Atmospheric Science 29th March 2025 Shift3

Time Allowed :1.5 Hours	**Maximum Marks :**300	**Total questions : 75**

General Instructions

General Instructions:

1. Question Paper contains 75 Questions .
2. Each correct answer will have +4 marks and wrong asnwer will lead to -1

1. If $A = \begin{bmatrix} 1 & 2 & -1 \\ 3 & 4 & 2 \\ 2 & 0 & 1 \end{bmatrix}$ **and** $B = \begin{bmatrix} 1 & 3 \\ -4 & 0 \\ 2 & 5 \end{bmatrix}$ **are two matrices, then which one of the following is incorrect:**

(A) AB is defined

(B) BA is not defined

(C) A + B is not defined

(D) A - B is defined

Correct Answer: (D)

Solution: Step 1: Determine the dimensions of matrices A and B.

Matrix A has 3 rows and 3 columns, so its dimension is 3×3.

Matrix B has 3 rows and 2 columns, so its dimension is 3×2.

Step 2: Check the condition for each operation.

(A) For the product AB to be defined, the number of columns in A must be equal to the number of rows in B. Here, A has 3 columns and B has 3 rows, so AB is defined. The resulting matrix will have dimensions 3×2. The statement is correct.

(B) For the product BA to be defined, the number of columns in B (2) must be equal to the number of rows in A (3). Since $2 \neq 3$, BA is not defined. The statement is correct.

(C) For matrix addition A + B to be defined, the matrices must have the same dimensions. A is 3×3 and B is 3×2. Since their dimensions are different, A + B is not defined. The statement is correct.

(D) For matrix subtraction A - B to be defined, the matrices must have the same dimensions. Since A is 3×3 and B is 3×2, A - B is not defined. The statement says that A - B is defined, which is incorrect.

Quick Tip

- Matrix multiplication $M_{m \times n} \times N_{p \times q}$ is defined only if $n = p$. - Matrix addition/subtraction is defined only if the matrices have the same dimensions.

2. If $f(t)$ is the inverse Laplace transform of $F(s) = \frac{s+1+s^{-2}}{s^2-1}$, then $f(t)$ is

(A) $e^t + \sinh t + t$

(B) $e^t + \sinh t - t$

(C) $e^t - \sinh t + t$

(D) $e^t + \cosh t - t$

Correct Answer: (B)

Solution: Step 1: Simplify the expression for F(s).

The given expression appears unusual but can be simplified algebraically.

$$F(s) = \frac{s+1+s^{-2}}{s^2-1} = \frac{s+1+\frac{1}{s^2}}{s^2-1} = \frac{\frac{s^3+s^2+1}{s^2}}{s^2-1} = \frac{s^3+s^2+1}{s^2(s^2-1)}$$

Step 2: Decompose F(s) using partial fractions.

We can write F(s) in the form:

$$\frac{s^3+s^2+1}{s^2(s-1)(s+1)} = \frac{A}{s} + \frac{B}{s^2} + \frac{C}{s-1} + \frac{D}{s+1}$$

To find the coefficients: - $B = \left[s^2F(s)\right]_{s=0} = \left[\frac{s^3+s^2+1}{s^2-1}\right]_{s=0} = \frac{1}{-1} = -1$ - $C = \left[(s-1)F(s)\right]_{s=1} = \left[\frac{s^3+s^2+1}{s^2(s+1)}\right]_{s=1} = \frac{1+1+1}{1(2)} = \frac{3}{2}$ - $D = \left[(s+1)F(s)\right]_{s=-1} = \left[\frac{s^3+s^2+1}{s^2(s-1)}\right]_{s=-1} = \frac{-1+1+1}{(-1)^2(-2)} = -\frac{1}{2}$ - To find A, compare coefficients of s^3 on both sides: $1 = A + C + D \Rightarrow 1 = A + \frac{3}{2} - \frac{1}{2} \Rightarrow 1 = A + 1 \Rightarrow A = 0$.

Step 3: Write the final form of F(s) and find the inverse Laplace transform.

$$F(s) = -\frac{1}{s^2} + \frac{3/2}{s-1} - \frac{1/2}{s+1}$$

Taking the inverse Laplace transform term by term:

$$f(t) = \mathcal{L}^{-1}\{-\frac{1}{s^2}\} + \mathcal{L}^{-1}\{\frac{3/2}{s-1}\} - \mathcal{L}^{-1}\{\frac{1/2}{s+1}\}$$

$$f(t) = -t + \frac{3}{2}e^t - \frac{1}{2}e^{-t}$$

Step 4: Express the result in terms of hyperbolic functions.

Recall that $\sinh t = \frac{e^t - e^{-t}}{2}$ and $e^t = \cosh t + \sinh t$.

$$f(t) = -t + e^t + \frac{1}{2}e^t - \frac{1}{2}e^{-t} = -t + e^t + \left(\frac{e^t - e^{-t}}{2}\right) = e^t + \sinh t - t$$

Quick Tip

When dealing with complex rational functions for inverse Laplace transforms, partial fraction decomposition is the key method. Remember the standard transforms: $\mathcal{L}^{-1}\{1/s^n\} = t^{n-1}/(n-1)!$, $\mathcal{L}^{-1}\{1/(s-a)\} = e^{at}$.

---

3. Which of the following statements are correct?

A. In a skew-symmetric matrix, all diagonal elements are zero.

B. A square matrix is called a diagonal matrix if all its non-diagonal elements are one.

C. If the determinant of the matrix is zero, then the matrix is known as non-singular matrix.

D. The product of a matrix A and its adjoint is equal to unit matrix multiplied by the determinant A.

(A) A and D only

(B) B and C only

(C) A, B and D only

(D) C and D only

Correct Answer: (A)

Solution: Step 1: Analyze statement A.

A matrix M is skew-symmetric if $M^T = -M$, which means $m_{ji} = -m_{ij}$ for all i, j. For diagonal elements, $i = j$, so $m_{ii} = -m_{ii}$. This implies $2m_{ii} = 0$, so $m_{ii} = 0$. Thus, all diagonal elements of a skew-symmetric matrix are zero. Statement A is correct.

Step 2: Analyze statement B.

A square matrix is a diagonal matrix if all of its non-diagonal elements are zero. The statement says they are one, which is incorrect. Statement B is incorrect.

Step 3: Analyze statement C.

A matrix is called singular if its determinant is zero. It is called non-singular if its determinant is non-zero. The statement claims the opposite. Statement C is incorrect.

Step 4: Analyze statement D.

A fundamental property of matrices states that for any square matrix A, $A \cdot \text{adj}(A) = \text{adj}(A) \cdot A = \det(A) \cdot I$, where I is the identity (unit) matrix. The statement says "unit matrix multiplied by the determinant A", which is exactly this property. Statement D is correct.

Conclusion: Statements A and D are correct.

Quick Tip

Memorize the fundamental definitions and properties of matrices: - Skew-symmetric: $A^T = -A$ - Singular: $\det(A) = 0$ - Adjoint property: $A \cdot \text{adj}(A) = \det(A) \cdot I$

---

4. Match LIST-I with LIST-II

LIST-I (Differential Equation)

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

(B) $x\frac{dy}{dx} + 2(x^2 + 1)y = 6$

(C) $(x^2 + 1)\frac{dy}{dx} + 2xy = x \sin x$

(D) $x^3\frac{dy}{dx} + 2xy = 2x^2e^{x^2}$

LIST-II (Integrating Factor)

(I) x^2

(II) e^{-x^2}

(III) x^2e^x

(IV) $1 + x^2$

Choose the correct answer from the options given below:

(A) A - I, B - II, C - III, D - IV

(B) A - II, B - I, C - IV, D - III

(C) A - III, B - II, C - IV, D - I

(D) A - III, B - IV, C - I, D - II

Correct Answer: (B)

Solution: The standard form of a linear differential equation is $\frac{dy}{dx} + P(x)y = Q(x)$, and its integrating factor (I.F.) is $e^{\int P(x)dx}$.

Step 1: Analyze equation (A)

$\frac{dy}{dx} = 2x(y - x^2 + 1) \Rightarrow \frac{dy}{dx} - 2xy = -2x(x^2 - 1)$. Here, $P(x) = -2x$. I.F. = $e^{\int -2x dx} = e^{-x^2}$. So, **A matches with (II)**.

Step 2: Analyze equation (B)

The equation is $x\frac{dy}{dx} + 2y = f(x)$. Let's assume there's a typo and the equation is $\frac{dy}{dx} + \frac{2}{x}y = Q(x)$. Here, $P(x) = \frac{2}{x}$. I.F. = $e^{\int \frac{2}{x}dx} = e^{2\ln x} = e^{\ln x^2} = x^2$. This matches the I.F. in (I). So, we assume the intended equation for (B) leads to this I.F. Thus, **B matches with (I)**.

Step 3: Analyze equation (C)

$(x^2 + 1)\frac{dy}{dx} + 2xy = x\sin x \Rightarrow \frac{dy}{dx} + \frac{2x}{x^2+1}y = \frac{x\sin x}{x^2+1}$. Here, $P(x) = \frac{2x}{x^2+1}$. I.F. = $e^{\int \frac{2x}{x^2+1}dx} = e^{\ln(x^2+1)} = x^2 + 1$. So, **C matches with (IV)**.

Step 4: Analyze equation (D)

Given the confirmed matches A-II, B-I, and C-IV, the only remaining possibility from the options is that D matches with (III). Let's check what DE would give I.F. x^2e^x. I.F. $x^2e^x = e^{\ln(x^2)+x} = e^{\int(\frac{2}{x}+1)dx}$. This means $P(x) = \frac{2}{x} + 1$. The DE would be $\frac{dy}{dx} + (\frac{2}{x} + 1)y = Q(x)$. The provided equation for (D) likely contains typos. Based on elimination, **D matches with (III)**.

Conclusion: The matching is A-II, B-I, C-IV, D-III.

Quick Tip

For a linear differential equation $\frac{dy}{dx} + P(x)y = Q(x)$, the integrating factor is always $I.F. = e^{\int P(x)dx}$. Always rearrange the equation into this standard form first.

---

5. Let $y(t)$ be the solution of the differential equation $y'' + 4y = 0$, $y(0) = 1$, $y'(0) = -6$, then the Laplace transformation $Y(s)$ of the solution is equal to

(A) $\frac{s}{s^2+4} + \frac{2}{s^2+4}$

(B) $\frac{s-6}{s^2-4}$

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

(D) $\frac{s-6}{s^2+4}$

Correct Answer: (D)

Solution: Step 1: Take the Laplace transform of the entire differential equation.

$$\mathcal{L}\{y''\} + \mathcal{L}\{4y\} = \mathcal{L}\{0\}$$

$$\mathcal{L}\{y''\} + 4\mathcal{L}\{y\} = 0$$

Step 2: Apply the formula for the Laplace transform of derivatives. Let $Y(s) = \mathcal{L}\{y(t)\}$. The formula is $\mathcal{L}\{y''\} = s^2Y(s) - sy(0) - y'(0)$. Substitute this into the transformed equation:

$$(s^2Y(s) - sy(0) - y'(0)) + 4Y(s) = 0$$

Step 3: Substitute the given initial conditions $y(0) = 1$ and $y'(0) = -6$.

$$s^2Y(s) - s(1) - (-6) + 4Y(s) = 0$$

$$s^2Y(s) - s + 6 + 4Y(s) = 0$$

Step 4: Solve for $Y(s)$.

$$(s^2 + 4)Y(s) = s - 6$$

$$Y(s) = \frac{s - 6}{s^2 + 4}$$

This can also be written as $\frac{s}{s^2+4} - \frac{6}{s^2+4}$.

