orthoclase, and lime feldspar is anorthite.

---

106. The chemical formula of Bauxite is

(A) $Al_2O_3 \cdot H_2O$

(B) $Al_2O_3 \cdot 3H_2O$

(C) Al_2O_3

(D) $Al_2O_3 \cdot 2H_2O$

Correct Answer: (D) $Al_2O_3 \cdot 2H_2O$

Solution:

Concept: Bauxite is an important ore of aluminium. It is mainly a hydrated oxide of aluminium.

Step 1: Aluminium oxide is:

$$Al_2O_3$$

Step 2: Bauxite is not pure anhydrous aluminium oxide. It contains water of hydration.

Step 3: The commonly represented formula of bauxite is:

$$Al_2O_3 \cdot 2H_2O$$

Step 4: Since bauxite is a hydrated aluminium oxide, the correct formula among the given options is:

$$\boxed{Al_2O_3 \cdot 2H_2O}$$

Quick Tip: Bauxite is a hydrated oxide of aluminium and is represented as $Al_2O_3 \cdot 2H_2O$.

---

107. Which of the following is called Black Mica?

(A) Muscovite

(B) Biotite

(C) Lepidolite

(D) Vermiculite

Correct Answer: (B) Biotite

Solution:

Concept: Mica minerals are sheet silicate minerals. Different varieties of mica have different colours and compositions.

Step 1: Muscovite is commonly called white mica because it is light-coloured.

Step 2: Biotite is dark brown to black in colour.

Step 3: Due to its dark or black appearance, biotite is called black mica.

Step 4: Therefore, the mineral called black mica is:

$$\boxed{\text{Biotite}}$$

Quick Tip: Biotite is black mica, while muscovite is white mica.

---

108. The Hardness of Corundum on Moh's scale is

(A) 5

(B) 6

(C) 7

(D) 9

Correct Answer: (D) 9

Solution:

Concept: Moh's scale of hardness is used to compare the scratch resistance of minerals. It ranges from 1 to 10.

Step 1: On Moh's scale:

$$\text{Talc} = 1$$

and

$$\text{Diamond} = 10$$

Step 2: Corundum is a very hard mineral.

Step 3: Corundum has hardness:

$$9$$

Step 4: Therefore, the hardness of corundum on Moh's scale is:

$$\boxed{9}$$

Quick Tip: On Moh's scale, corundum has hardness 9, and diamond has hardness 10.

---

109. Which of the following is an example of an Igneous rock?

(A) Sandstone

(B) Marble

(C) Basalt

(D) Lime stone

Correct Answer: (C) Basalt

Solution:

Concept: Igneous rocks are formed by the cooling and solidification of molten magma or lava.

Step 1: Sandstone is a sedimentary rock.

Step 2: Marble is a metamorphic rock formed from limestone under heat and pressure.

Step 3: Limestone is a sedimentary rock.

Step 4: Basalt is formed from cooled lava and is an igneous rock.

Therefore, the igneous rock among the options is:

$$\boxed{\text{Basalt}}$$

Quick Tip: Basalt and granite are common examples of igneous rocks.

110. Sedimentary rocks are formed mainly by

(A) Melting and cooling

(B) Heat and pressure

(C) Deposition, compaction and cementation

(D) Volcanic eruption

Correct Answer: (C) Deposition, compaction and cementation

Solution:

Concept: Sedimentary rocks are formed from sediments that are deposited in layers and later compacted and cemented together.

Step 1: Weathering breaks rocks into small particles called sediments.

Step 2: These sediments are transported by water, wind, or ice.

Step 3: The sediments are deposited in layers.

Step 4: With time, pressure causes compaction of sediments.

Step 5: Minerals act as cementing material and bind the particles together.

Step 6: Hence, sedimentary rocks are formed by:

Deposition, compaction and cementation

Quick Tip: Sedimentary rocks are formed from sediments by deposition, compaction, and cementation.

---

111. Which of the following is a Metamorphic rock?

(A) Granite

(B) Coal

(C) Sandstone

(D) Slate

Correct Answer: (D) Slate

Solution:

Concept: Metamorphic rocks are formed when existing rocks are changed due to heat, pressure,

or chemically active fluids.

Step 1: Granite is an igneous rock.

Step 2: Coal is generally considered an organic sedimentary rock.

Step 3: Sandstone is a sedimentary rock.

Step 4: Slate is formed from shale due to metamorphism.

Step 5: Therefore, the metamorphic rock among the given options is:

Slate

Quick Tip: Slate, marble, quartzite, and gneiss are common examples of metamorphic rocks.

---

112. The study of Minerals is called

(A) Geology

(B) Mineralogy

(C) Petrology

(D) Metallurgy

Correct Answer: (B) Mineralogy

Solution:

Concept: Different branches of earth science study different materials and processes.

Step 1: Geology is the broad study of the earth, rocks, and earth processes.

Step 2: Petrology is the study of rocks.

Step 3: Metallurgy is the science of extraction and processing of metals.

Step 4: Mineralogy is the branch that deals with the study of minerals, their composition, structure, properties, and classification.

Therefore, the study of minerals is called:

Mineralogy

Quick Tip: Mineralogy is the study of minerals, while petrology is the study of rocks.

113. The Hardest mineral on the Moh's scale is

(A) Quartz

(B) Topaz

(C) Corundum

(D) Diamond

Correct Answer: (D) Diamond

Solution:

Concept: Moh's scale of hardness ranks minerals from 1 to 10 based on their ability to scratch other minerals.

Step 1: On Moh's scale:

$$1 = \text{Talc}$$

which is the softest mineral.

Step 2: The highest hardness value on Moh's scale is:

$$10$$

Step 3: Diamond has hardness:

$$10$$

Step 4: Therefore, diamond is the hardest mineral on Moh's scale.

Hence,

$$\boxed{\text{Diamond}}$$

Quick Tip: Diamond is the hardest mineral on Moh's scale with hardness 10.

114. The color of a Mineral in powdered form is called

(A) Luster

(B) Streak

(C) Texture

(D) Shade

Correct Answer: (B) Streak

Solution:

Concept: In mineralogy, minerals are identified by several physical properties such as color, luster, hardness, cleavage, fracture, and streak.

Step 1: The ordinary color of a mineral is the color seen on the mineral surface.

Step 2: Sometimes the surface color of a mineral may vary due to impurities, weathering, or surface oxidation.

Step 3: Therefore, for better identification, the mineral is rubbed on an unglazed porcelain plate.

Step 4: The color of the powder left behind by the mineral is called its streak.

$$\text{Color of mineral in powdered form} = \text{Streak}$$

Step 5: Luster means the way a mineral reflects light from its surface, texture means the surface feel or arrangement, and shade is simply a variation of color.

Therefore, the correct answer is:

$$\boxed{\text{Streak}}$$

Quick Tip: Streak is the color of a mineral in powdered form and is often more reliable than surface color for mineral identification.

---

115. Which of the following is a Clay mineral?

(A) Quartz

(B) Gypsum

(C) Kaolinite

(D) Feldspar

Correct Answer: (C) Kaolinite

Solution:

Concept: Clay minerals are fine-grained hydrous alumino-silicate minerals. They are important raw materials in ceramic bodies because they provide plasticity and help in shaping.

Step 1: Quartz is a silica mineral.

$$Quartz = SiO_2$$

It is not a clay mineral.

Step 2: Gypsum is calcium sulphate dihydrate.

$$Gypsum = CaSO_4 \cdot 2H_2O$$

It is not a clay mineral.

Step 3: Feldspar is an alumino-silicate mineral of potassium, sodium, or calcium. It is mainly used as a flux in ceramics.

Step 4: Kaolinite is a true clay mineral. Its formula is commonly written as:

$$Al_2Si_2O_5(OH)_4$$

Step 5: Since kaolinite belongs to the clay mineral group, the correct answer is:

$$\boxed{\text{Kaolinite}}$$

Quick Tip: Kaolinite is an important clay mineral and is widely used in whiteware and ceramic industries.

---

116. Which of the following is not a Triaxial material in whiteware?

(A) Clay

(B) Feldspar

(C) Quartz

(D) Rutile

Correct Answer: (D) Rutile

Solution:

Concept: Whiteware bodies are commonly prepared using three main raw materials. These are called triaxial materials.

Step 1: The three main triaxial materials used in whiteware are:

$$\text{Clay}, \quad \text{Feldspar}, \quad \text{Quartz}$$

Step 2: Clay provides plasticity to the ceramic body and helps in shaping.

Step 3: Feldspar acts as a flux. It lowers the vitrification temperature and helps in forming a glassy phase during firing.

Step 4: Quartz acts as a filler and improves dimensional stability.

Step 5: Rutile is mainly titanium dioxide mineral:

$$TiO_2$$

It is not one of the three basic triaxial materials of whiteware.

Therefore, the material which is not a triaxial material in whiteware is:

$$\boxed{\text{Rutile}}$$

Quick Tip: The triaxial whiteware composition consists mainly of clay, feldspar, and quartz.

---

117. Which kiln is used for Firing of Ceramic tiles?

(A) Tunnel kiln

(B) Shaft kiln

(C) Roller hearth kiln

(D) Rotary kiln

Correct Answer: (C) Roller hearth kiln

Solution:

Concept: Ceramic tiles require controlled, uniform, and continuous firing. For this purpose, kilns that allow rapid and uniform heating are preferred.

Step 1: A roller hearth kiln is a continuous kiln in which ceramic products move on rotating rollers.

Step 2: Ceramic tiles are flat products, so they can be easily transported on rollers through the

kiln.

Step 3: Roller hearth kilns provide uniform temperature distribution and rapid firing.

Step 4: They are widely used in the tile industry because they improve production speed and firing quality.

Step 5: Shaft kiln is generally used for lime or similar materials, rotary kiln is used for cement and refractory raw materials, and tunnel kiln is used for many ceramic products but modern tiles are commonly fired in roller hearth kilns.