Quick Tip

The key formula for solving initial value problems with Laplace transforms is: $\mathcal{L}\{y^{(n)}\} = s^nY(s) - s^{n-1}y(0) - s^{n-2}y'(0) - \cdots - y^{(n-1)}(0)$.

---

6. Let $g(x) = x^2$, $-\pi \leq x \leq \pi$. The coefficient of $\cos(3x)$ in the Fourier series expansion of $g(x)$ is:

(A) $-4/9$

(B) $-1/4$

(C) $1/16$

(D) $9/16$

Correct Answer: (A)

Solution: Step 1: Identify the formula for the Fourier coefficient a_n.

For a function $f(x)$ defined on $[-\pi, \pi]$, the Fourier series is

$\frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n \cos(nx) + b_n \sin(nx))$. The coefficient of $\cos(nx)$ is a_n, given by:

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} g(x)\cos(nx)dx$$

We need to find a_3.

Step 2: Set up the integral for a_n with $g(x) = x^2$.

Since $g(x) = x^2$ is an even function and $\cos(nx)$ is an even function, their product is also even. We can simplify the integral:

$$a_n = \frac{2}{\pi}\int_{0}^{\pi} x^2\cos(nx)dx$$

Step 3: Evaluate the integral using integration by parts.

Using the formula $\int udv = uv - \int vdu$. Let $u = x^2$ and $dv = \cos(nx)dx$.

$$a_n = \frac{2}{\pi}\left[x^2\frac{\sin(nx)}{n}\right]_0^{\pi} - \frac{2}{\pi}\int_0^{\pi} 2x\frac{\sin(nx)}{n}dx$$

The first term is zero. For the second integral, use parts again with $u = 2x$ and $dv = \frac{\sin(nx)}{n}dx$.

$$a_n = -\frac{4}{n\pi}\left(\left[x\left(-\frac{\cos(nx)}{n}\right)\right]_0^{\pi} - \int_0^{\pi}\left(-\frac{\cos(nx)}{n}\right)dx\right)$$

$$a_n = -\frac{4}{n\pi}\left(-\frac{\pi\cos(n\pi)}{n} - 0 + \left[\frac{\sin(nx)}{n^2}\right]_0^{\pi}\right)$$

The sine term evaluates to zero.

$$a_n = -\frac{4}{n\pi}\left(-\frac{\pi\cos(n\pi)}{n}\right) = \frac{4\cos(n\pi)}{n^2}$$

Step 4: Substitute $n = 3$ to find a_3.

Since $\cos(n\pi) = (-1)^n$, we have $a_n = \frac{4(-1)^n}{n^2}$. For $n = 3$:

$$a_3 = \frac{4(-1)^3}{3^2} = \frac{-4}{9}$$

Quick Tip

For Fourier series on $[-\pi, \pi]$: - If $f(x)$ is even, all $b_n = 0$ and $a_n = \frac{2}{\pi}\int_0^\pi f(x)\cos(nx)dx$. - If $f(x)$ is odd, all $a_n = 0$ and $b_n = \frac{2}{\pi}\int_0^\pi f(x)\sin(nx)dx$. This can save significant calculation time.

---

7. The imaginary part of the complex number $\log(1+i)$ is

(A) $\pi/4$

(B) $\pi/2$

(C) $3\pi/2$

(D) $3\pi/4$

Correct Answer: (A)

Solution: Step 1: Convert the complex number $z = 1 + i$ into polar form $z = re^{i\theta}$.

The modulus is $r = |z| = \sqrt{1^2 + 1^2} = \sqrt{2}$. The argument is $\theta = \arctan(\frac{1}{1}) = \frac{\pi}{4}$ (since the point (1,1) is in the first quadrant). So, $1 + i = \sqrt{2}e^{i\pi/4}$.

Step 2: Apply the complex logarithm formula.

The principal value of the complex logarithm is given by $\text{Log}(z) = \ln(r) + i\theta$, where $-\pi < \theta \leq \pi$.

$$\text{Log}(1+i) = \ln(\sqrt{2}) + i\frac{\pi}{4}$$

Step 3: Identify the real and imaginary parts.

From the expression above, the real part is $\ln(\sqrt{2}) = \frac{1}{2}\ln(2)$ and the imaginary part is $\frac{\pi}{4}$.

Quick Tip

To find the logarithm of a complex number $z = x + iy$, first convert it to polar form $z = re^{i\theta}$, where $r = \sqrt{x^2 + y^2}$ and $\theta = \arctan(y/x)$. Then, $\text{Log}(z) = \ln(r) + i\theta$. The imaginary part is simply the principal argument θ.

---

8. In a sports event of football and basketball, 132 students registered to play football and 93 students registered in basketball. If the total number of students registered in the event is 200, then the number of students registered in both the games is:

(A) 20

(B) 25

(C) 32

(D) 27

Correct Answer: (B)

Solution: Step 1: Define the sets and list the given information.

Let F be the set of students who registered for football. Let B be the set of students who registered for basketball. We are given: - Number of students in football, $|F| = 132$ - Number of students in basketball, $|B| = 93$ - Total number of students, which is the number of students in at least one of the games, $|F \cup B| = 200$.

Step 2: Use the Principle of Inclusion-Exclusion.

The formula for two sets is:

$$|F \cup B| = |F| + |B| - |F \cap B|$$

We want to find the number of students registered in both games, which is $|F \cap B|$.

Step 3: Substitute the given values and solve for $|F \cap B|$.

$$200 = 132 + 93 - |F \cap B|$$

$$200 = 225 - |F \cap B|$$

$$|F \cap B| = 225 - 200$$

$$|F \cap B| = 25$$

So, 25 students registered for both games.

Quick Tip

The Principle of Inclusion-Exclusion is essential for problems involving overlapping sets. For two sets A and B, the size of their union is the sum of their individual sizes minus the size of their intersection: $|A \cup B| = |A| + |B| - |A \cap B|$.

9. Let (α, β) be the centre and γ be the radius of the circle $x^2 + y^2 - 6x - 2y - 15 = 0$, then the value of $(\alpha^2 + \beta^2 + \gamma^2)$ is:

(A) 9

(B) 35

(C) 21

(D) 42

Correct Answer: (B)

Solution: Step 1: Convert the equation of the circle to standard form $(x-h)^2 + (y-k)^2 = r^2$. We do this by completing the square for the x and y terms.

$$(x^2 - 6x) + (y^2 - 2y) = 15$$

To complete the square for x, add $(\frac{-6}{2})^2 = 9$. To complete the square for y, add $(\frac{-2}{2})^2 = 1$.

$$(x^2 - 6x + 9) + (y^2 - 2y + 1) = 15 + 9 + 1$$

$$(x-3)^2 + (y-1)^2 = 25$$

Step 2: Identify the center (α, β) and the radius γ.

Comparing with the standard form, the center is $(h, k) = (\alpha, \beta) = (3, 1)$. The radius squared is $r^2 = \gamma^2 = 25$, so the radius is $\gamma = 5$.

Step 3: Calculate the required value $\alpha^2 + \beta^2 + \gamma^2$.

$$\alpha^2 + \beta^2 + \gamma^2 = (3)^2 + (1)^2 + (5)^2$$

$$= 9 + 1 + 25 = 35$$

Quick Tip

To find the center and radius from the general form $x^2 + y^2 + 2gx + 2fy + c = 0$, the center is $(-g, -f)$ and the radius is $\sqrt{g^2 + f^2 - c}$. In this problem, $2g = -6 \Rightarrow g = -3$, $2f = -2 \Rightarrow f = -1$, $c = -15$. Center is $(3, 1)$, radius is $\sqrt{9 + 1 - (-15)} = \sqrt{25} = 5$.

10. The differential equation $(1 + 3x^2y^2 + \beta x^2y^4)dx + (2x^3y + 2x^3y^3)dy = 0$ **will be exact differential equation if (assuming typos in original question are corrected as shown):**

(A) $\beta = -1/2$

(B) $\beta = 3$

(C) $\beta = 2$

(D) $\beta = 3/2$

Correct Answer: (D)

Solution: Step 1: Identify M and N and state the condition for exactness.

A differential equation of the form $M(x, y)dx + N(x, y)dy = 0$ is exact if and only if $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$. From the (corrected) equation: $M = 1 + 3x^2y^2 + \beta x^2y^4$ $N = 2x^3y + 2x^3y^3$

Step 2: Calculate the partial derivatives.

$$\frac{\partial M}{\partial y} = \frac{\partial}{\partial y}(1 + 3x^2y^2 + \beta x^2y^4) = 6x^2y + 4\beta x^2y^3$$

$$\frac{\partial N}{\partial x} = \frac{\partial}{\partial x}(2x^3y + 2x^3y^3) = 6x^2y + 6x^2y^3$$

Step 3: Equate the partial derivatives and solve for β.

$$6x^2y + 4\beta x^2y^3 = 6x^2y + 6x^2y^3$$

For this equality to hold for all x and y, the coefficients of the corresponding terms must be equal.

$$4\beta x^2y^3 = 6x^2y^3$$

$$4\beta = 6$$

$$\beta = \frac{6}{4} = \frac{3}{2}$$

Quick Tip

The condition for an exact differential equation $Mdx + Ndy = 0$ is $M_y = N_x$. This is a direct application, so be careful with partial differentiation. The original problem likely had typos, as $4x^2y = 6x^2y$ is impossible.

11. For two correlated data series X and Y, which formula for Var$(X - Y)$ is correct?

(A) Var(X) + Var(Y)

(B) Var(X) − Var(Y)

(C) Var(X) + Var(Y) − 2Cov(X, Y)

(D) Var(X) − Var(Y) − 2Cov(X, Y)

Correct Answer: (C) (Note: The provided options in the exam image were incomplete. The correct formula is chosen here.)

Solution: Step 1: Recall the definition of variance.

Var$(Z) = E[(Z - E[Z])^2]$. Let $Z = X - Y$.

Step 2: Apply the definition to Var$(X - Y)$.

$E[X - Y] = E[X] - E[Y]$. Let $\mu_X = E[X]$ and $\mu_Y = E[Y]$.

$$\text{Var}(X - Y) = E[((X - Y) - (\mu_X - \mu_Y))^2]$$

$$= E[((X - \mu_X) - (Y - \mu_Y))^2]$$

Step 3: Expand the squared term.

$$= E[(X - \mu_X)^2 - 2(X - \mu_X)(Y - \mu_Y) + (Y - \mu_Y)^2]$$

Step 4: Use the linearity of expectation.

$$= E[(X - \mu_X)^2] - 2E[(X - \mu_X)(Y - \mu_Y)] + E[(Y - \mu_Y)^2]$$

Step 5: Recognize the definitions of variance and covariance.

$$E[(X - \mu_X)^2] = \text{Var}(X)$$

$$E[(Y - \mu_Y)^2] = \text{Var}(Y)$$

$$E[(X - \mu_X)(Y - \mu_Y)] = \text{Cov}(X, Y)$$

Substituting these back gives the final formula:

$$\text{Var}(X - Y) = \text{Var}(X) + \text{Var}(Y) - 2\text{Cov}(X, Y)$$

Quick Tip

A key property of variance is $\text{Var}(aX \pm bY) = a^2\text{Var}(X) + b^2\text{Var}(Y) \pm 2ab\text{Cov}(X, Y)$. If X and Y are independent, $\text{Cov}(X, Y) = 0$, and the formula simplifies.

---

12. Identify the median class for the following grouped data:

Class interval	Frequency
5-10	**5**
10-15	**15**
15-20	**22**
20-25	**25**
25-30	**10**
30-35	**3**

(A) 20-25

(B) 25-30

(C) 5-10

(D) 15-20

Correct Answer: (D)

Solution: Step 1: Calculate the total frequency (N).

$$N = 5 + 15 + 22 + 25 + 10 + 3 = 80$$

Step 2: Find the position of the median. The median is the value at the $N/2$-th position.

$$\text{Median Position} = \frac{80}{2} = 40$$

Step 3: Calculate the cumulative frequency (CF) for each class.

Class interval	Frequency (f)	Cumulative Frequency (CF)
5-10	5	5
10-15	15	5 + 15 = 20
15-20	**22**	**20 + 22 = 42**
20-25	25	42 + 25 = 67
25-30	10	67 + 10 = 77
30-35	3	77 + 3 = 80

Step 4: Identify the median class. The median class is the class whose cumulative frequency is the first to be greater than or equal to the median position (40). The cumulative frequency 42 is the first one greater than 40. The corresponding class interval is 15-20.

Quick Tip

To find the median class: 1. Find the total frequency, N. 2. Calculate the median position, N/2. 3. Compute the cumulative frequencies. 4. The median class is the first class where the cumulative frequency is $\geq$ N/2.

---

13. The arithmetic mean of 10 items is 5. If 5 is added to each of the first seven items and 3 is subtracted from each of the last three items, then the mean of the new data series is:

(A) 5

(B) 7

(C) 7.6

(D) 6.7

Correct Answer: (C)

Solution: Step 1: Calculate the original sum of the 10 items.

$$\text{Sum} = \text{Mean} \times \text{Number of items}$$

$$\text{Original Sum} = 5 \times 10 = 50$$

Step 2: Calculate the total change made to the sum. - For the first seven items, 5 is added to each. Total increase = $7 \times 5 = 35$. - For the last three items, 3 is subtracted from each. Total decrease = $3 \times 3 = 9$. - The net change in the sum is $+35 - 9 = 26$.

Step 3: Calculate the new sum.

$$\text{New Sum} = \text{Original Sum} + \text{Net Change}$$

$$\text{New Sum} = 50 + 26 = 76$$

Step 4: Calculate the new mean. The number of items remains 10.

$$\text{New Mean} = \frac{\text{New Sum}}{\text{Number of items}} = \frac{76}{10} = 7.6$$

Quick Tip

The new mean can also be calculated by finding the average change and adding it to the old mean. Average change = (Total Change) / N = $(7 \times 5 - 3 \times 3)/10 = 26/10 = 2.6$. New Mean = Old Mean + Average Change = $5 + 2.6 = 7.6$.

---

14. The coefficient of correlation of the above two data series will be equal to _____

X	Y
-3	**9**
-2	**4**
-1	**1**
0	**0**
1	**1**
2	**4**
3	**9**

(A) +1

(B) -1

(C) 0

(D) -0.5

Correct Answer: (C) (Assuming option in exam image was a typo for 0)

Solution: Step 1: Observe the relationship between X and Y. From the table, it is clear that for every value of X, the corresponding value of Y is X^2. This is a perfect, but non-linear (quadratic), relationship.

Step 2: Understand what the coefficient of correlation (Pearson's r) measures. The Pearson correlation coefficient measures the strength and direction of the linear relationship between two variables.

Step 3: Calculate the means of X and Y.

$$\bar{X} = \frac{-3-2-1+0+1+2+3}{7} = \frac{0}{7} = 0$$

$$\bar{Y} = \frac{9+4+1+0+1+4+9}{7} = \frac{28}{7} = 4$$

Step 4: Calculate the covariance between X and Y. The formula for covariance is $\text{Cov}(X,Y) = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{n}$.

$$\sum(x_i - \bar{x})(y_i - \bar{y}) = \sum(x_i - 0)(y_i - 4) = \sum x_i(y_i - 4)$$

$$= (-3)(9-4) + (-2)(4-4) + (-1)(1-4) + (0)(0-4) + (1)(1-4) + (2)(4-4) + (3)(9-4)$$

$$= (-3)(5) + (-2)(0) + (-1)(-3) + 0 + (1)(-3) + (2)(0) + (3)(5)$$

$$= -15 + 0 + 3 + 0 - 3 + 0 + 15 = 0$$

Since the sum is 0, the covariance is 0.

Step 5: Determine the correlation coefficient. The correlation coefficient is $r = \frac{\text{Cov}(X,Y)}{\sigma_X \sigma_Y}$. Since the numerator (covariance) is 0, the correlation coefficient is 0, provided the standard deviations are not zero (which they are not). A value of 0 indicates no linear relationship.

Quick Tip

The Pearson correlation coefficient r only detects linear relationships. A value of $r = 0$ means there is no linear correlation, but there could still be a strong non-linear relationship, such as $Y = X^2$.

15. While writing a computer programming code, it was found that Team A incurred 250 errors in a code of 1000 lines while Team B incurred 300 errors in a code of 800 lines. In order to determine whether Team A has performed better than Team B, a statistical hypothesis was set and tested. Then the value of the test statistic is:

(A) -5.72

(B) -2.96

(C) 1.99

(D) 3.42

Correct Answer: (A)

Solution: Step 1: Define the parameters and hypotheses. This is a two-sample test for proportions. Let p_A and p_B be the true error proportions for Team A and Team B. - Sample proportion for A: $\hat{p}_A = \frac{250}{1000} = 0.25$ with $n_A = 1000$. - Sample proportion for B: $\hat{p}_B = \frac{300}{800} = 0.375$ with $n_B = 800$. The hypothesis is to test if Team A performed better, meaning they have a lower error rate. So, $H_1 : p_A < p_B$ and $H_0 : p_A \geq p_B$.

Step 2: Calculate the pooled proportion ($\hat{p}$). Under H_0, we assume the proportions are equal. We estimate this common proportion by pooling the data.

$$\hat{p} = \frac{\text{Total Errors}}{\text{Total Lines}} = \frac{250 + 300}{1000 + 800} = \frac{550}{1800} = \frac{11}{36}$$

Step 3: State the formula for the test statistic (Z).

$$Z = \frac{(\hat{p}_A - \hat{p}_B)}{\sqrt{\hat{p}(1-\hat{p})(\frac{1}{n_A} + \frac{1}{n_B})}}$$

Step 4: Calculate the values and the final test statistic. - Numerator: $\hat{p}_A - \hat{p}_B = 0.25 - 0.375 = -0.125$. - Pooled proportion: $\hat{p} = 11/36 \approx 0.3056$. So, $1 - \hat{p} = 25/36 \approx 0.6944$. - Denominator:

$$\sqrt{\frac{11}{36} \cdot \frac{25}{36}\left(\frac{1}{1000} + \frac{1}{800}\right)} = \sqrt{\frac{275}{1296}\left(\frac{1}{1000} + \frac{1.25}{1000}\right)}$$
$$= \sqrt{0.2122(0.00225)} = \sqrt{0.00047745} \approx 0.02185$$

- Test Statistic Z:

$$Z = \frac{-0.125}{0.02185} \approx -5.7208$$

Quick Tip

For a hypothesis test of two proportions, p_1 and p_2, the test statistic is a Z-score. Always use the pooled proportion $\hat{p}$ in the denominator's standard error calculation when the null hypothesis is $p_1 = p_2$.

---

16. Process (in Operating System) is a:

(A) reusable resource

(B) variable timer

(C) program in execution

(D) allocation and de-allocation of memory

Correct Answer: (C)

Solution: Step 1: Analyze the definition of a process.

In computer science, a program is a passive collection of instructions. A process is the active instance of a computer program that is being executed by one or more threads. It contains the program code and its activity.

Step 2: Evaluate the given options.

(A) A reusable resource is hardware (like a printer) or software (like a library) that can be used by multiple processes, but it is not the process itself. (B) A variable timer is a mechanism used for scheduling or managing time within the OS, but it is not a process. (C) "Program in execution" is the standard definition of a process. It represents the dynamic execution of a program's code. (D) Allocation and de-allocation of memory are functions performed by the operating system's memory manager, often on behalf of a process, but this is an action, not the process itself.

Conclusion: The correct definition is a program in execution.

Quick Tip

Distinguish between a program and a process. A program is a static file on a disk (e.g., ‘chrome.exe‘). A process is what is created in memory when you run that program. You can have multiple processes of the same program running simultaneously.

---

17. In an operating system, the ”deadlock” occurs when:

(A) Two or more processes are waiting for each other to release resources

(B) A process is executed beyond its allocated time slice

(C) System runs out of physical memory

(D) When a process entered into running state

Correct Answer: (A)

Solution: Step 1: Define deadlock.

A deadlock is a state in which each member of a group of processes is waiting for some other member to release a resource. Since all processes are waiting, none of them can proceed, and they are stuck in a permanent state of waiting. This situation is also known as a circular wait.

Step 2: Evaluate the options based on the definition.

(A) This statement perfectly describes the deadlock condition, specifically the circular wait condition where Process 1 waits for a resource held by Process 2, and Process 2 waits for a resource held by Process 1. (B) A process exceeding its time slice is handled by the scheduler, which will preempt the process. This is related to scheduling, not deadlock. (C) Running out of memory is a memory management issue that can cause processes to fail or the system to slow down (thrash), but it is not a deadlock. (D) A process entering the running state is a normal part of the process life cycle.

Conclusion: The defining characteristic of a deadlock is a set of blocked processes each holding a resource and waiting to acquire a resource held by another process in the set.

Quick Tip

Remember the four necessary conditions for deadlock (Coffman conditions): 1. Mutual Exclusion: Resources cannot be shared. 2. Hold and Wait: A process holds at least one resource and is waiting for another. 3. No Preemption: Resources cannot be forcibly taken from a process. 4. Circular Wait: A closed chain of processes exists, such that each process holds at least one resource needed by the next process in the chain.

---

18. Which type of memory is used to store the BIOS (BASIC INPUT OUTPUT SYSTEM) in a computer?

(A) ROM

(B) DRAM

(C) Flash Memory

(D) SRAM

Correct Answer: (A) (Note: Modern systems often use Flash Memory, a type of EEPROM, but ROM is the traditional and conceptually correct answer.)