Therefore, the kiln used for firing ceramic tiles is:

$$\boxed{\text{Roller hearth kiln}}$$

Quick Tip: Roller hearth kilns are commonly used for ceramic tile firing because tiles can move smoothly on rollers through the kiln.

---

118. The Vitrified tile has a Water absorption of

(A) Less than 5%

(B) Less than 10%

(C) Less than 0.5%

(D) Less than 15%

Correct Answer: (C) Less than 0.5%

Solution:

Concept: Vitrified tiles are highly dense ceramic tiles. They are fired at high temperature so that the body becomes vitrified and develops very low porosity.

Step 1: Water absorption depends on the porosity of the ceramic body.

Step 2: If a tile has more open pores, it absorbs more water.

Step 3: Vitrified tiles have very low open porosity because a glassy phase forms during firing and fills the pores.

Step 4: Due to vitrification, the water absorption of vitrified tiles is very low.

Step 5: The standard value for vitrified tiles is generally:

$$\text{Water absorption} < 0.5\%$$

Therefore, the correct answer is:

$$\boxed{\text{Less than } 0.5\%}$$

Quick Tip: Vitrified tiles are dense and highly vitrified, so their water absorption is less than 0.5%.

---

119. _____ is used to prepare granules from slip.

(A) Spray dryer

(B) Infrared moisture balance

(C) Filter press

(D) Pug mill

Correct Answer: (A) Spray dryer

Solution:

Concept: In ceramic processing, slip is a suspension of ceramic raw materials in water. To convert this liquid slip into free-flowing granules or powder, a drying process is required. Spray drying is one of the most commonly used methods for preparing granules from ceramic slip.

Step 1: Understand what slip means.

A ceramic slip is a liquid mixture containing fine ceramic particles and water.

$$\text{Slip} = \text{Ceramic powder} + \text{Water} + \text{Additives}$$

Step 2: In many ceramic forming processes, especially pressing, the material should not remain in liquid slip form.

It should be converted into granules because granules:

- flow easily,
- fill moulds uniformly,
- compact properly during pressing,
- give better green strength.

Step 3: A spray dryer converts ceramic slip into granules.

In a spray dryer, the slip is sprayed as fine droplets into a hot air chamber.

$$\text{Slip droplets} + \text{Hot air} \rightarrow \text{Dry granules}$$

Step 4: Water evaporates quickly from the droplets, and dry spherical granules are obtained.

Step 5: Now check the other options.

- Infrared moisture balance is used to measure moisture content.
- Filter press is used to remove water and form filter cake.
- Pug mill is used for mixing and de-airing plastic clay mass.

Therefore, the equipment used to prepare granules from slip is:

$$\boxed{\text{Spray dryer}}$$

Quick Tip: Spray dryer converts ceramic slip into dry, free-flowing granules suitable for pressing.

---

120. Which of the following is not Glaze application machine?

(A) Water fall

(B) The Bell

(C) Rotating Disc

(D) Digital printing machine

Correct Answer: (D) Digital printing machine

Solution:

Concept: Glaze application machines are used to apply a layer of glaze slurry on the ceramic surface. Glaze can be applied by different techniques such as waterfall glazing, bell glazing, spraying, disc application, etc.

Step 1: Understand glaze application.

Glaze is a glassy coating applied on ceramic products before firing.

$$\text{Ceramic body} + \text{Glaze coating} \rightarrow \text{Glossy/vitrified surface after firing}$$

Step 2: Waterfall glazing is a glaze application method.

In this method, a curtain or waterfall of glaze falls on the surface of tiles or ceramic products.

So, Water fall is a glaze application machine.

Step 3: The Bell is also used for glaze application.

In bell glazing, glaze is spread uniformly using a bell-shaped device.

So, The Bell is also a glaze application machine.

Step 4: Rotating Disc is also used for glaze application.

The rotating disc spreads glaze by centrifugal action.

So, Rotating Disc is also a glaze application machine.

Step 5: Digital printing machine is not mainly a glaze application machine.

It is used for printing decorative designs, patterns, and images on ceramic tiles.

$$\text{Digital printing} \rightarrow \text{Decoration/design application}$$

It does not primarily apply glaze like waterfall, bell, or rotating disc systems.

Therefore, the option which is not a glaze application machine is:

$$\boxed{\text{Digital printing machine}}$$

Quick Tip: Glaze application machines apply glaze coating, while digital printing machines are mainly used for decorative printing on ceramic surfaces.

---

121. Which product belongs to Heavy clay ware?

(A) Bone china

(B) Electrical porcelain

(C) Sewer pipe

(D) Sanitary ware

Correct Answer: (C) Sewer pipe

Solution:

Concept: Ceramic products are classified into different groups such as whiteware, heavy clay ware, refractories, glass, cement, etc. Heavy clay wares are generally large, coarse ceramic products made from common clay or shale.

Step 1: Heavy clay products are usually made from low-cost clay materials.
They are generally:

- coarse ceramic products,
- used in construction and drainage,
- fired at relatively high temperatures,
- mechanically strong and durable.

Step 2: Common examples of heavy clay wares include:

Bricks, roofing tiles, floor tiles, drain pipes, sewer pipes

Step 3: Now check each option.
Bone china is a fine whiteware product.
Electrical porcelain is a technical/whiteware ceramic product used for electrical insulation.
Sanitary ware is generally included in whiteware ceramics.
Step 4: Sewer pipe is a heavy clay product because it is a large, coarse ceramic product used in drainage and sewage systems.
Therefore, the product belonging to heavy clay ware is:

Sewer pipe

Quick Tip: Heavy clay wares include bricks, roofing tiles, drain pipes, and sewer pipes.

---

122. Quartz in White ware mainly acts as

(A) Plasticizer

(B) Flux

(C) Colorant

(D) Filler

Correct Answer: (D) Filler

Solution:

Concept: Whiteware bodies are commonly made from a triaxial composition consisting of clay, feldspar, and quartz. Each material has a specific role in the ceramic body.

Step 1: In whiteware composition, the three main raw materials are:

$$\text{Clay} + \text{Feldspar} + \text{Quartz}$$

Step 2: Clay provides plasticity.

It helps the ceramic body to be shaped easily.

$$\text{Clay} \rightarrow \text{Plasticity}$$

Step 3: Feldspar acts as a flux.

It lowers the melting or vitrification temperature and helps in forming the glassy phase during firing.

$$\text{Feldspar} \rightarrow \text{Flux}$$

Step 4: Quartz mainly acts as a filler.

It provides dimensional stability and controls shrinkage during drying and firing.

$$\text{Quartz} \rightarrow \text{Filler}$$

Step 5: Quartz also improves the mechanical stability of the ceramic body and reduces excessive deformation during firing.

Therefore, quartz in whiteware mainly acts as:

$$\boxed{\text{Filler}}$$

Quick Tip: In whiteware, clay gives plasticity, feldspar acts as flux, and quartz acts as filler.

---

123. Spark plugs are made up of

(A) Alumina

(B) Bone china

(C) Cordierite

(D) Soft Porcelain

Correct Answer: (A) Alumina

Solution:

Concept: Spark plugs require a ceramic material that can work at high temperature, has high electrical insulation, good mechanical strength, and good thermal shock resistance.

Step 1: A spark plug is used in an internal combustion engine.

Step 2: The ceramic part of the spark plug acts as an electrical insulator.

Step 3: This insulator must withstand high temperature and high voltage without electrical breakdown.

Step 4: Alumina (Al_2O_3) has:

- high dielectric strength,
- high thermal stability,
- good mechanical strength,
- good corrosion resistance.

Step 5: Because of these properties, alumina is widely used in spark plug insulators.

Therefore, spark plugs are made up of:

Alumina

Quick Tip: Alumina is used in spark plugs because it has high electrical insulation and high thermal stability.

---

124. Ability of Electrical insulator to resist the electrical breakdown is called

(A) Dielectric constant

(B) Dielectric Strength

(C) Polarization

(D) Loss factor

Correct Answer: (B) Dielectric Strength

Solution:

Concept: Dielectric strength is the maximum electric field that an insulating material can withstand without electrical breakdown.

Step 1: An electrical insulator is a material that does not allow current to pass easily.

Step 2: When very high voltage is applied, even an insulator can fail and allow current to pass.

Step 3: This failure of insulation is called electrical breakdown.

Step 4: The ability of an insulating material to resist this breakdown is called dielectric strength.

Step 5: Dielectric constant is related to energy storage, polarization is related to displacement of charges, and loss factor is related to dielectric losses.

Therefore, the correct term is:

$$\boxed{\text{Dielectric Strength}}$$

Quick Tip: Dielectric strength tells how much electric stress an insulator can withstand before breakdown.

---

125. Which of the following forming technique is used to make ceramic rods and tubes?

(A) Slip casting

(B) Pressing

(C) Extrusion

(D) Injection molding

Correct Answer: (C) Extrusion

Solution:

Concept: Extrusion is a forming process in which a plastic ceramic mass is forced through a die to produce long products of uniform cross-section.

Step 1: Ceramic rods and tubes have continuous and uniform cross-sections.

Step 2: For such shapes, the ceramic body should be pushed through a shaped die.

Step 3: In extrusion, a plastic clay body is forced through a die opening.

$$\text{Plastic ceramic mass} \rightarrow \text{Die} \rightarrow \text{Rod/Tube}$$

Step 4: If the die opening is circular, rods can be formed.

Step 5: If the die has a hollow shape, tubes can be formed.

Step 6: Slip casting is used for hollow complex shapes, pressing is used for compact shapes, and injection molding is used for complex small ceramic parts.

Therefore, the technique used for ceramic rods and tubes is:

Extrusion

Quick Tip: Extrusion is best suited for long ceramic products with uniform cross-section, such as rods, tubes, and pipes.

---

126. Black core defect in whiteware occurs due to

(A) Excess Silica

(B) Trapped carbon

(C) Over vitrification

(D) Rapid cooling

Correct Answer: (B) Trapped carbon

Solution:

Concept: Black core is a firing defect in ceramic bodies. It occurs when carbonaceous matter inside the ceramic body is not completely burnt out during firing.