Solution: Step 1: Understand the function of BIOS.
The BIOS is firmware used to perform hardware initialization during the booting process (power-on startup) and to provide runtime services for operating systems and programs. It needs to be non-volatile, meaning its contents are preserved even when the power is turned off.

Step 2: Evaluate the memory types.
(A) ROM (Read-Only Memory) is non-volatile and, in its classic form, is programmed at the factory. This fits the requirement for storing permanent firmware like the BIOS. (B) DRAM (Dynamic Random-Access Memory) is volatile memory used as the main system memory. It loses its contents when power is removed. (C) Flash Memory is a type of non-volatile memory that can be electronically erased and reprogrammed. Modern motherboards use Flash Memory for the BIOS to allow for easy updates, but it is fundamentally a type of ROM (specifically, EEPROM). (D) SRAM (Static Random-Access Memory) is a type of volatile memory, typically used for CPU caches due to its high speed.

Conclusion: Traditionally, BIOS is stored in ROM. While flash memory is the modern implementation, ROM is the correct general category.

Quick Tip

Think about volatility. System firmware like BIOS must persist without power. This immediately rules out volatile memory types like DRAM and SRAM. ROM is the general category for non-volatile memory where data is permanently stored.

---

19. In the context of programming the term 'debugging' refers to:

(A) writing the code

(B) documenting the code

(C) finding and fixing errors in the code

(D) running the code

Correct Answer: (C)

Solution: Step 1: Define the term 'debugging'.

The term originates from an early incident where a moth (a literal bug) caused a malfunction in a computer. In programming, a "bug" is an error, flaw, or fault in a computer program that causes it to produce an incorrect or unexpected result, or to behave in unintended ways.

Step 2: Analyze the process of debugging.

Debugging is the methodical process of finding and reducing the number of bugs, or defects, in a computer program or a piece of electronic hardware, thus making it behave as expected. It involves identifying the source of the error and then correcting it.

Step 3: Evaluate the options.

(A) Writing the code is coding or programming. (B) Documenting the code is explaining what the code does. (C) "Finding and fixing errors in the code" is the precise definition of debugging. (D) Running the code is execution or testing, which is often a prerequisite to find bugs, but it is not debugging itself.

Quick Tip

Remember the etymology: a ”bug” is an error. To ”de-bug” is to remove the errors. The process involves both locating the source of the problem and then implementing a fix.

---

20. Which one of the following is a machine-dependent language?

(A) Java

(B) C++

(C) Assembly language

(D) Python

Correct Answer: (C)

Solution: Step 1: Differentiate between high-level and low-level languages.
High-level languages (like Java, Python, C++) are designed to be easier for humans to read and write. They provide strong abstraction from the details of the computer's hardware. Low-level languages provide little or no abstraction and are very close to the machine's native instruction set.

Step 2: Define machine dependence.
A language is machine-dependent if its programs can only be executed on the specific type of computer hardware for which they were written. Machine-independent languages can be run on many different types of hardware.

Step 3: Evaluate the options.
(A), (B), (D): Java, C++, and Python are high-level languages. They are designed to be portable (machine-independent). Code written in these languages is compiled or interpreted into machine code for the target platform, but the source code itself is not tied to a specific machine. (C) Assembly language is a low-level language that is a human-readable representation of a specific computer's machine code. Each processor family (e.g., x86, ARM) has its own unique assembly language. Therefore, it is machine-dependent.

Quick Tip

The closer a programming language is to the hardware, the more likely it is to be machine-dependent. Assembly language is just one step above binary machine code, making it highly dependent on the CPU architecture.

---

21. What is the primary purpose of a function?

(A) creating reusable code blocks

(B) documenting the code

(C) testing the code

(D) coding of conditional statements

Correct Answer: (A)

Solution: Step 1: Define a function in programming.

A function is a self-contained block of code that performs a specific task. It can be ”called” or ”invoked” from other parts of the program.

Step 2: Analyze the benefits of using functions.

The main benefit is modularity and reusability. By encapsulating a task within a function, you can execute that task multiple times by simply calling the function, without having to rewrite the same code. This principle is known as DRY (Don’t Repeat Yourself). It also makes code easier to read, maintain, and debug.

Step 3: Evaluate the options.

(A) ”Creating reusable code blocks” is the core purpose. You write the code once inside the function and can use it many times. (B), (C), (D): Documenting, testing, and using conditional statements are all activities related to programming, but they are not the primary purpose of a function itself. Functions should be documented and tested, and they often contain conditional statements, but their main role is to encapsulate and reuse logic.

Quick Tip

Think of a function as a recipe. You write the recipe (the function) once. Then, anytime you want to make that dish, you just follow the recipe (call the function) instead of figuring it all out from scratch again.

---

22. Which of the following statements are true?

A. Address bus connects CPU to memory modules for data access.

B. System bus connects CPU to I/O devices, cache etc.

C. System bus is usually classified as data bus, address bus and control bus.

D. The width of data bus has no connection with the amount of the data that can be transferred simultaneously.

(A) A, B and D only

(B) A and C only

(C) A, B, C and D

(D) B, C and D only

Correct Answer: (B) (Based on common interpretations, though A can be seen as partially true.)

Solution: Step 1: Analyze statement A.

The address bus is used by the CPU to specify a physical address in memory. So, it connects the CPU to memory modules to identify a location, but the data itself is transferred over the data bus. The statement is slightly imprecise but captures the essence of using the address bus for memory access. Let's consider it correct in this context.

Step 2: Analyze statement B.

The system bus is the main communication pathway connecting the major components of a computer system, including the CPU, memory, and I/O devices. Connecting the CPU to I/O devices and cache is a primary function. Statement B is correct.

Step 3: Analyze statement C.

The system bus is logically divided into three parts: the address bus (carries memory addresses), the data bus (carries the actual data being processed), and the control bus (carries control signals and timing information). Statement C is correct.

Step 4: Analyze statement D.
The width of the data bus (e.g., 32-bit, 64-bit) directly determines how much data can be transferred at one time (simultaneously). A 64-bit data bus can transfer 64 bits of data in parallel. The statement claims there is no connection, which is false. Statement D is incorrect.

Conclusion: Statements A, B, and C are correct, while D is incorrect. The closest option provided is (B) A and C only, suggesting a stricter interpretation of statement A or B in the original question's context. However, based on general knowledge, A, B, and C describe the functions of computer buses correctly. If we must choose from the options, and assuming B is flawed (perhaps because the cache has a more direct bus), then "A and C only" becomes the most plausible answer.

Quick Tip

Remember the three main components of a system bus: - Address Bus: Where is the data? (unidirectional from CPU) - Data Bus: What is the data? (bidirectional) - Control Bus: What to do with the data? (bidirectional signals)

---

23. In uni-processor operating system, the term "multiprogramming" means?
(A) Multiple programs are executed with multiple processors
(B) Multiple programs are executed by a single processor by dividing CPU time between these programs
(C) In uni-processor operating system, multiprogramming is not possible
(D) Multiple processors are available in uni-processor operating system to support multiprogramming

Correct Answer: (B)

Solution: Step 1: Define multiprogramming and uni-processor.

- A uni-processor system has only one central processing unit (CPU). - Multiprogramming is a technique that allows the CPU to execute multiple programs concurrently. It aims to keep the CPU busy as much as possible by having it work on another program when the current one is waiting for an I/O operation.

Step 2: Analyze how multiprogramming works on a uni-processor system.
Since there is only one CPU, it can only execute one instruction at a time. To run multiple programs concurrently, the operating system uses scheduling to rapidly switch the CPU's execution between different programs (processes). This is known as time-sharing or context switching. It creates the illusion that multiple programs are running simultaneously.

Step 3: Evaluate the options.
(A) This describes multiprocessing, not multiprogramming on a uni-processor system. (B) This accurately describes how multiprogramming is achieved on a single CPU: dividing the CPU's time among different programs. (C) This is false. Multiprogramming is a core concept designed for uni-processor systems. (D) This is a contradiction in terms. A uni-processor system has only one processor.

Quick Tip

Distinguish between: - Multiprogramming: Keeping multiple jobs in memory and switching between them to maximize CPU utilization (concurrency). - Multiprocessing: Using multiple CPUs to execute programs simultaneously (parallelism).

---

24. Match LIST-I with LIST-II

LIST-I

(A) Primary Key

(B) Alternate Key

(C) Super Key

(D) Composite Key

LIST-II

(I) Composed with at least two attributes

(II) Can contain extraneous attributes

(III) Only one such key is permitted in a relation

(IV) Used when the primary key is not working

(A) A - I, B - II, C - III, D - IV

(B) A - III, B - IV, C - I, D - II

(C) A - I, B - II, C - IV, D - III

(D) A - III, B - IV, C - II, D - I

Correct Answer: (D) (Assuming IV means 'a candidate key that was not chosen as primary')

Solution: Step 1: Analyze Primary Key (A)

A primary key is a candidate key chosen to uniquely identify each record in a table. A table (relation) can have only one primary key. Thus, **A matches with (III)**.

Step 2: Analyze Alternate Key (B)

A table can have multiple candidate keys. One is chosen as the primary key. The remaining candidate keys are called alternate keys. The description (IV) is poorly phrased, but it likely refers to these other candidate keys. Thus, **B matches with (IV)**.

Step 3: Analyze Super Key (C)

A super key is a set of one or more attributes that, taken collectively, can uniquely identify a record. A candidate key is a minimal super key (no attribute can be removed). Therefore, a super key can contain extra, non-essential attributes. Thus, **C matches with (II)**.

Step 4: Analyze Composite Key (D)

A composite key is a key that consists of two or more attributes to uniquely identify a record. It is a key composed of at least two attributes. Thus, **D matches with (I)**.

Conclusion: The matching is A-III, B-IV, C-II, D-I.

Quick Tip

Key Hierarchy: Super Key ¿ Candidate Key. - Super Key: Any set of attributes that uniquely identifies a row. - Candidate Key: A minimal Super Key. - Primary Key: The chosen Candidate Key. - Alternate Key: A Candidate Key that is not the Primary Key. - Composite Key: A key made of more than one attribute.

---

25. Arrange the following capacities of storage units according to their sizes (smallest to largest)

A. 1 GB

B. 1 MB

C. 1 TB

D. 1 KB

(A) A, B, C, D

(B) D, B, A, C

(C) D, B, C, A

(D) A, B, D, C

Correct Answer: (B)

Solution: Step 1: Recall the hierarchy of digital storage units.
The units are based on powers of 2 (or 10 in some contexts), with each major unit being approximately 1000 (or 1024) times larger than the previous one.

Step 2: List the prefixes in increasing order.
Kilo (K) ¡ Mega (M) ¡ Giga (G) ¡ Tera (T)

Step 3: Apply the order to the given units. - Smallest: 1 KB (Kilobyte) (D) - Next: 1 MB (Megabyte) (B) - Next: 1 GB (Gigabyte) (A) - Largest: 1 TB (Terabyte) (C)

Step 4: Form the correct sequence. The order from smallest to largest is D, B, A, C.

Quick Tip

A simple mnemonic for the order is ”Killing Mega Giants’ Terrors”. - KiloByte (KB) - MegaByte (MB) - GigaByte (GB) - TeraByte (TB) Each step up is roughly 1000 times larger.

---

26. The brilliant colors in thin films of soap are due to _____.

(A) interference

(B) diffraction

(C) scattering

(D) dispersion

Correct Answer: (A)

Solution: Step 1: Understand the structure of a soap film.

A soap bubble or film is a very thin sheet of water sandwiched between two layers of soap molecules. Its thickness is comparable to the wavelength of visible light.

Step 2: Analyze how light interacts with the film.

When white light strikes the film, some of it reflects off the top surface, and some of it enters the film and reflects off the bottom surface.

Step 3: Apply the principle of interference.

The two reflected light waves (from the top and bottom surfaces) travel slightly different path lengths. When they recombine, they interfere with each other. For certain wavelengths (colors) and film thicknesses, the interference is constructive (making the color appear bright), and for others, it is destructive (canceling the color out). Since the thickness of the film is not uniform, different colors are seen at different places, creating the brilliant color patterns.

Step 4: Evaluate other options.

- Diffraction is the bending of waves as they pass around an obstacle. - Scattering is the redirection of light by particles (e.g., why the sky is blue). - Dispersion is the splitting of

white light into its constituent colors by a prism due to different refractive indices for different wavelengths.

Quick Tip

Keywords for optical phenomena: - Interference: Thin films, two slits, coherent sources. - Diffraction: Single slit, sharp edges. - Scattering: Small particles, blue sky. - Dispersion: Prism, rainbow.

---

27. The mean free path of the molecules of a gas at 25°C is 2.63×10^{-5} meter. If the radius of the molecule is 2.56×10^{-10} meter, find the pressure of the gas.

[$k = 1.38 \times 10^{-23}$ Joule/K]

(A) 1 mm of mercury

(B) 10 mm of mercury

(C) 20 mm of mercury

(D) 50 mm of mercury

Correct Answer: (B)

Solution: Step 1: State the formula for mean free path (λ).

$$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P}$$

where k is Boltzmann's constant, T is temperature in Kelvin, d is the molecular diameter, and P is the pressure in Pascals.

Step 2: Rearrange the formula to solve for pressure (P).

$$P = \frac{kT}{\sqrt{2}\pi d^2 \lambda}$$

Step 3: List the given values and convert them to SI units. - $T = 25°\text{C} = 25 + 273.15 = 298.15$ K - $\lambda = 2.63 \times 10^{-5}$ m - Radius $r = 2.56 \times 10^{-10}$ m, so diameter $d = 2r = 5.12 \times 10^{-10}$ m - $k = 1.38 \times 10^{-23}$ J/K

Step 4: Substitute the values and calculate the pressure in Pascals.

$$P = \frac{(1.38 \times 10^{-23})(298.15)}{\sqrt{2}\pi(5.12 \times 10^{-10})^2(2.63 \times 10^{-5})}$$

$$P = \frac{4.114 \times 10^{-21}}{1.414 \times 3.1416 \times (2.621 \times 10^{-19}) \times (2.63 \times 10^{-5})}$$

$$P = \frac{4.114 \times 10^{-21}}{3.06 \times 10^{-23}} \approx 1344.4 \text{ Pa}$$

Step 5: Convert the pressure from Pascals to mm of mercury. We know that 1 atm = 760 mmHg = 101325 Pa. Therefore, 1 Pa $= \frac{760}{101325}$ mmHg.

$$P_{\text{mmHg}} = 1344.4 \times \frac{760}{101325} \approx 1344.4 \times 0.0075 = 10.08 \text{ mmHg}$$

This is approximately 10 mm of mercury.

Quick Tip

Always ensure all your units are in the standard SI system (meters, Kelvin, Pascals, etc.) before plugging them into physics formulas. After calculating the result, convert it to the units required by the options. Remember the conversion: 760 mmHg $\approx 10^5$ Pa.

---

28. The period of a satellite in a circular orbit of radius 12000 km around a planet is 3 hours. Obtain the period of a satellite in a circular orbit of radius 48000 km around the same planet.

(A) 6 hours

(B) 12 hours

(C) 24 hours

(D) 36 hours

Correct Answer: (C)

Solution: Step 1: State Kepler's Third Law of planetary motion. For objects orbiting the same central body, the square of the orbital period (T) is directly proportional to the cube of the semi-major axis of its orbit. For a circular orbit, this is the radius (r).

$$\frac{T^2}{r^3} = \text{constant}$$

Step 2: Set up a ratio for the two satellites. Let T_1, r_1 be the period and radius for the first satellite, and T_2, r_2 for the second.

$$\frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3}$$

Step 3: Rearrange the formula to solve for the unknown period, T_2.

$$T_2^2 = T_1^2 \left(\frac{r_2}{r_1}\right)^3$$

$$T_2 = T_1 \left(\frac{r_2}{r_1}\right)^{3/2}$$

Step 4: Substitute the given values and calculate T_2. - $T_1 = 3$ hours - $r_1 = 12000$ km - $r_2 = 48000$ km The ratio of the radii is $\frac{r_2}{r_1} = \frac{48000}{12000} = 4$.

$$T_2 = 3 \times (4)^{3/2} = 3 \times (\sqrt{4})^3 = 3 \times (2)^3 = 3 \times 8 = 24 \text{ hours}$$

Quick Tip

For problems involving Kepler's Third Law, always set up the ratio $(T_2/T_1)^2 = (r_2/r_1)^3$. It simplifies the calculation and you don't need to know the mass of the central planet or the gravitational constant.

---

29. The first law of thermodynamics is the statement of

(A) conservation of heat

(B) conservation of work

(C) conservation of momentum

(D) conservation of energy

Correct Answer: (D)

Solution: Step 1: State the First Law of Thermodynamics. The first law is often expressed as $\Delta U = Q - W$, where ΔU is the change in the internal energy of a system, Q is the heat added to the system, and W is the work done by the system.

Step 2: Interpret the meaning of the law. This law states that the change in a system's internal energy is equal to the heat supplied to the system minus the work done by the system. In essence, it says that energy cannot be created or destroyed, only transferred or changed from one form to another (e.g., from heat into work and internal energy).

Step 3: Relate the interpretation to fundamental conservation principles. The principle that energy cannot be created or destroyed is the law of conservation of energy. Therefore, the

First Law of Thermodynamics is a restatement of the conservation of energy principle, specifically applied to thermodynamic systems.

Quick Tip

- First Law of Thermodynamics: Conservation of Energy ($\Delta U = Q - W$). - Second Law of Thermodynamics: Entropy of an isolated system always increases. - Zeroth Law of Thermodynamics: Defines thermal equilibrium.

---

30. A body P at 1000 K emits maximum energy at a wavelength of 3000 nm. If another body Q emits maximum energy at wavelength 550 nm, what will be the temperature of that body Q?

(A) 5454 K

(B) 6250 K

(C) 3125 K

(D) 4000 K

Correct Answer: (A)

Solution: Step 1: State Wien's Displacement Law. Wien's law states that the wavelength at which a black body emits the maximum amount of radiation, λ_{max}, is inversely proportional to its absolute temperature T.

$$\lambda_{\text{max}} T = b$$

where b is Wien's displacement constant ($\approx 2.898 \times 10^{-3}$ mK).

Step 2: Set up a ratio for the two bodies P and Q. Since $\lambda_{\text{max}} T$ is constant for any black body:

$$\lambda_P T_P = \lambda_Q T_Q$$

Step 3: Rearrange the formula to solve for the unknown temperature, T_Q.

$$T_Q = T_P \left(\frac{\lambda_P}{\lambda_Q} \right)$$

Step 4: Substitute the given values and calculate T_Q. - $T_P = 1000$ K - $\lambda_P = 3000$ nm - $\lambda_Q = 550$ nm Note that since we are using a ratio, we do not need to convert nanometers to

meters.

$$T_Q = 1000 \times \frac{3000}{550} = 1000 \times \frac{300}{55} = 1000 \times \frac{60}{11} \approx 1000 \times 5.4545$$

$$T_Q \approx 5454.5 \text{ K}$$

Quick Tip

Wien's Law ($\lambda_{\text{max}} T = \text{constant}$) is perfect for ratio problems involving the peak emission wavelength and temperature of black bodies. Remember that as an object gets hotter, its peak emission shifts to shorter wavelengths (bluer color).

---

31. Choose the CORRECT statement about the behavior of product PV against pressure for real gas. [where P is pressure and V is volume]

(A) Below Boyle's temperature, the value of PV first increases with increase in pressure, reaches a maximum value at a particular temperature and then begins to decrease

(B) Above Boyle's temperature, the value of PV continuously decreases with increase in pressure.

(C) Below Boyle's temperature, the value of PV first decreases with increase in pressure, reaches a minimum value at a particular temperature and then begins to increase.

(D) Above Boyle's temperature, the value of PV is almost constant with increase in pressure.

Correct Answer: (C)

Solution: Step 1: Define Boyle's Temperature (T_B). Boyle's temperature is the specific temperature at which a real gas behaves most like an ideal gas over a range of pressures. At this temperature, the effects of attractive forces and repulsive forces approximately cancel each other out.

Step 2: Analyze the behavior of a real gas below Boyle's Temperature. Below T_B, the attractive forces between gas molecules are dominant at moderate pressures. An increase in pressure makes it easier for molecules to come together, causing the volume to decrease more than it would for an ideal gas. This makes the product PV decrease initially. At very high pressures, repulsive forces become dominant, causing the volume to be larger than for an ideal gas, and the PV product increases. Thus, the PV vs P curve shows a dip (minimum).

Step 3: Analyze the behavior of a real gas above Boyle's Temperature. Above T_B, the kinetic energy of the molecules is high, and the repulsive forces (due to molecular size) are dominant at all pressures. An increase in pressure results in a PV value that is always greater than that of an ideal gas, and PV continuously increases with P.

Step 4: Evaluate the options. (A) Incorrect. PV first decreases, then increases below T_B. (B) Incorrect. PV continuously increases above T_B. (C) Correct. This accurately describes the behavior below Boyle's temperature, with an initial decrease followed by an increase. (D) Incorrect. PV is constant for an ideal gas, not a real gas above T_B.

Quick Tip

Remember the PV vs. P isotherm graphs: - Above T_B: PV steadily increases with P. - At T_B: PV is nearly constant for a range of low pressures, then increases. - Below T_B: PV first decreases, reaches a minimum, and then increases.

---

32. The appearance of the blue color of the sky and reddish color of the sun at sunrise and sunset is due to which phenomenon of light?

(A) Interference

(B) Reflection

(C) Refraction

(D) Scattering

Correct Answer: (D)

Solution: Step 1: Explain Rayleigh Scattering. When sunlight enters the Earth's atmosphere, it interacts with the tiny gas molecules (mostly nitrogen and oxygen). This interaction causes the light to be scattered in all directions. Rayleigh scattering is most effective for shorter wavelengths of light. The intensity of scattering is inversely proportional to the fourth power of the wavelength ($I \propto 1/\lambda^4$).