Step 1: Ceramic raw materials may contain organic impurities or carbonaceous matter.

Step 2: During firing, these carbon-containing materials should burn out properly.

Step 3: If firing is too fast or oxygen supply is insufficient, carbon does not burn completely.

Step 4: The unburnt or trapped carbon remains inside the body.

Step 5: This produces a dark or black region inside the ceramic body, known as black core defect.

Therefore, black core defect occurs due to:

Trapped carbon

Quick Tip: Black core defect occurs when carbonaceous material is trapped inside the ceramic body due to incomplete oxidation during firing.

---

127. _____ is used to test Crazing resistance

(A) Autoclave

(B) Impact tester

(C) Penetration test

(D) Pot mill

Correct Answer: (A) Autoclave

Solution:

Concept: Crazing is a defect in glazed ceramic products. It appears as fine cracks in the glaze layer due to stress between glaze and body.

Step 1: Crazing resistance means the ability of a glazed ceramic article to resist formation of fine cracks.

Step 2: To test crazing resistance, the ceramic sample is exposed to high-pressure steam.

Step 3: An autoclave is a closed pressure vessel used to create high temperature and high-pressure steam conditions.

Step 4: These severe conditions accelerate the tendency of glaze to craze.

Step 5: If cracks appear after autoclave treatment, the product has poor crazing resistance.

Therefore, the equipment used to test crazing resistance is:

Autoclave

Quick Tip: Autoclave testing is commonly used to check crazing resistance of glazed ceramic products.

---

128. Which of the following is not an Opacifier?

(A) As_2O_3

(B) Sb_2O_3

(C) ZnO

(D) Al_2O_3

Correct Answer: (D) Al_2O_3

Solution:

Concept: Opacifiers are materials added to glazes or glasses to make them opaque by scattering light.

Step 1: In ceramic glaze, opacity is produced by adding special oxides.

Step 2: These oxides scatter light and reduce transparency.

Step 3: As_2O_3, Sb_2O_3, and ZnO can act as opacifying agents in ceramic/glass systems.

Step 4: Al_2O_3 is mainly used as an alumina source. It improves viscosity, strength, and stability of glaze or ceramic body.

Step 5: It is not generally considered a standard opacifier among the given options.

Therefore, the compound which is not an opacifier is:

$$\boxed{Al_2O_3}$$

Quick Tip: Opacifiers are added to reduce transparency; alumina is mainly a stabilizer and refractory oxide, not a common opacifier.

---

129. Which of the following coloring agent is used to impart Blue color in Glaze?

(A) NiO

(B) CoO

(C) MnO

(D) ZnO

Correct Answer: (B) CoO

Solution:

Concept: Metal oxides are commonly used as coloring agents in ceramic glazes. Different oxides produce different colors.

Step 1: Cobalt oxide is one of the strongest ceramic colorants.

Step 2: Cobalt oxide produces blue color in ceramic glaze.

$$CoO \rightarrow \text{Blue color}$$

Step 3: Nickel oxide generally gives grey, brown, or greenish shades depending on glaze composition.

Step 4: Manganese oxide generally gives brown, purple, or black shades.

Step 5: Zinc oxide is not mainly used to produce blue color.

Therefore, the coloring agent used to impart blue color in glaze is:

$$\boxed{CoO}$$

Quick Tip: Cobalt oxide (CoO) is a common ceramic colorant used to produce blue color in glazes.

---

130. Dental Porcelain contains high percentage of

(A) Feldspar

(B) Quartz

(C) Clay

(D) Cordierite

Correct Answer: (A) Feldspar

Solution:

Concept: Dental porcelain is a special type of porcelain used for dental crowns, bridges, and artificial teeth. It should have good translucency, strength, and appearance similar to natural teeth.

Step 1: Dental porcelain mainly contains feldspar as the major constituent.

Step 2: Feldspar melts during firing and forms a glassy phase.

Step 3: This glassy phase gives translucency and smooth appearance to dental porcelain.

Step 4: Quartz provides strength and dimensional stability, but it is not the highest percentage component.

Step 5: Clay is used in small amounts because too much clay reduces translucency.

Therefore, dental porcelain contains high percentage of:

$$\boxed{\text{Feldspar}}$$

Quick Tip: Dental porcelain is feldspar-rich because feldspar helps in producing a glassy and translucent appearance.

---

131. The Modulus of Rupture (MOR) test for Tiles measures

(A) Hardness

(B) Plasticity

(C) Flexural strength

(D) Abrasion resistance

Correct Answer: (C) Flexural strength

Solution:

Concept: Modulus of Rupture is a measure of the maximum bending stress a material can withstand before breaking.

Step 1: Tiles are brittle ceramic products.

Step 2: Their strength is commonly tested under bending load.

Step 3: In the MOR test, a tile sample is supported and load is applied until fracture occurs.

Step 4: The calculated value gives flexural strength.

$$MOR = \text{Flexural strength}$$

Step 5: Hardness, plasticity, and abrasion resistance are different properties and are tested by different methods.

Therefore, MOR test measures:

$$\boxed{\text{Flexural strength}}$$

Quick Tip: MOR stands for Modulus of Rupture and is used to measure flexural or bending strength.

---

132. Bone ash content in Bone China is in the range of

(A) $10-20\%$

(B) $25-35\%$

(C) $40-50\%$

(D) $60-70\%$

Correct Answer: (C) $40-50\%$

Solution:

Concept: Bone china is a type of porcelain containing bone ash, feldspar, and kaolin. Bone ash gives whiteness, translucency, and special quality to bone china.

Step 1: Bone ash is mainly composed of calcium phosphate.

Step 2: It is an important raw material in bone china.

Step 3: Bone china normally contains a high amount of bone ash.

Step 4: The usual bone ash content in bone china is approximately:

$$40-50\%$$

Step 5: This high bone ash content gives bone china its characteristic whiteness, translucency, and strength.

Therefore, the correct range is:

$$\boxed{40-50\%}$$

Quick Tip: Bone china contains about 40—50% bone ash, which gives it high whiteness and translucency.

---

133. The firing temperature of Porcelain is typically

(A) $900-1000^{\circ}C$

(B) $1000-1100^{\circ}C$

(C) $1200-1400^{\circ}C$

(D) Above $1600^{\circ}C$

Correct Answer: (C) $1200-1400^{\circ}C$

Solution:

Concept: Porcelain is a high-fired whiteware ceramic product. It requires a high firing temperature so that proper vitrification takes place.

Step 1: Porcelain is made mainly from:

$$\text{Kaolin} + \text{Feldspar} + \text{Quartz}$$

Step 2: During firing, feldspar acts as a flux and helps in forming a glassy phase.

Step 3: This glassy phase gives porcelain:

- strength,
- translucency,
- low porosity,
- white appearance.

Step 4: Porcelain is fired at a higher temperature than earthenware and stoneware.

Step 5: The usual firing temperature range of porcelain is:

$$1200 - 1400^{\circ}C$$

Therefore, the correct answer is:

$$\boxed{1200 - 1400^{\circ}C}$$

Quick Tip: Porcelain is a high-fired ceramic and is typically fired in the range of $1200 - 1400^{\circ}C$.

---

134. Which White ware has highest firing temperature?

(A) Earthen ware

(B) Porcelain

(C) Stone ware

(D) Terracotta

Correct Answer: (B) Porcelain

Solution:

Concept: Whitewares are ceramic products made from white burning clays and other raw materials. Their firing temperatures depend on their degree of vitrification.

Step 1: Earthenware and terracotta are usually fired at comparatively lower temperatures.

Step 2: Stoneware is fired at a higher temperature than earthenware, but it is generally lower than porcelain.

Step 3: Porcelain is a highly vitrified whiteware product.

Step 4: It requires high temperature firing to develop:

- high strength,
- translucency,
- low water absorption,
- dense body.

Step 5: Hence, among the given whitewares, porcelain has the highest firing temperature. Therefore, the correct answer is:

Porcelain

Quick Tip: Among common whitewares, porcelain is fired at the highest temperature because it requires high vitrification.

---

135. _____ is the one of the Phase present in fired white ware products

(A) Mullite

(B) Rutile

(C) Wollastonite

(D) Cordierite

Correct Answer: (A) Mullite

Solution:

Concept: Fired whiteware products contain different phases after firing. One of the most important crystalline phases formed during firing is mullite.

Step 1: Whiteware bodies commonly contain clay, feldspar, and quartz.

Step 2: During firing, clay minerals decompose and react to form new high-temperature phases.

Step 3: One important phase formed from alumino-silicate raw materials is mullite.

$$\text{Mullite} = 3Al_2O_3 \cdot 2SiO_2$$

Step 4: Mullite improves:

- mechanical strength,
- thermal stability,
- fired strength,
- resistance to deformation.

Step 5: Therefore, one of the phases present in fired whiteware products is:

$$\boxed{\text{Mullite}}$$

Quick Tip: Mullite is an important crystalline phase formed in fired whiteware bodies and improves strength and thermal stability.

---

136. The Fusion temperature of Super refractory material is above

(A) $1000^{\circ}C$

(B) $1500^{\circ}C$

(C) $2000^{\circ}C$

(D) $1200^{\circ}C$

Correct Answer: (C) $2000^{\circ}C$

Solution:

Concept: Refractories are materials that can withstand high temperatures without softening or melting. Super refractories are the highest temperature class of refractories.

Step 1: Ordinary refractory materials are used at high temperatures.

Step 2: High refractory materials withstand still higher temperatures.

Step 3: Super refractory materials have very high fusion temperatures.

Step 4: A refractory material is called super refractory when its fusion temperature is above:

$$2000^{\circ}C$$

Therefore, the correct answer is:

$$\boxed{2000^{\circ}C}$$

Quick Tip: Super refractories are materials whose fusion temperature is above $2000^{\circ}C$.

---

137. _____ is used to prepare Silica refractories

(A) Quartz

(B) Quartzite

(C) Sandstone

(D) Flint

Correct Answer: (B) Quartzite

Solution:

Concept: Silica refractories are mainly made from raw materials rich in silica (SiO_2). The commonly used raw material for silica bricks is quartzite.