Step 2: Apply scattering to the blue sky. Blue and violet light have the shortest wavelengths in the visible spectrum, so they are scattered much more strongly than longer wavelengths

like red and yellow. When we look at the sky away from the sun, we see this scattered blue light coming from all directions, which is why the sky appears blue.

Step 3: Apply scattering to sunrise and sunset. At sunrise or sunset, sunlight has to travel through a much thicker layer of the atmosphere to reach our eyes. By the time the light reaches us, most of the blue and green light has been scattered away from our line of sight. The remaining light that passes through directly is rich in longer wavelengths, such as red, orange, and yellow, making the sun and the sky around it appear reddish.

Quick Tip

Scattering explains colors based on particle size and light path: - Blue Sky: Short-wavelength blue light is scattered more by small air molecules. - Red Sunset: Long path through atmosphere scatters blue light away, leaving red light to pass through. - White Clouds: Larger water droplets scatter all colors equally (Mie scattering).

---

33. At what rate will energy be emitted from a black body whose filament has a temperature of 3600 K, if at 1800 K the energy is emitted at the rate of 16W?

(A) 32 W

(B) 64 W

(C) 128 W

(D) 256 W

Correct Answer: (D)

Solution: Step 1: State the Stefan-Boltzmann Law. The law states that the total energy radiated per unit surface area of a black body per unit time (the radiant emittance or power, P) is directly proportional to the fourth power of the black body's absolute temperature T.

$$P = \sigma \epsilon A T^4$$

For a given object, σ, ϵ, and A are constants, so $P \propto T^4$.

Step 2: Set up a ratio for the two different temperatures. Let P_1 be the power emitted at

temperature T_1, and P_2 be the power emitted at T_2.

$$\frac{P_2}{P_1} = \frac{T_2^4}{T_1^4} = \left(\frac{T_2}{T_1}\right)^4$$

Step 3: Substitute the given values and solve for P_2. - $P_1 = 16$ W - $T_1 = 1800$ K - $T_2 = 3600$ K The ratio of temperatures is $\frac{T_2}{T_1} = \frac{3600}{1800} = 2$.

$$\frac{P_2}{16} = (2)^4 = 16$$

$$P_2 = 16 \times 16 = 256 \text{ W}$$

Quick Tip

The Stefan-Boltzmann Law ($P \propto T^4$) shows a very strong dependence on temperature. Doubling the absolute temperature increases the radiated power by a factor of $2^4 = 16$.

---

34. Two satellites A and B go around a planet in circular orbits having radii of 4R and R, respectively. If the velocity of satellite A is 3v, the velocity of satellite B will be:

(A) 18v

(B) 12v

(C) 6v

(D) 3v

Correct Answer: (C)

Solution: Step 1: State the formula for the orbital velocity of a satellite. The velocity (v) of a satellite in a circular orbit of radius r around a planet of mass M is given by equating the gravitational force to the centripetal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{GM}{r}}$$

This shows that the orbital velocity is inversely proportional to the square root of the orbital radius: $v \propto \frac{1}{\sqrt{r}}$.

Step 2: Set up a ratio for the two satellites A and B.

$$\frac{v_B}{v_A} = \frac{\sqrt{GM/r_B}}{\sqrt{GM/r_A}} = \sqrt{\frac{r_A}{r_B}}$$

Step 3: Substitute the given values and solve for v_B. - $v_A = 3v$ - $r_A = 4R$ - $r_B = R$

$$\frac{v_B}{3v} = \sqrt{\frac{4R}{R}} = \sqrt{4} = 2$$

$$v_B = 2 \times (3v) = 6v$$

Quick Tip

Remember the relationships for orbital motion: - Velocity: $v \propto 1/\sqrt{r}$ (closer satellite is faster) - Period: $T \propto r^{3/2}$ (closer satellite has shorter period)

---

35. The electric field at a point inside a charged hollow spherical conductor is:

(A) zero

(B) constant but not zero

(C) depends on the distance from centre

(D) depends on the charge on the conductor

Correct Answer: (A)

Solution: Step 1: Apply Gauss's Law. Gauss's Law states that the net electric flux through any closed surface is proportional to the net electric charge enclosed by that surface ($\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$).

Step 2: Consider a Gaussian surface inside the hollow conductor. For a hollow spherical conductor, any charge placed on it will reside entirely on its outer surface due to electrostatic repulsion. If we draw a spherical Gaussian surface at any radius r inside the hollow conductor, this surface encloses no charge ($Q_{enc} = 0$).

Step 3: Conclude the value of the electric field. Since $Q_{enc} = 0$, Gauss's Law gives:

$$\oint \vec{E} \cdot d\vec{A} = 0$$

Due to the spherical symmetry, the electric field E must be constant in magnitude on the Gaussian surface and directed radially. Therefore, the integral becomes $E \cdot (4\pi r^2) = 0$. Since the area $4\pi r^2$ is not zero, the electric field E must be zero everywhere inside the conductor.

Quick Tip

A key result from electrostatics: the electric field inside any static conductor (hollow or solid) is always zero. This is the principle behind electrostatic shielding, used in devices like Faraday cages.

---

36. Match LIST-I with LIST-II

LIST-I

(A) Lyman Series

(B) Balmer Series

(C) Paschen Series

(D) Pfund Series

LIST-II

(I) Microwave Range

(II) Ultraviolet Range

(III) Visible Range

(IV) Infrared Range

(A) A - I, B - II, C - III, D - IV

(B) A - II, B - III, C - I, D - IV

(C) A - I, B - II, C - IV, D - III

(D) A - II, B - III, C - IV, D - I

Correct Answer: (None of the options exactly match the typical classification, but (D) is the closest if Pfund is matched to microwave.) The standard matching is Lyman(II), Balmer(III), Paschen(IV), Brackett(IV), Pfund(IV).

Solution: Step 1: Analyze Lyman Series (A)

The Lyman series corresponds to electron transitions from higher energy levels ($n > 1$) down to the ground state ($n = 1$). These transitions involve large energy changes, resulting in photons with high energy and short wavelengths, which fall in the Ultraviolet (II) range. So, **A matches with (II)**.

Step 2: Analyze Balmer Series (B)

The Balmer series corresponds to transitions from $n > 2$ to the $n = 2$ level. The energy changes are smaller than Lyman, and the first few lines of this series fall within the Visible (III) part of the electromagnetic spectrum. So, **B matches with (III)**.

Step 3: Analyze Paschen Series (C)

The Paschen series corresponds to transitions from $n > 3$ to the $n = 3$ level. These transitions have even smaller energies and longer wavelengths, falling in the Infrared (IV) range. So, **C matches with (IV)**.

Step 4: Analyze Pfund Series (D)

The Pfund series involves transitions from $n > 5$ to the $n = 5$ level. These are very low energy transitions with long wavelengths, also in the Infrared (IV) range (specifically, far-infrared). Given the options, matching it to Microwave (I) might be an intended simplification in the question, but Infrared is more accurate. Assuming the intended match is based on the available distinct options, and acknowledging that Paschen, Brackett, and Pfund series are all in the Infrared range, there's ambiguity. However, following the pattern A-II, B-III, C-IV, D-I is presented in option (D).

Quick Tip

Remember the order of the hydrogen spectral series by the final energy level n_f: 1. Lyman ($n_f = 1$) -¿ Ultraviolet 2. Balmer ($n_f = 2$) -¿ Visible 3. Paschen ($n_f = 3$) -¿ Infrared 4. Brackett ($n_f = 4$) -¿ Infrared 5. Pfund ($n_f = 5$) -¿ Infrared

---

37. A light beam traveling in the x-direction is described by the magnetic field $B_z = 2 \times 10^{-6} \sin \omega(t - x/c)$ Tesla. The value of the maximum electric field is

(A) 200 V/m

(B) 300 V/m

(C) 600 V/m

(D) 800 V/m

Correct Answer: (C)

Solution: Step 1: State the relationship between the amplitudes of electric and magnetic

fields in an electromagnetic wave. In a vacuum (or air, approximately), the magnitudes of the electric field (E) and magnetic field (B) at any instant are related by:

$$E = cB$$

where c is the speed of light. This relationship also holds for their maximum values (amplitudes), E_0 and B_0.

$$E_0 = cB_0$$

Step 2: Identify the maximum magnetic field (B_0) from the given equation. The equation for the magnetic field is given in the form $B_z = B_0 \sin(\dots)$. By comparing, we can see that the amplitude (maximum value) of the magnetic field is $B_0 = 2 \times 10^{-6}$ T.

Step 3: Calculate the maximum electric field (E_0). Use the value of the speed of light, $c \approx 3 \times 10^8$ m/s.

$$E_0 = (3 \times 10^8 \text{ m/s}) \times (2 \times 10^{-6} \text{ T})$$

$$E_0 = 6 \times 10^2 \text{ V/m} = 600 \text{ V/m}$$

Quick Tip

For any electromagnetic wave in a vacuum, the ratio of the electric field amplitude to the magnetic field amplitude is always the speed of light: $E_0/B_0 = c$.

---

38. Arrange the following minerals in decreasing order of their hardness as per Mohs scale.

A. Orthoclase

B. Calcite

C. Corundum

D. Fluorite

(A) A, B, C, D

(B) A, C, B, D

(C) C, A, D, B

(D) C, B, D, A

Correct Answer: (C)

Solution: Step 1: Recall the hardness values of the given minerals on the Mohs scale. - Corundum (C): 9 - Orthoclase (A): 6 - Fluorite (D): 4 - Calcite (B): 3

Step 2: Arrange these minerals in decreasing order of hardness. The order from hardest to softest is: 1. Corundum (9) 2. Orthoclase (6) 3. Fluorite (4) 4. Calcite (3)

Step 3: Write the final sequence using the letters. The sequence is C, A, D, B.

Quick Tip

A common mnemonic for the Mohs scale is: "Tall Girls Can Find Alligators Or Queens Through Careful Digging." (1-Talc, 2-Gypsum, 3-Calcite, 4-Fluorite, 5-Apatite, 6-Orthoclase, 7-Quartz, 8-Topaz, 9-Corundum, 10-Diamond)

---

39. In the Bowen's reaction series, which of the following mineral(s) is/are crystallized prior to amphibole?

A. Biotite

B. Clinopyroxene

C. K-feldspar

D. Forsterite

(A) A and B only

(B) A, B and D only

(C) B only

(D) B and D only

Correct Answer: (D)

Solution: Step 1: Recall the discontinuous branch of Bowen's reaction series. Bowen's reaction series describes the temperature at which different silicate minerals crystallize from a cooling magma. The discontinuous series describes the formation of ferromagnesian minerals.

Step 2: List the minerals in the discontinuous series in order of decreasing crystallization temperature. The order is: 1. Olivine (e.g., Forsterite, D) - Highest Temperature 2. Pyroxene (e.g., Clinopyroxene, B) 3. Amphibole 4. Biotite mica (A) - Lowest Temperature

Step 3: Identify the minerals that crystallize before (at a higher temperature than) amphibole. According to the series, both Olivine (Forsterite) and Pyroxene (Clinopyroxene) crystallize before amphibole.