Step 1: Silica refractories contain a high percentage of:

$$SiO_2$$

Step 2: Quartzite is a dense and hard rock rich in silica.

Step 3: It is suitable for preparing silica bricks because it provides high silica content and good refractory properties.

Step 4: During firing, silica undergoes phase transformations such as quartz to tridymite and cristobalite.

Step 5: Therefore, quartzite is commonly used to prepare silica refractories.

Hence, the correct answer is:

Quartzite

Quick Tip: Quartzite is the main raw material used for preparing silica refractories.

---

138. Which of the following is a Basic refractory?

(A) Silica

(B) Fireclay

(C) Magnesite

(D) Alumina

Correct Answer: (C) Magnesite

Solution:

Concept: Refractories are classified chemically as acidic, basic, or neutral. Basic refractories contain basic oxides such as MgO and CaO.

Step 1: Silica refractory is acidic in nature because it contains:

$$SiO_2$$

Step 2: Fireclay refractories are mainly alumino-silicate refractories and are generally acidic to neutral.

Step 3: Magnesite refractory mainly contains:

$$MgO$$

Step 4: Since MgO is a basic oxide, magnesite is a basic refractory.

Therefore, the correct answer is:

$$\boxed{\text{Magnesite}}$$

Quick Tip: Magnesite refractories are basic refractories because they mainly contain MgO.

---

139. Pyrometric Cone Equivalent (PCE) test measures

(A) Porosity

(B) Strength

(C) Refractoriness

(D) Thermal shock

Correct Answer: (C) Refractoriness

Solution:

Concept: PCE stands for Pyrometric Cone Equivalent. It is used to measure the refractoriness of a refractory material.

Step 1: Refractoriness means the ability of a material to withstand high temperature without softening.

Step 2: In the PCE test, a cone made from the refractory sample is heated along with standard pyrometric cones.

Step 3: The cone bends or softens at a certain temperature.

Step 4: By comparing it with standard cones, the refractoriness of the material is determined.

Therefore, PCE test measures:

Refractoriness

Quick Tip: PCE test is used to determine the refractoriness or softening behavior of refractory materials at high temperature.

---

140. Alumina content in Fireclay refractories is

(A) 10 – 20%

(B) 25 – 45%

(C) 60 – 80%

(D) 90 – 100%

Correct Answer: (B) 25 – 45%

Solution:

Concept: Fireclay refractories are alumino-silicate refractories. They contain both silica and alumina.

Step 1: Fireclay refractories are made from fireclay, which mainly contains:

$$Al_2O_3 \quad \text{and} \quad SiO_2$$

Step 2: Alumina provides refractoriness and improves high-temperature performance.

Step 3: Silica is also present in significant amount.

Step 4: The alumina content in fireclay refractories generally lies in the range:

$$25 - 45\%$$

Therefore, the correct answer is:

$$\boxed{25-45\%}$$

Quick Tip: Fireclay refractories are alumino-silicate refractories and usually contain about $25-45\%$ alumina.

---

141. Bonding Agent used in making Silica bricks is

(A) Chromia powder

(B) Zircon flour

(C) Hydrated lime

(D) Hydrated alumina

Correct Answer: (C) Hydrated lime

Solution:

Concept: Silica bricks are made from silica-rich raw materials like quartzite. A small amount of bonding agent is required to bind the particles and assist brick formation.

Step 1: Silica bricks are mainly made from:

$$SiO_2$$

Step 2: During manufacturing, quartzite particles need a suitable bonding material.

Step 3: Hydrated lime is commonly used as a bonding agent in silica brick making.

$$Ca(OH)_2 = \text{Hydrated lime}$$

Step 4: It helps in bonding and also assists in transformation of silica phases during firing.

Therefore, the bonding agent used in making silica bricks is:

$$\boxed{\text{Hydrated lime}}$$

Quick Tip: Hydrated lime is used as a bonding agent in the manufacture of silica bricks.

142. The chemical nature of Chromite refractory is

(A) Neutral

(B) Acidic

(C) Basic

(D) Super

Correct Answer: (A) Neutral

Solution:

Concept: Refractories are classified based on their chemical behavior as acidic, basic, or neutral.

Step 1: Acidic refractories contain acidic oxides such as:

$$SiO_2$$

Step 2: Basic refractories contain basic oxides such as:

$$MgO,\ CaO$$

Step 3: Neutral refractories do not strongly react with either acidic or basic slags.

Step 4: Chromite refractory is chemically neutral in nature.

Therefore, the correct answer is:

$$\boxed{\text{Neutral}}$$

Quick Tip: Chromite refractories are neutral refractories and can resist both acidic and basic environments to some extent.

143. Which Refractories are used for Crown of Glass melting furnace?

(A) Fire clay

(B) Chromite

(C) Magnesite

(D) Silica

Correct Answer: (D) Silica

Solution:

Concept: The crown of a glass melting furnace is exposed to very high temperatures and vapors from the glass batch. It requires refractories with good high-temperature stability.

Step 1: Silica refractories have excellent performance at high temperatures.

Step 2: They have high refractoriness and good resistance to deformation at furnace crown temperatures.

Step 3: In glass melting furnaces, silica bricks are commonly used in the crown area.

Step 4: Therefore, the refractory used for the crown of glass melting furnace is:

Silica

Quick Tip: Silica refractories are commonly used for the crown of glass melting furnaces due to their high-temperature stability.

---

144. Dolomite refractory contains

(A) MgO only

(B) CaO only

(C) CaO & MgO

(D) Al_2O_3

Correct Answer: (C) CaO & MgO

Solution:

Concept: Dolomite is a double carbonate of calcium and magnesium. On calcination, it gives calcium oxide and magnesium oxide.

Step 1: Dolomite has formula:

$$CaMg(CO_3)_2$$

Step 2: On heating or calcination:

$$CaMg(CO_3)_2 \rightarrow CaO + MgO + 2CO_2$$

Step 3: Therefore, dolomite refractory contains both:

$$CaO \quad \text{and} \quad MgO$$

Therefore, the correct answer is:

$$\boxed{CaO \ \& \ MgO}$$

Quick Tip: Dolomite refractory is made from dolomite and contains both CaO and MgO.

---

145. The important characteristic of insulating refractory is

(A) High density

(B) High porosity

(C) High strength

(D) Metallic nature

Correct Answer: (B) High porosity

Solution:

Concept: Insulating refractories are used to reduce heat loss. They have low thermal conductivity.

Step 1: Heat transfer is reduced when a material contains many pores.

Step 2: Air trapped inside pores is a poor conductor of heat.

Step 3: Therefore, high porosity reduces thermal conductivity.

Step 4: Insulating refractories are made light and porous so that they can act as thermal insulators.

Step 5: Hence, the important characteristic of insulating refractory is:

$$\boxed{\text{High porosity}}$$

Quick Tip: Insulating refractories have high porosity and low thermal conductivity.

---

146. Castables are a type of

(A) Shaped refractory

(B) Monolithic refractory

(C) Insulating brick

(D) Formed refractory

Correct Answer: (B) Monolithic refractory

Solution:

Concept: Monolithic refractories are unshaped refractory materials that are installed without being pre-formed into bricks.

Step 1: Castables are supplied as dry refractory mixes.

Step 2: Water is added before installation.

Step 3: The mixture is then cast into place like concrete.

Step 4: Since castables are not pre-shaped bricks, they belong to the class of monolithic refractories.

Therefore, the correct answer is:

Monolithic refractory

Quick Tip: Castables, ramming masses, and gunning mixes are examples of monolithic refractories.

---

147. Refractoriness under load test is used to determine

(A) Thermal conductivity

(B) The temperature at which a brick collapse under load

(C) Resistance to chemical corrosion

(D) Abrasion resistance

Correct Answer: (B) The temperature at which a brick collapse under load

Solution:

Concept: Refractoriness under load, commonly called RUL, measures the ability of a refractory material to resist deformation under load at high temperature.

Step 1: A refractory brick in a furnace is exposed to high temperature.

Step 2: It also carries load due to furnace structure or other bricks.

Step 3: At high temperature, the brick may soften and deform.

Step 4: RUL test determines the temperature at which the brick starts to deform or collapse under a specified load.

Therefore, the correct answer is:

The temperature at which a brick collapse under load

Quick Tip: RUL test gives the softening or collapse temperature of a refractory under load.

---

148. The Alumina content in High Alumina refractory should be more than

(A) 10%

(B) 25%

(C) 15%

(D) 45%

Correct Answer: (D) 45%

Solution:

Concept: High alumina refractories are alumino-silicate refractories with alumina content higher than that of ordinary fireclay refractories.

Step 1: Fireclay refractories usually contain alumina in the range:

$$25 - 45\%$$

Step 2: If the alumina content is more than the upper limit of fireclay refractories, the material is classified as high alumina refractory.

Step 3: Therefore, high alumina refractories contain more than:

$$45\%\ Al_2O_3$$

Hence, the correct answer is:

$$\boxed{45\%}$$

Quick Tip: High alumina refractories contain more than 45% alumina.

---

149. Cermet's are combination of

(A) Ceramics & glass

(B) Ceramics & metal

(C) Cement & Metal

(D) Carbon and Metals

Correct Answer: (B) Ceramics & metal

Solution:

Concept: The word cermet is formed by combining two words:

$$\text{Ceramic} + \text{Metal}$$

Step 1: Cermets contain ceramic particles and a metallic phase.

Step 2: The ceramic phase provides hardness, wear resistance, and high-temperature resistance.

Step 3: The metallic phase provides toughness, ductility, and better thermal shock resistance.

Step 4: Therefore, cermets are composite materials made from:

$$\text{Ceramics and metal}$$

Hence, the correct answer is:

$$\boxed{\text{Ceramics \& metal}}$$

Quick Tip: Cermet means ceramic-metal composite; it combines hardness of ceramics with toughness of metals.

---

150. Which Refractories are used in Regenerator of Glass tank furnace?

(A) Carbon blocks

(B) Dolomite

(C) Magnesite

(D) Silicon carbide

Correct Answer: (C) Magnesite

Solution:

Concept: Regenerators in glass tank furnaces are used for heat recovery. They require refractories that can withstand high temperature and repeated heating conditions.

Step 1: In a glass tank furnace, regenerators store heat from outgoing hot gases.

Step 2: This stored heat is then transferred to incoming air or fuel mixture.

Step 3: The refractory used in regenerators should have good resistance to high temperature and thermal cycling.

Step 4: Magnesite refractories are used in regenerator areas because they have good refractoriness and basic nature.

Therefore, the refractories used in regenerator of glass tank furnace are:

Magnesite

Quick Tip: Magnesite refractories are used in regenerators of glass tank furnaces due to their good high-temperature performance.

---

151. _____ refractories are used in construction of Coke oven wall

(A) Silica

(B) Fire clay

(C) Magnesite

(D) Chromite

Correct Answer: (A) Silica

Solution:

Concept: Coke oven walls require refractories that can withstand high temperature and maintain dimensional stability for a long time.

Step 1: Coke ovens operate at high temperatures for carbonization of coal.
Step 2: The refractory used in coke oven walls should have:

- high refractoriness,
- good thermal stability,
- good load-bearing capacity at high temperature,
- resistance to deformation.

Step 3: Silica bricks are commonly used in coke oven walls because they have excellent high-temperature strength and good resistance to load at coke oven temperatures.
Step 4: Fire clay, magnesite, and chromite refractories are used in other furnace applications, but coke oven walls are generally made using silica refractories.
Therefore, the correct answer is:

Silica

Quick Tip: Silica refractories are commonly used in coke oven walls because of their high-temperature stability and strength.

---

152. _____ refractories are used in Hearth of Blast furnace

(A) Carbon
(B) Dolomite
(C) Magnesite
(D) Chromite

Correct Answer: (A) Carbon

Solution:
Concept: The hearth of a blast furnace is the lower part where molten iron and slag collect. It experiences very severe conditions.
Step 1: The hearth of a blast furnace is exposed to:

- very high temperature,
- molten metal,

- molten slag,
- chemical attack,
- mechanical wear.

Step 2: Carbon refractories have high thermal conductivity and good resistance to molten iron.

Step 3: Carbon blocks are commonly used in blast furnace hearths because they can resist severe service conditions.

Step 4: Dolomite, magnesite, and chromite refractories are used in other metallurgical furnaces, but the hearth of blast furnace commonly uses carbon refractories.

Therefore, the correct answer is:

Carbon

Quick Tip: Blast furnace hearths commonly use carbon refractories because they resist molten iron and high-temperature attack.

---

153. The specific gravity of Alumina is

(A) 3.0

(B) 4.0

(C) 2.5

(D) 5.0

Correct Answer: (B) 4.0

Solution:

Concept: Specific gravity is the ratio of the density of a substance to the density of water at a standard temperature.

Step 1: Alumina is aluminium oxide:

$$Al_2O_3$$

Step 2: Alumina is a dense ceramic oxide with high hardness, high melting point, and good chemical stability.

Step 3: The specific gravity of alumina is approximately:

$$3.9 \text{ to } 4.0$$

Step 4: Among the given options, the nearest and correct value is:

$$4.0$$

Therefore, the correct answer is:

$$\boxed{4.0}$$

Quick Tip: Alumina (Al_2O_3) has specific gravity close to 4.0.

---

154. The presence of _____ in chromite refractory leads to bursting

(A) Lead oxide

(B) Potassium oxide

(C) Iron oxide

(D) Magnesium oxide

Correct Answer: (C) Iron oxide

Solution:

Concept: Chromite refractories contain chromium oxide and iron oxide phases. Certain oxides can cause volume changes during firing or service.

Step 1: Chromite refractories are prepared from chromite mineral.

Step 2: If excess iron oxide is present, it may undergo oxidation-reduction changes at high temperature.

Step 3: These changes may cause volume expansion or internal stress.

Step 4: Due to internal stress, the refractory can crack or burst.

Step 5: Hence, the presence of iron oxide in chromite refractory may lead to bursting.

Therefore, the correct answer is:

$$\boxed{\text{Iron oxide}}$$

Quick Tip: In chromite refractories, iron oxide can cause bursting due to volume changes and internal stresses.

---

155. Silica bricks have high thermal shock resistance above

(A) $600^{\circ}C$

(B) $400^{\circ}C$

(C) $1000^{\circ}C$

(D) $1200^{\circ}C$

Correct Answer: (A) $600^{\circ}C$

Solution:

Concept: Silica bricks show poor thermal shock resistance at lower temperatures because of phase transformations of silica. At higher temperatures, they become more stable.

Step 1: Silica exists in different polymorphic forms such as quartz, tridymite, and cristobalite.

Step 2: These forms undergo volume changes at certain temperatures.

Step 3: At low and intermediate temperatures, these transformations may create thermal stress.

Step 4: Above about $600^{\circ}C$, silica bricks show better thermal shock resistance because the phase changes become less harmful in service.

Therefore, silica bricks have high thermal shock resistance above:

$$\boxed{600^{\circ}C}$$

Quick Tip: Silica bricks perform better under thermal shock conditions above $600^{\circ}C$.

---

156. Surface alkalinity of Glass is measured by using

(A) Autoclave

(B) Impact tester

(C) Flame photometer

(D) Dilatometer

Correct Answer: (A) Autoclave

Solution:

Concept: Surface alkalinity of glass is related to the alkali released from the glass surface under severe testing conditions.

Step 1: Glass contains alkali oxides such as:

$$Na_2O,\ K_2O$$

Step 2: Under moisture, steam, or pressure conditions, alkali may leach out from the glass surface.

Step 3: An autoclave provides high-pressure steam conditions.

Step 4: These conditions accelerate the surface reaction and help in measuring surface alkalinity.

Step 5: Impact tester measures impact strength, flame photometer measures metal ions, and dilatometer measures thermal expansion.

Therefore, surface alkalinity of glass is measured by:

$$\boxed{\text{Autoclave}}$$

Quick Tip: Autoclave testing is used when high-pressure steam conditions are needed for testing glass or ceramic surfaces.

---

157. Which of the following fabrication method is used to make Wide neck glass bottles?

(A) Pressing

(B) Blow & Blow

(C) Press & Blow

(D) Drawing

Correct Answer: (C) Press & Blow

Solution:

Concept: Glass containers are commonly manufactured by blow and blow or press and blow processes. The choice depends on the type and shape of container.

Step 1: Wide neck glass bottles and jars require accurate control of mouth and body shape.

Step 2: In the press and blow process, the parison is first formed by pressing the molten glass with a plunger.

Step 3: Then compressed air is used to blow the parison into the final shape.

Step 4: This method is suitable for wide-mouth containers because pressing gives better control over glass distribution.

Therefore, wide neck glass bottles are made by:

Press & Blow

Quick Tip: Wide-mouth glass containers are commonly made by the press and blow process.

---

158. Which raw material is the most important mineral for supplying CaO in glass production?

(A) Soda ash

(B) Sand

(C) Pearl ash

(D) Lime stone

Correct Answer: (D) Lime stone

Solution:

Concept: In glass production, different raw materials supply different oxides. Limestone is mainly used to supply calcium oxide.

Step 1: Limestone is calcium carbonate:

$$CaCO_3$$

Step 2: During heating, limestone decomposes:

$$CaCO_3 \rightarrow CaO + CO_2$$

Step 3: The CaO produced acts as a stabilizer in soda-lime glass.

Step 4: Soda ash supplies Na_2O, sand supplies SiO_2, and pearl ash supplies K_2O.

Therefore, the most important raw material for supplying CaO is:

$$\boxed{\text{Lime stone}}$$

Quick Tip: Limestone ($CaCO_3$) is used in glass batches to supply CaO.

---

159. B_2O_3 **is a**

(A) Network former

(B) Network modifier

(C) Intermittent oxide

(D) Stabilizing oxide

Correct Answer: (A) Network former

Solution:

Concept: In glass chemistry, oxides are classified as network formers, network modifiers, and intermediates.

Step 1: Network formers are oxides that can form the basic glass network.

Step 2: Common network formers include:

$$SiO_2,\ B_2O_3,\ P_2O_5$$

Step 3: B_2O_3 forms borate glass networks and is an important constituent in borosilicate glass.

Step 4: Therefore:

$$B_2O_3 = \text{Network former}$$

Hence, the correct answer is:

$$\boxed{\text{Network former}}$$

Quick Tip: SiO_2 and B_2O_3 are important glass network formers.

---

160. Which impurity in Silica sand must be avoided for glass making?

(A) Sodium chloride

(B) Calcium oxide

(C) Potassium oxide

(D) Iron oxide

Correct Answer: (D) Iron oxide

Solution:

Concept: Silica sand is the main source of SiO_2 in glass making. It must be pure, especially for clear and colorless glass.

Step 1: Iron oxide is a common impurity in silica sand.

Step 2: Even small amounts of iron oxide can impart greenish or brownish color to glass.

Step 3: This is undesirable when making clear or colorless glass.

Step 4: Therefore, iron oxide impurity must be avoided in silica sand for glass making.

Hence, the correct answer is:

Iron oxide

Quick Tip: Iron oxide is an undesirable impurity in silica sand because it colors the glass.

---

161. 'E-glass' is mainly used as

(A) Bottles and jars for food storage

(B) Reinforcement fibers for plastics & printed circuit boards

(C) Architectural windows

(D) Lead crystal vases

Correct Answer: (B) Reinforcement fibers for plastics & printed circuit boards

Solution:

Concept: E-glass is an electrical-grade glass with good electrical insulation and mechanical properties.

Step 1: E-glass is commonly made into glass fibers.

Step 2: These fibers are used to reinforce polymer materials.

Step 3: E-glass fibers are widely used in:

- fiberglass reinforced plastics,

- electrical insulation,
- printed circuit boards.

Step 4: It is not mainly used for bottles, windows, or lead crystal decorative articles.