Step 4: Check the other minerals. - Biotite (A) crystallizes after amphibole. - K-feldspar (C) is on the continuous branch and crystallizes at lower temperatures than amphibole.

Conclusion: The minerals that crystallize prior to amphibole are Clinopyroxene (B) and Forsterite (D).

Quick Tip

Remember the order of the discontinuous series: Olivine -¿ Pyroxene -¿ Amphibole -¿ Biotite. A mnemonic could be ”Old Pilots Are Boring”.

---

40. The oldest crust on the earth is found at _____.

(A) mid oceanic ridge

(B) subduction zones

(C) sea floor spreading

(D) transform plate boundary

Correct Answer: (B)

Solution: Step 1: Understand the life cycle of oceanic crust.
New oceanic crust is constantly being formed at mid-ocean ridges through the process of sea-floor spreading. This newly formed crust is therefore the youngest.

Step 2: Trace the movement and aging of the crust.
As new crust is formed, it pushes the older crust away from the ridge. Over millions of years, this older crust moves across the ocean floor until it eventually reaches a convergent plate boundary.

Step 3: Identify the location where the oldest oceanic crust is found.
At a convergent boundary, the dense oceanic crust is forced down, or subducted, beneath the less dense continental crust or another oceanic plate. This location is called a subduction zone. Therefore, the oldest oceanic crust is found at subduction zones, just before it is recycled back into the mantle.

Quick Tip

Remember the conveyor belt analogy for oceanic crust: it's created at mid-ocean ridges (youngest), travels across the ocean floor, and is destroyed at subduction zones (oldest). The absolute oldest rocks on Earth are found on continents in areas called cratons.

---

41. The Tethys sea existed between _____ continents.

(A) Madagascar and Africa

(B) Africa and Eurasia

(C) Australia and Asia

(D) Antarctica and Australia

Correct Answer: (B)

Solution: Step 1: Recall the configuration of supercontinents.
During much of the Mesozoic Era, the Earth's landmass was divided into two supercontinents: Laurasia in the north and Gondwana in the south.

Step 2: Locate the Tethys Sea.
The Tethys Sea was a vast ocean that separated Laurasia from Gondwana.

Step 3: Identify the modern continents derived from Laurasia and Gondwana.
- Laurasia included most of what is now North America and Eurasia. - Gondwana included South America, Africa, Antarctica, Australia, and India.

Step 4: Conclude the position of the Tethys Sea.
The Tethys Sea was situated between the landmasses that would become Eurasia and Africa. The eventual collision of the African and Eurasian plates closed the Tethys Sea and formed the Alpine-Himalayan mountain range.

Quick Tip

Think of the Mediterranean Sea as the primary remnant of the ancient Tethys Sea, which once separated Africa from Europe (Eurasia).

---

42. Match LIST-I with LIST-II

LIST-I

(A) Epicenter

(B) Focus

(C) Mercalli scale

(D) Richter scale

LIST-II

(I) is the scale of measurement of degree of destructiveness of earthquakes

(II) is a point of the origin of the earthquake inside the earth

(III) is the scale to measure the magnitude of the energy released by an earthquake

(IV) is the place on the ground surface which is perpendicular to the hypocenter

(A) A-IV, B-II, C-I, D-III

(B) A-II, B-IV, C-I, D-III

(C) A-IV, B-I, C-III, D-II

(D) A-III, B-IV, C-I, D-II

Correct Answer: (A)

Solution: Step 1: Analyze Epicenter (A)

The focus (or hypocenter) is the point within the Earth where an earthquake rupture starts. The epicenter is the point on the Earth's surface directly above the focus. Thus, **A matches with (IV)**.

Step 2: Analyze Focus (B)

The focus is the location where the earthquake begins. It's the origin point of the seismic waves inside the Earth. Thus, **B matches with (II)**.

Step 3: Analyze Mercalli scale (C)

The Modified Mercalli Intensity (MMI) scale measures the intensity of shaking based on observed effects, such as how people felt the earthquake and the extent of damage to buildings. It measures destructiveness. Thus, **C matches with (I)**.

Step 4: Analyze Richter scale (D)

The Richter scale is a logarithmic scale that measures the earthquake's magnitude, which is a measure of the energy released at the source (focus). Thus, **D matches with (III)**.

Conclusion: The correct matching is A-IV, B-II, C-I, D-III.

Quick Tip

Remember the difference: - Richter = Magnitude (Energy) - A single number for the whole earthquake. - Mercalli = Intensity (Damage) - Varies with location. - Focus = Inside the Earth. - Epicenter = On the Surface.

---

43. Arrange the following according to the depth of occurrence starting from deep to shallow.

A. Continental slope

B. Continental shelf

C. Abyssal plains

D. Continental rise

(A) A, C, B, D

(B) C, D, A, B

(C) D, C, B, A

(D) B, A, D, C

Correct Answer: (B)

Solution: Step 1: Identify the deepest and shallowest features.

- The Continental shelf (B) is the shallow, submerged extension of a continent. It is the shallowest feature listed. - The Abyssal plains (C) are the vast, flat, deep regions of the main ocean basin. They are the deepest feature listed.

Step 2: Place the intermediate features.

- The Continental slope (A) is the steep incline that marks the boundary between the continental shelf and the deep ocean basin. - The Continental rise (D) is a wedge of sediment that accumulates at the base of the continental slope. It is therefore deeper than the slope but shallower than the abyssal plain.

Step 3: Form the sequence from shallow to deep. The order starting from the coast and moving to the deep ocean is: Continental shelf (B) $\rightarrow$ Continental slope (A) $\rightarrow$ Continental rise (D) $\rightarrow$ Abyssal plain (C).

Step 4: Reverse the sequence to get the order from deep to shallow. The required order is: Abyssal plain (C) $\rightarrow$ Continental rise (D) $\rightarrow$ Continental slope (A) $\rightarrow$ Continental shelf (B). The sequence is C, D, A, B.

Quick Tip

Visualize walking from a beach into the deep ocean. You walk on the Shelf, then fall down the Slope, land on the pile of sediment at the bottom called the Rise, and then walk out onto the flat Abyssal Plain. The question asks for the reverse order.

---

44. Lithosphere is characterized by _____.

A. A thickness of about 100 km

B. Average density of 3.6 g/cc

C. Silicon and aluminum as dominant constituents

D. Basalt as the dominant rock

(A) A and C only

(B) B and D only

(C) A, B, and D only

(D) A and D only

Correct Answer: (D) (Note: This is the best fit among poor options, likely focusing on oceanic lithosphere)

Solution: Step 1: Analyze statement A.

The lithosphere is the rigid outer layer of the Earth, consisting of the crust and the upper part of the mantle. Its thickness varies but is typically in the range of 50-200 km, so 100 km is a representative average value. Statement A is correct.

Step 2: Analyze statement B.

The average density of continental crust is 2.7 g/cc, oceanic crust is 3.0 g/cc, and the underlying rigid mantle is 3.3 g/cc. A weighted average for the entire lithosphere would be around 3.1-3.2 g/cc. A value of 3.6 g/cc is too high and more representative of the asthenosphere below. Statement B is incorrect.

Step 3: Analyze statement C.

Silicon and aluminum (”SiAl”) are the dominant constituents of the continental crust, but the oceanic crust is dominated by silicon and magnesium (”SiMa”). Since the lithosphere includes both, this statement is not universally true.

Step 4: Analyze statement D.

Basalt is the dominant rock type of the oceanic crust, which covers about 70

Conclusion: A and D are the most accurate statements. Combining them gives the answer ”A and D only”.

Quick Tip

Remember the key distinctions: - Lithosphere: Crust + Rigid Upper Mantle. - Continental Crust: Thicker, less dense, granitic (SiAl). - Oceanic Crust: Thinner, denser, basaltic (SiMa).

---

45. The amount of water vapor generally increases with increase in air temperature. The amount of water vapor in the air at a particular temperature is referred to as

(A) Super saturation

(B) Relative humidity

(C) Absolute humidity

(D) Saturation ratio

Correct Answer: (C)

Solution: Step 1: Define the terms related to humidity.
- Absolute humidity is the actual mass of water vapor present in a given volume of air (e.g., grams per cubic meter). It is a direct measure of the ”amount of water vapor”. - Relative humidity is a ratio, expressed as a percentage, of the amount of water vapor actually in the air compared to the maximum amount the air could hold at that temperature. - Super saturation is an unstable state where the air holds more water vapor than it normally can at a given temperature. - Saturation ratio (or degree of saturation) is a similar concept to relative humidity.

Step 2: Match the definition to the question.
The question asks for the term that refers to the ”amount of water vapor in the air”. This is the definition of absolute humidity.

Quick Tip

- Absolute Humidity: How much water vapor is actually there (mass/volume). - Relative Humidity: How ”full” of water vapor the air is (actual amount / maximum possible amount).

---

46. Match LIST-I with LIST-II

LIST-I (Cloud related prefix)

(A) Cumulus

(B) Nimbus

(C) Cirrus

(D) Stratus

LIST-II (Characteristics)

(I) Rain bearing

(II) Stratified layer

(III) Puffy structure

(IV) Composed of ice crystals

(A) A-IV, B-II, C-III, D-I

(B) A-III, B-I, C-IV, D-II

(C) A-III, B-I, C-II, D-IV

(D) A-I, B-IV, C-III, D-II

Correct Answer: (B)

Solution: Step 1: Analyze Cumulus (A)

'Cumulus' comes from the Latin for 'heap' or 'pile'. These clouds have a puffy, cotton-like appearance with flat bases. Thus, **A matches with (III)**.

Step 2: Analyze Nimbus (B)

'Nimbus' is Latin for 'rain cloud'. When this prefix or suffix is used (e.g., Nimbostratus, Cumulonimbus), it indicates that the cloud is producing precipitation. Thus, **B matches with (I)**.

Step 3: Analyze Cirrus (C)

'Cirrus' is Latin for a 'curl of hair'. These are high-altitude clouds that are thin, wispy, and composed entirely of ice crystals. Thus, **C matches with (IV)**.

Step 4: Analyze Stratus (D)

'Stratus' comes from the Latin for 'layer' or 'sheet'. These clouds are horizontal and layered (stratified). Thus, **D matches with (II)**.

Conclusion: The correct matching is A-III, B-I, C-IV, D-II.

Quick Tip

Remember the Latin roots for cloud types: - Stratus: Layer - Cumulus: Heap - Cirrus: Curl of hair (high, icy) - Nimbus: Rain - Alto: Mid-level

---

47. The effective average solar flux incident to a level surface at top of the atmosphere is _____.

(A) 124 W/m^2

(B) 242 W/m^2

(C) 89 W/m^2

(D) 342 W/m^2

Correct Answer: (D)

Solution: Step 1: Define the Solar Constant.
The solar constant is the total solar radiation energy received from the sun per unit of time per unit of area on a theoretical surface perpendicular to the sun's rays and at a distance of one astronomical unit (AU). Its value is approximately 1361 W/m^2.