Therefore, E-glass is mainly used as:

Reinforcement fibers for plastics & printed circuit boards

Quick Tip: E-glass is mainly used as glass fiber reinforcement in plastics and electrical applications.

---

162. Making of glass bubble free is called

(A) Oxidizing

(B) Reducing

(C) Refining

(D) Firing

Correct Answer: (C) Refining

Solution:

Concept: During glass melting, gases may remain trapped in the molten glass as bubbles. Removing these bubbles is an important stage.

Step 1: In glass melting, batch materials melt and form molten glass.

Step 2: During melting, gases such as CO_2, SO_2, and air bubbles may remain inside the glass melt.

Step 3: These bubbles reduce the quality and transparency of glass.

Step 4: The process of removing bubbles and making glass homogeneous is called refining or fining.

Therefore, making glass bubble free is called:

Refining

Quick Tip: Refining or fining is the process of removing gas bubbles from molten glass.

---

163. Uncontrolled crystallization of glass is called

(A) Melting

(B) Refining

(C) Heat conditioning

(D) Devitrification

Correct Answer: (D) Devitrification

Solution:

Concept: Glass is normally an amorphous material. If crystals form in glass unintentionally, the glass may lose transparency and quality.

Step 1: Glass does not have a regular crystalline structure.

Step 2: During cooling or heat treatment, crystals may sometimes form inside the glass.

Step 3: When this crystallization occurs in an uncontrolled manner, it is called devitrification.

Step 4: Devitrification is usually considered a defect because it can make glass cloudy or weak.

Therefore, uncontrolled crystallization of glass is called:

Devitrification

Quick Tip: Devitrification means unwanted or uncontrolled crystallization in glass.

---

164. Crooke's glass contains

(A) Cerium oxide

(B) Lead oxide

(C) Potassium oxide

(D) Sodium oxide

Correct Answer: (A) Cerium oxide

Solution:

Concept: Crooke's glass is a special glass used for protection from harmful radiations, especially ultraviolet radiation.

Step 1: Ordinary glass may transmit some harmful radiation.

Step 2: Crooke's glass is made by adding certain oxides that absorb harmful rays.

Step 3: Cerium oxide is used in Crooke's glass because it helps absorb ultraviolet rays.

Step 4: Therefore, Crooke's glass contains:

Cerium oxide

Quick Tip: Crooke's glass contains cerium oxide and is used for absorbing harmful ultraviolet radiation.

---

165. Which of the following process is absent in glass manufacturing?

(A) Annealing

(B) Forming

(C) Sintering

(D) Melting

Correct Answer: (C) Sintering

Solution:

Concept: Glass manufacturing involves batch preparation, melting, refining, forming, and annealing. Sintering is mainly associated with ceramic powder processing.

Step 1: In glass manufacturing, raw materials are first melted to form molten glass.

$$\text{Batch} \rightarrow \text{Melting}$$

Step 2: The molten glass is refined to remove bubbles.

Step 3: The glass is then formed into products such as sheets, bottles, or fibers.

Step 4: Finally, the glass is annealed to remove internal stresses.

Step 5: Sintering is not a normal process in glass manufacturing. It is mainly used in ceramic processing where powder particles bond together below melting point.

Therefore, the process absent in glass manufacturing is:

Sintering

Quick Tip: Glass manufacturing involves melting, forming, and annealing; sintering is mainly a ceramic powder process.

---

166. Glass ceramics contain

(A) Fully crystalline structure

(B) Amorphous matrix with crystalline phases

(C) Only silica

(D) Only alumina

Correct Answer: (B) Amorphous matrix with crystalline phases

Solution:

Concept: Glass ceramics are produced by controlled crystallization of glass. They contain both glassy and crystalline phases.

Step 1: Ordinary glass is amorphous.

Step 2: When glass is heat-treated under controlled conditions, crystals form inside the glass.

Step 3: This produces a material having an amorphous glassy matrix along with crystalline phases.

Step 4: Such materials are called glass ceramics.

Therefore, glass ceramics contain:

Amorphous matrix with crystalline phases

Quick Tip: Glass ceramics are made by controlled crystallization and contain both glassy and crystalline phases.

---

167. Lead glass is used for

(A) Insulation

(B) Tubes

(C) Windows

(D) Optical lenses

Correct Answer: (D) Optical lenses

Solution:

Concept: Lead glass contains lead oxide (PbO), which increases refractive index and brilliance.

Step 1: Lead oxide makes glass dense and optically brilliant.

Step 2: It also increases the refractive index of glass.

Step 3: Because of high refractive index, lead glass is useful in optical applications.

Step 4: Therefore, lead glass is commonly used for optical lenses and optical components.

Hence, the correct answer is:

$$\boxed{\text{Optical lenses}}$$

Quick Tip: Lead glass has high refractive index, so it is used in optical lenses and optical glass.

---

168. The main purpose of annealing is to

(A) Increase optical clarity

(B) Relieve stresses

(C) Harden the surface

(D) Add color

Correct Answer: (B) Relieve stresses

Solution:

Concept: Annealing is a heat treatment process used to remove internal stresses from glass or ceramic products.

Step 1: During forming and cooling, glass develops internal stresses because different parts cool at different rates.

Step 2: If these stresses remain, the glass may crack or break later.

Step 3: In annealing, glass is heated or held near annealing temperature and then cooled slowly.

Step 4: Slow cooling allows internal stresses to relax.

Therefore, the main purpose of annealing is:

Relieve stresses

Quick Tip: Annealing removes internal stresses in glass by controlled heating and slow cooling.

---

169. Borosilicate glass is widely used in

(A) Containers

(B) Laboratory ware

(C) Lenses

(D) Fiber glass

Correct Answer: (B) Laboratory ware

Solution:

Concept: Borosilicate glass contains silica and boron oxide. It has low thermal expansion and excellent thermal shock resistance.

Step 1: Laboratory glassware is frequently heated and cooled.

Step 2: Therefore, it must resist thermal shock.

Step 3: Borosilicate glass has low coefficient of thermal expansion.

Step 4: Due to this property, it does not crack easily when heated or cooled suddenly.

Step 5: Hence, borosilicate glass is widely used for laboratory ware such as beakers, flasks, and test tubes.

Therefore, the correct answer is:

Laboratory ware

Quick Tip: Borosilicate glass is used for laboratory ware because it has high thermal shock resistance.

---

170. Which of the following, imparts Green color in glass?

(A) Cupric oxide

(B) Magnesium oxide

(C) Selenium

(D) Chromium oxide

Correct Answer: (D) Chromium oxide

Solution:

Concept: Color in glass is produced by adding small amounts of metal oxides. Different oxides produce different colors.

Step 1: Chromium oxide is a common coloring oxide used in glass.

$$Cr_2O_3 = \text{Chromium oxide}$$

Step 2: Chromium oxide generally gives green color to glass.

Step 3: Cupric oxide may give blue-green color depending on glass composition, but the standard green colorant among the given options is chromium oxide.

Step 4: Selenium is commonly used for red or pink shades and magnesium oxide is not used as the main green colorant.

Therefore, the oxide which imparts green color in glass is:

$$\boxed{\text{Chromium oxide}}$$

Quick Tip: Chromium oxide is commonly used to impart green color to glass.

---

171. The crown glass is an

(A) Optical glass

(B) Radiation shield glass

(C) Tempered glass

(D) Safety glass

Correct Answer: (A) Optical glass

Solution:

Concept: Crown glass is a type of optical glass. It is commonly used in lenses and optical

instruments because it has good transparency and relatively low dispersion.

Step 1: Crown glass belongs to the category of optical glasses.

Step 2: Optical glasses are used where control of light transmission, refraction, and dispersion is required.

Step 3: Crown glass is different from lead glass or flint glass because crown glass usually has lower refractive index and lower dispersion.

Step 4: Therefore, crown glass is mainly used as:

Optical glass

Hence, the correct answer is:

Optical glass

Quick Tip: Crown glass and flint glass are important optical glasses used in lenses and optical instruments.

---

172. Regenerators are associated with

(A) Roller kiln

(B) Pot furnace

(C) Tank furnaces

(D) Shuttle kiln

Correct Answer: (C) Tank furnaces

Solution:

Concept: Regenerators are heat recovery chambers used in glass tank furnaces. They store heat from outgoing hot gases and use it to preheat incoming air.

Step 1: In glass melting, large tank furnaces operate continuously at high temperature.

Step 2: A large amount of heat is carried away by exhaust gases.

Step 3: Regenerators recover this heat and improve fuel efficiency.

Step 4: They are commonly associated with regenerative tank furnaces used in glass production.

Therefore, regenerators are associated with:

Tank furnaces

Quick Tip: Regenerators are used in tank furnaces to recover heat from exhaust gases and preheat combustion air.

---

173. The Danner process is a

(A) Continuous process for drawing fibers

(B) Continuous process for drawing sheets

(C) Continuous process for drawing rods & tubes

(D) Container glass manufacturing process

Correct Answer: (C) Continuous process for drawing rods & tubes

Solution:

Concept: The Danner process is a glass forming process used mainly for producing glass tubes and rods continuously.

Step 1: In the Danner process, molten glass flows over a rotating mandrel.

Step 2: Air is blown through the center to form a hollow tube.

Step 3: The tube is drawn continuously and cooled.

Step 4: By controlling pulling speed, air pressure, and glass flow, rods or tubes of desired size are obtained.

Therefore, the Danner process is:

Continuous process for drawing rods & tubes

Quick Tip: Danner process is mainly used for continuous manufacture of glass tubes and rods.

---

174. Which of the following is the first automatic glass bottle making machine?

(A) IS Machine

(B) Owen's machine

(C) O'Neill's machine

(D) Twin table machine

Correct Answer: (B) Owen's machine

Solution:

Concept: Automatic bottle making machines revolutionized glass container manufacturing by replacing manual blowing methods.

Step 1: Earlier glass bottles were produced manually by blowing.

Step 2: The first successful automatic glass bottle making machine was developed by Michael Owens.

Step 3: It is commonly known as Owen's machine.

Step 4: This machine allowed faster and more uniform production of glass bottles.

Therefore, the first automatic glass bottle making machine is:

Owen's machine

Quick Tip: Owen's machine was the first automatic glass bottle making machine.

---

175. Marved glass is called

(A) Parison

(B) Crany

(C) Puffed glass

(D) Preform

Correct Answer: (B) Crany

Solution:

Concept: In glass forming, a gathered mass of molten glass may be shaped and rolled on a flat surface called a marver. This operation helps in giving preliminary shape and uniformity.

Step 1: Marvering means rolling or shaping molten glass on a flat metal or stone surface.

Step 2: The purpose of marvering is to control shape and temperature distribution.

Step 3: The marved glass form is referred to as crany in the given terminology.

Step 4: Therefore, marved glass is called:

$$\boxed{\text{Crany}}$$

Quick Tip: Marvering is a preliminary shaping operation in glass forming.

---

176. Which of the following phase is responsible for Strength of Cement?

(A) C_2S

(B) C_3A

(C) C_3S

(D) C_4AF

Correct Answer: (C) C_3S

Solution:

Concept: The main clinker phases in Portland cement are C_3S, C_2S, C_3A, and C_4AF. Among these, C_3S, also called alite, is mainly responsible for early strength.

Step 1: C_3S means tricalcium silicate.

$$C_3S = 3CaO \cdot SiO_2$$

Step 2: During hydration, C_3S reacts with water and forms calcium silicate hydrate gel.

$$C_3S + H_2O \rightarrow C-S-H \text{ gel} + Ca(OH)_2$$

Step 3: The $C-S-H$ gel gives strength to cement paste.

Step 4: C_2S contributes to later strength, but C_3S is mainly responsible for early and major strength development.

Therefore, the correct answer is:

$$\boxed{C_3S}$$

Quick Tip: C_3S gives early strength to Portland cement, while C_2S contributes to later strength.

177. What is the % of CaO in Portland Cement?

(A) $40-45$

(B) $70-75$

(C) $50-55$

(D) $60-65$

Correct Answer: (D) $60-65$

Solution:

Concept: Portland cement mainly contains lime (CaO), silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3).

Step 1: Lime is the major oxide present in Portland cement.

Step 2: Lime combines with silica, alumina, and iron oxide to form clinker phases.

Step 3: The usual percentage of CaO in ordinary Portland cement is approximately:

$$60-65\%$$

Step 4: Therefore, the correct range is:

$$\boxed{60-65}$$

Quick Tip: Portland cement contains about $60-65\%$ lime (CaO), which is its major oxide constituent.

---

178. Gypsum is added to cement to:

(A) Accelerate setting

(B) Retard setting

(C) Increase strength

(D) Reduce heat of hydration

Correct Answer: (B) Retard setting

Solution:

Concept: Gypsum is added to cement to control the setting time. Without gypsum, cement may set very quickly due to rapid reaction of C_3A.

Step 1: Cement contains tricalcium aluminate:

$$C_3A$$

Step 2: C_3A reacts very fast with water.

Step 3: If this reaction is not controlled, flash setting occurs.

Step 4: Gypsum slows down the reaction of C_3A, thereby increasing the setting time.

Therefore, gypsum is added to cement to:

$$\boxed{\text{Retard setting}}$$

Quick Tip: Gypsum prevents flash setting of cement by retarding the rapid hydration of C_3A.

---

179. In Portland Pozzolana Cement, pozzolanic material reacts with

(A) Water

(B) Lime

(C) Gypsum

(D) Sand

Correct Answer: (B) Lime

Solution:

Concept: Pozzolanic materials contain reactive silica and alumina. They react with calcium hydroxide produced during cement hydration.

Step 1: During hydration of cement, lime or calcium hydroxide is formed:

$$Ca(OH)_2$$

Step 2: Pozzolanic material reacts with this lime.

Step 3: The reaction forms additional calcium silicate hydrate gel:

$$\text{Pozzolana} + Ca(OH)_2 + H_2O \rightarrow C-S-H$$

Step 4: This improves strength and durability of cement.

Therefore, pozzolanic material reacts with:

$$\boxed{\text{Lime}}$$

Quick Tip: In PPC, pozzolana reacts with lime ($Ca(OH)_2$) to form additional cementitious compounds.

---

180. _____ is used to measure initial setting time of cement

(A) Autoclave

(B) Vicat apparatus

(C) Sieve

(D) Lechatelier apparatus

Correct Answer: (B) Vicat apparatus

Solution:

Concept: Vicat apparatus is used to determine the consistency and setting time of cement paste.

Step 1: Initial setting time is the time at which cement paste starts losing plasticity.

Step 2: Vicat apparatus uses a standard needle to measure penetration in cement paste.

Step 3: When the needle penetration reaches the specified value, the initial setting time is recorded.

Step 4: Lechatelier apparatus is used for soundness test, and sieve is used for fineness test.

Therefore, initial setting time of cement is measured by:

$$\boxed{\text{Vicat apparatus}}$$

Quick Tip: Vicat apparatus is used to test consistency and setting time of cement.

---

181. Heating of coal in absence of air is called

(A) Carbonization

(B) Calcination

(C) Refining

(D) Clinkerization

Correct Answer: (A) Carbonization

Solution:

Concept: Carbonization is the process of heating coal in the absence of air to obtain coke and other by-products.

Step 1: If coal is heated in presence of air, it burns.

Step 2: If coal is heated in absence of air, volatile matter is removed.

Step 3: The solid carbon-rich product formed is coke.

Step 4: This process is called carbonization.

Therefore, heating of coal in absence of air is:

Carbonization

Quick Tip: Carbonization of coal produces coke by heating coal in absence of air.

---

182. Which of the following is used to analyze Flue gas?

(A) Bomb calorimeter

(B) Orsat apparatus

(C) Infrared balance

(D) Spectrophotometer

Correct Answer: (B) Orsat apparatus

Solution:

Concept: Flue gas analysis is done to determine the percentage of gases such as CO_2, O_2, and CO in combustion gases.

Step 1: Flue gas is produced during combustion of fuels.

Step 2: Its analysis helps in checking combustion efficiency.

Step 3: Orsat apparatus is used for volumetric analysis of flue gases.

Step 4: Bomb calorimeter measures calorific value of fuel, not flue gas composition.

Therefore, the apparatus used to analyze flue gas is:

$$\boxed{\text{Orsat apparatus}}$$

Quick Tip: Orsat apparatus is used for flue gas analysis, especially for CO_2, O_2, and CO.

---

183. Which of the following is Renewable Energy Sources?

(A) Coal

(B) Crude oil

(C) Natural gas

(D) Wind energy

Correct Answer: (D) Wind energy

Solution:

Concept: Renewable energy sources are naturally replenished and can be used repeatedly without being exhausted quickly.

Step 1: Coal, crude oil, and natural gas are fossil fuels.

Step 2: Fossil fuels are non-renewable because they take millions of years to form.

Step 3: Wind energy is obtained from moving air and is naturally replenished.

Step 4: Therefore, wind energy is a renewable energy source.

Hence:

$$\boxed{\text{Wind energy}}$$

Quick Tip: Solar, wind, hydro, geothermal, and biomass are common renewable energy sources.

---

184. A thermocouple works on the Principle of

(A) Hall effect

(B) Peltier effect

(C) Seebeck effect

(D) Ferroelectric effect

Correct Answer: (C) Seebeck effect

Solution:

Concept: A thermocouple is a temperature measuring device based on the generation of voltage due to temperature difference between two junctions.

Step 1: A thermocouple is made by joining two dissimilar metals.

Step 2: When the two junctions are kept at different temperatures, an emf is produced.

Step 3: This phenomenon is called Seebeck effect.

Step 4: The generated emf is used to measure temperature.

Therefore, a thermocouple works on:

Seebeck effect

Quick Tip: Thermocouples work on Seebeck effect, where temperature difference produces an emf.

---

185. Which of the following is Periodic kiln?

(A) Scove kiln

(B) Tunnel kiln

(C) Rotary kiln

(D) Roller hearth kiln

Correct Answer: (A) Scove kiln

Solution:

Concept: Kilns may be classified as periodic kilns and continuous kilns. In periodic kilns, loading, firing, cooling, and unloading occur in cycles.

Step 1: A periodic kiln works batch by batch.

Step 2: Scove kiln is a simple periodic kiln used traditionally for firing bricks.

Step 3: Tunnel kiln, rotary kiln, and roller hearth kiln are continuous kilns.

Step 4: Hence, the periodic kiln among the given options is:

Scove kiln

Quick Tip: Periodic kilns operate batchwise, while tunnel and roller hearth kilns operate continuously.

---

186. Which of the following conduct electricity but undergo internal charge polarization that allows for storage of an electrical charge?

(A) Capacitor

(B) Resistor

(C) Diodes

(D) Transistors

Correct Answer: (A) Capacitor

Solution:

Concept: A capacitor is an electrical component that stores electrical energy in an electric field. It contains dielectric material between conducting plates.

Step 1: A capacitor consists of two conducting plates separated by a dielectric.

Step 2: When voltage is applied, charge accumulates on the plates.

Step 3: The dielectric between the plates undergoes polarization.

Step 4: This polarization helps the capacitor store electrical charge.

Therefore, the correct answer is:

Capacitor

Quick Tip: A capacitor stores electrical charge using dielectric polarization between two conducting plates.

---

187. Which of the following is a Semiconductor?

(A) Cu

(B) Fe

(C) Si

(D) Au

Correct Answer: (C) Si

Solution:

Concept: Semiconductors have electrical conductivity between conductors and insulators.

Step 1: Copper (Cu), iron (Fe), and gold (Au) are metals.

Step 2: Metals are good conductors of electricity.

Step 3: Silicon (Si) is a well-known semiconductor.

Step 4: It is widely used in diodes, transistors, and integrated circuits.

Therefore, the semiconductor among the given options is:

$$\boxed{Si}$$

Quick Tip: Silicon and germanium are common semiconductor materials.

---

188. The charge carriers in P-type semiconductor is

(A) Electrons

(B) Electron holes

(C) Cations

(D) Anions

Correct Answer: (B) Electron holes

Solution:

Concept: A P-type semiconductor is formed by doping a pure semiconductor with trivalent impurity atoms.

Step 1: Trivalent impurities create deficiency of electrons.

Step 2: This deficiency behaves as a positive charge carrier called a hole.

Step 3: In P-type semiconductors, holes are majority carriers.

Step 4: Electrons are minority carriers.

Therefore, charge carriers in P-type semiconductor are:

Electron holes

Quick Tip: P-type semiconductor has holes as majority charge carriers.

---

189. _____ have zero electrical resistance

(A) Semiconductors

(B) Conductors

(C) Insulators

(D) Super conductors

Correct Answer: (D) Super conductors

Solution:

Concept: Superconductors are materials that show zero electrical resistance below a certain critical temperature.

Step 1: Ordinary conductors have small but finite resistance.

Step 2: Semiconductors have conductivity between conductors and insulators.

Step 3: Insulators have very high resistance.

Step 4: Superconductors show zero resistance below their critical temperature.

Therefore, materials having zero electrical resistance are:

Super conductors

Quick Tip: Superconductors show zero electrical resistance below their critical temperature.

---

190. Which of the following material has highest Dielectric constant?

(A) Rubber

(B) Al_2O_3

(C) Glass

(D) $BaTiO_3$

Correct Answer: (D) $BaTiO_3$

Solution:

Concept: Dielectric constant shows the ability of a material to store electrical energy in an electric field.

Step 1: Rubber, alumina, and glass have moderate or low dielectric constants.

Step 2: Barium titanate ($BaTiO_3$) is a ferroelectric ceramic.

Step 3: Ferroelectric ceramics have very high dielectric constants.

Step 4: Therefore, among the given options, the highest dielectric constant is shown by:

$$\boxed{BaTiO_3}$$

Quick Tip: Barium titanate ($BaTiO_3$) is a ferroelectric ceramic with very high dielectric constant.

---

191. Acheson process is used to prepare

(A) SiC

(B) Al_2O_3

(C) Y_2O_3

(D) ZrO_2

Correct Answer: (A) SiC

Solution:

Concept: The Acheson process is an industrial process used for manufacturing silicon carbide.

Step 1: Silicon carbide is represented as:

$$SiC$$

Step 2: In the Acheson process, silica and carbon are heated together at very high temperature.

$$SiO_2 + 3C \rightarrow SiC + 2CO$$

Step 3: The product formed is silicon carbide.

Step 4: Silicon carbide is used as an abrasive and refractory material.

Therefore, Acheson process is used to prepare:

$$\boxed{SiC}$$

Quick Tip: Acheson process is the industrial method for producing silicon carbide (SiC).

---

192. Thin sheets used for substrates for electronics are produced by

(A) Extrusion

(B) Injection moulding

(C) Isostatic pressing

(D) Tape casting

Correct Answer: (D) Tape casting

Solution:

Concept: Tape casting is a ceramic forming process used to produce thin, flat ceramic sheets.

Step 1: Electronic substrates require thin ceramic sheets with uniform thickness.

Step 2: In tape casting, ceramic slurry is spread over a moving carrier film using a doctor blade.

Step 3: After drying, a flexible ceramic tape is obtained.

Step 4: These tapes are used for electronic substrates, multilayer capacitors, and circuit components.

Therefore, the correct process is:

$$\boxed{\text{Tape casting}}$$

Quick Tip: Tape casting is used to make thin ceramic sheets for electronic substrates.

---

193. Bayer process is used to produce

(A) TiO_2

(B) Al_2O_3

(C) ZrO_2

(D) SiO_2

Correct Answer: (B) Al_2O_3

Solution:

Concept: The Bayer process is used to extract alumina from bauxite ore.

Step 1: Bauxite is an ore of aluminium.

Step 2: It contains hydrated aluminium oxide along with impurities.

Step 3: In the Bayer process, bauxite is treated with sodium hydroxide to dissolve alumina.

Step 4: Alumina is then precipitated and calcined to obtain:

$$Al_2O_3$$

Therefore, Bayer process is used to produce:

$$\boxed{Al_2O_3}$$

Quick Tip: Bayer process is used for producing alumina (Al_2O_3) from bauxite.

---

194. Advanced Ceramics are also known as

(A) Traditional ceramics

(B) Whiteware

(C) Structural ceramics

(D) Technical ceramics

Correct Answer: (D) Technical ceramics

Solution:

Concept: Advanced ceramics are specially designed ceramics made for high-performance applications.

Step 1: Traditional ceramics include bricks, tiles, whitewares, and pottery.

Step 2: Advanced ceramics are made from highly pure raw materials and controlled processing.

Step 3: They are used in engineering, electronics, biomedical, aerospace, and cutting tool applications.

Step 4: Because of their special technical applications, they are also called technical ceramics.

Therefore:

$$\boxed{\text{Technical ceramics}}$$

Quick Tip: Advanced ceramics are also called technical ceramics due to their high-performance engineering applications.

---

195. Which of the following is a non-oxide ceramic?

(A) Alumina

(B) Zirconia

(C) Silicon nitride

(D) Magnesia

Correct Answer: (C) Silicon nitride

Solution:

Concept: Advanced ceramics are classified into oxide ceramics and non-oxide ceramics.

Step 1: Alumina is:

$$Al_2O_3$$

So it is an oxide ceramic.

Step 2: Zirconia is:

$$ZrO_2$$

So it is also an oxide ceramic.

Step 3: Magnesia is:

$$MgO$$

So it is also an oxide ceramic.

Step 4: Silicon nitride is:

$$Si_3N_4$$

It does not contain oxygen as the main anion.

Therefore, silicon nitride is a non-oxide ceramic:

$$\boxed{\text{Silicon nitride}}$$

Quick Tip: Carbides, nitrides, and borides are common non-oxide ceramics.

---

196. A Cation vacancy and an anion vacancy in a crystal of the type *AB* is called

(A) Frenkel defect

(B) Schottky defect

(C) Vacancy defect

(D) Interstitial defect

Correct Answer: (B) Schottky defect

Solution:

Concept: Schottky defect is a point defect in ionic crystals where equal numbers of cations and anions are missing from their lattice sites.

Step 1: In an ionic crystal of type *AB*, there are equal numbers of cations and anions.

Step 2: If one cation vacancy and one anion vacancy are created, electrical neutrality remains maintained.

Step 3: This paired vacancy defect is known as Schottky defect.

Step 4: Frenkel defect involves displacement of an ion from its normal site to an interstitial site.

Therefore, the correct answer is:

Schottky defect

Quick Tip: Schottky defect consists of paired cation and anion vacancies in an ionic crystal.

---

197. Burger's vector is perpendicular to

(A) Edge dislocation

(B) Screw dislocation

(C) Frenkel defect

(D) Schottky defect

Correct Answer: (A) Edge dislocation

Solution:

Concept: Burger's vector describes the magnitude and direction of lattice distortion due to dislocation.

Step 1: In an edge dislocation, Burger's vector is perpendicular to the dislocation line.

Step 2: In a screw dislocation, Burger's vector is parallel to the dislocation line.

Step 3: Frenkel and Schottky defects are point defects, not line dislocations.

Step 4: Therefore, Burger's vector is perpendicular in the case of edge dislocation.

Hence:

Edge dislocation

Quick Tip: For edge dislocation, Burger's vector is perpendicular to the dislocation line; for screw dislocation, it is parallel.

---

198. The eutectic point in the $SiO_2 - Na_2O$ phase diagram occurs at

(A) $1200^\circ C$

(B) $1590^\circ C$

(C) $1390^\circ C$

(D) $790^\circ C$

Correct Answer: (D) $790^{\circ}C$

Solution:

Concept: A eutectic point is the lowest melting point composition in a binary phase diagram where liquid transforms into two solid phases simultaneously.

Step 1: The system given is:

$$SiO_2 - Na_2O$$

Step 2: In this binary system, the eutectic point occurs at a relatively low temperature compared with pure silica melting temperature.

Step 3: The given options include $790^{\circ}C$, which is the eutectic temperature for the given system.

Therefore, the eutectic point occurs at:

$$\boxed{790^{\circ}C}$$

Quick Tip: A eutectic point is the lowest melting temperature point in a binary phase diagram.

---

199. A Covalent bond is formed due to

(A) Transfer of electrons

(B) Sharing of electrons

(C) Attraction between ions

(D) Presence of free electrons

Correct Answer: (B) Sharing of electrons

Solution:

Concept: Chemical bonds are formed in different ways. Ionic bonds form by transfer of electrons, while covalent bonds form by sharing of electrons.

Step 1: In a covalent bond, two atoms share one or more pairs of electrons.

Step 2: This sharing helps both atoms complete their valence shell.

Step 3: Transfer of electrons forms ionic bonds.

Step 4: Presence of free electrons is related to metallic bonding.

Therefore, covalent bond is formed due to:

$$\boxed{\text{Sharing of electrons}}$$

Quick Tip: Covalent bond means sharing of electrons between atoms.

---

200. Diffusion in Solids occurs mainly due to

(A) Gravitational force

(B) Electric field

(C) Concentration gradient

(D) Magnetic field

Correct Answer: (C) Concentration gradient

Solution:

Concept: Diffusion is the movement of atoms, ions, or molecules from a region of higher concentration to a region of lower concentration.

Step 1: In solids, atoms can move through vacancies, interstitial sites, or lattice defects.

Step 2: The driving force for diffusion is usually the difference in concentration between two regions.

Step 3: This difference is called concentration gradient.

$$\text{Concentration gradient} = \frac{dC}{dx}$$

Step 4: Particles move in such a way as to reduce this concentration difference.

Therefore, diffusion in solids occurs mainly due to:

$$\boxed{\text{Concentration gradient}}$$

Quick Tip: Diffusion occurs from high concentration to low concentration and is mainly driven by concentration gradient.