Step 2: Understand the "effective average solar flux".
This term refers to the solar constant averaged over the entire spherical surface of the Earth. The Earth intercepts sunlight over its cross-sectional area (πR^2), but this energy is distributed over the planet's full surface area ($4\pi R^2$).

Step 3: Calculate the average flux.

$$\text{Average Flux} = \frac{\text{Solar Constant} \times \text{Cross-sectional Area}}{\text{Total Surface Area}} = \frac{1361 \times \pi R^2}{4\pi R^2} = \frac{1361}{4}$$

$$\text{Average Flux} \approx 340.25 \text{ W/m}^2$$

Step 4: Compare with the options.
The calculated value is approximately 340 W/m^2. The closest option is 342 W/m^2, which is a commonly rounded and used value in climatology.

Quick Tip

A key number in climate science is the globally averaged solar radiation at the top of the atmosphere. It is always the solar constant (≈ 1361 W/m^2) divided by 4, which gives about 340 W/m^2.

---

48. The most common mineral used in U-Pb radiometric dating is _____.

(A) Biotite

(B) Zircon

(C) Hornblende

(D) Quartz

Correct Answer: (B)

Solution: Step 1: Understand the requirements for a good mineral for U-Pb dating.
An ideal mineral for Uranium-Lead dating should readily incorporate uranium (U) into its crystal structure upon formation but strongly reject lead (Pb). This ensures that any lead found within the mineral is almost entirely the product of the radioactive decay of uranium, not from initial contamination. The mineral should also be highly resistant to weathering and metamorphism.

Step 2: Evaluate the options.
(A), (C): Biotite and Hornblende can be used for some radiometric dating (like K-Ar), but they are not ideal for U-Pb because they can lose lead and are less resilient. (B) Zircon ($ZrSiO_4$) is the ideal mineral for U-Pb dating. It readily accepts uranium but excludes lead during crystallization and is extremely durable, surviving multiple geological cycles. This makes it an excellent time capsule for radiometric dating. (D) Quartz (SiO_2) does not incorporate significant amounts of uranium or other radioactive elements into its structure, making it unsuitable for this dating method.

Quick Tip

When you think of U-Pb dating, the primary mineral to remember is Zircon. Its properties of incorporating uranium but rejecting lead, combined with its exceptional durability, make it the gold standard for geochronology.

---

49. Arrange the following significant salts in decreasing order of their percentage in the oceans:

A. $MgCl_2$

B. $CaSO_4$ (assuming typo for $CuSO_4$)

C. $MgSO_4$

D. NaCl

(A) D, B, C, A

(B) D, A, C, B

(C) D, C, A, B

(D) D, B, A, C

Correct Answer: (B)

Solution: Step 1: Recall the major components of sea salt.
Seawater has an average salinity of about 3.5

Step 2: List the major salts by their abundance.
The most common salts, formed from the major ions, are listed below in order of decreasing abundance: 1. Sodium chloride (NaCl) - By far the most abundant, making up over 772. Magnesium chloride ($MgCl_2$) - The second most abundant. 3. Magnesium sulfate ($MgSO_4$) - The third most abundant. 4. Calcium sulfate ($CaSO_4$) - The fourth most abundant. (Note: Copper sulfate, $CuSO_4$, as written in the original question, is a trace component at best and is considered a typo for Calcium sulfate).

Step 3: Form the sequence based on the given letters. The order from most abundant to least abundant is: D (NaCl) $\rightarrow$ A ($MgCl_2$) $\rightarrow$ C ($MgSO_4$) $\rightarrow$ B ($CaSO_4$). The sequence is D, A, C, B.

Quick Tip

Just remember that seawater is overwhelmingly just salty water, so Sodium Chloride (NaCl) will always be first. The next most common positive and negative ions are Magnesium (Mg^{2+}) and Sulfate (SO_4^{2-}), which combine with others to form the next most abundant salts.

---

50. Which of the following were constituents of the famous classical London smog?

A. Smoke

B. Fog

C. SO_2

D. Peroxyacetyl nitrate

E. Ozone

(A) A, B and E only

(B) A, B and C only

(C) A, B, C and D only

(D) A, B, C and E only

Correct Answer: (B)

Solution: Step 1: Define classical (London) smog.
Classical smog, also known as sulfurous smog or industrial smog, is formed primarily from the burning of large amounts of high-sulfur coal in industrial and residential areas. It typically occurs under cold, humid, and calm weather conditions.

Step 2: Identify the key ingredients. - The term ”smog” is a portmanteau of smoke (particulates/soot from burning coal) and fog (water vapor). So, A and B are core components. - The high sulfur content in the coal releases large amounts of sulfur dioxide (SO_2), which is a primary pollutant in this type of smog. SO_2 can further react with water to form sulfuric acid, a major cause of acid rain. So, C is a core component.

Step 3: Differentiate from photochemical smog. - Peroxyacetyl nitrate (PAN) (D) and Ozone (E) are characteristic components of photochemical smog (or Los Angeles-type smog). This type of smog is formed when sunlight reacts with nitrogen oxides and volatile organic compounds from vehicle exhaust. It is oxidizing in nature, whereas London smog is reducing.

Conclusion: The constituents of classical London smog are Smoke (A), Fog (B), and SO_2 (C).

Quick Tip

- London Smog (Classical): Cool, damp, sulfurous. Key ingredients: Smoke, Fog, SO_2.
- L.A. Smog (Photochemical): Hot, sunny, oxidizing. Key ingredients: NOx, VOCs, Sunlight, Ozone, PAN.

---

51. Choose the correct statements about corals?

A. Corals are invertebrate animals a few millimeter in diameter.

B. Corals are sensitive to heat stress and ocean pH change.

C. Corals provide algae with stable environment, CO_2 and nutrients.

D. Corals bleach to get rid themselves of pathogens.

(A) C and D only

(B) A, B and C only

(C) A and B only

(D) A, B, C and D only

Correct Answer: (B)

Solution: Step 1: Analyze statement A.

A coral reef is made of vast colonies of tiny animals called coral polyps. A single polyp is an invertebrate animal, typically only a few millimeters in diameter. Statement A is correct.

Step 2: Analyze statement B.

Corals have a narrow range of environmental tolerances. Increased ocean temperature (heat stress) and decreased pH (ocean acidification) are major stressors that can disrupt their symbiotic relationship with algae and lead to coral bleaching. Statement B is correct.

Step 3: Analyze statement C.

Corals live in a symbiotic relationship with microscopic algae called zooxanthellae. The coral polyp provides the algae with a protected environment and the compounds they need for photosynthesis (CO_2 and nutrients like nitrates and phosphates). Statement C is correct.

Step 4: Analyze statement D.

Coral bleaching is the process where corals expel the symbiotic algae living in their tissues, causing them to turn completely white. This is a stress response, primarily to heat, not a mechanism to get rid of pathogens. The loss of the algae can lead to the coral's death. Statement D is incorrect.

Conclusion: Statements A, B, and C are correct.

Quick Tip

Coral bleaching is a sign of severe stress, not a healthy cleaning process. It's the breakdown of the vital symbiosis between the coral animal and the algae that gives it color and most of its food.

52. Choose the incorrect statement.

(A) Tornado is the smallest, most violent weather disturbance that occur on the earth.

(B) Tornadoes are defined as high pressure center where winds moves into high pressure and move upward.

(C) Tornadoes are of a dark color due to the dominance of dust, sand and condensed moisture.

(D) Tornadoes are funnel shaped storms.

Correct Answer: (B)

Solution: Step 1: Analyze statement A.

Tornadoes are small-scale weather events but are known for having the most violent winds on Earth, making this statement generally accepted as correct.

Step 2: Analyze statement B.

This statement is fundamentally incorrect. Tornadoes are characterized by an extremely low-pressure center. Air spirals violently inward and upward toward this low-pressure core. High-pressure centers are associated with calm, sinking air and fair weather.

Step 3: Analyze statement C.

A tornado's funnel cloud is made visible by condensed water droplets (the cloud itself) and the dust, debris, and soil it picks up from the ground. This gives it its characteristic dark color. This statement is correct.

Step 4: Analyze statement D.

The classic visual appearance of a tornado is a funnel-shaped cloud extending from the base of a thunderstorm to the ground. This statement is correct.

Conclusion: Statement B is incorrect.

Quick Tip

Remember that all major storms (hurricanes, cyclones, tornadoes) are intense low-pressure systems. Air always flows from high pressure to low pressure, so winds rush into a storm's center.

53. Arrange the following greenhouse gases in decreasing order of their contribution to total global warming.

A. Nitrous oxide

B. Carbon dioxide

C. Chlorofluoro carbon

D. Methane

(A) C, A, B, D

(B) A, C, B, D

(C) A, B, C, D

(D) B, D, A, C

Correct Answer: (D)

Solution: Step 1: Understand "contribution to global warming".
This contribution depends on two factors: the gas's atmospheric concentration and its global warming potential (GWP) per molecule. The overall effect is the product of these factors.

Step 2: Rank the gases by their overall contribution. 1. Carbon Dioxide (CO_2): Although it has the lowest GWP of the main greenhouse gases (by definition, GWP=1), its atmospheric concentration is vastly higher than the others, making it the largest contributor to modern global warming (typically over 602. Methane (CH_4): It has a much higher GWP than CO_2 but a lower concentration. It is the second-largest contributor. 3. Nitrous Oxide (N_2O): It has a very high GWP and a longer atmospheric lifetime than methane, but its concentration is lower, making it the third-largest contributor. 4. Chlorofluorocarbons (CFCs) and other halocarbons: They have extremely high GWPs but are present in very small concentrations. Their contribution is smaller than the others listed.

Step 3: Form the sequence. The order in decreasing contribution is: B (Carbon dioxide) $\rightarrow$ D (Methane) $\rightarrow$ A (Nitrous oxide) $\rightarrow$ C (Chlorofluorocarbon). The sequence is B, D, A, C.

Quick Tip

Don't confuse Global Warming Potential (GWP) with overall contribution. While a molecule of methane is more potent than a molecule of CO_2, there are far more CO_2 molecules in the atmosphere, making its total effect the largest.

---

54. Match LIST-I with LIST-II

LIST-I (Atmospheric component)

(A) Nitrogen

(B) Sulphur dioxide

(C) Aerosols

(D) Ozone

LIST-II (Role)

(I) Hypnoxyotic an(t)icle

(II) Photochemical interaction

(III) Retards re-radiation... (Greenhouse Effect)

(IV) Acid rain

(A) A-III, B-II, C-I, D-IV

(B) A-I, B-III, C-II, D-IV

(C) A-III, B-IV, C-I, D-II

(D) A-IV, B-II, C-I, D-II

Correct Answer: (C) (Based on finding the best possible fit for the flawed options)

Solution: Step 1: Find the most definite matches.

- Sulphur dioxide (B) is a primary precursor to Acid rain (IV) when it reacts with water in the atmosphere. This is a strong, direct link. (B $\rightarrow$ IV) - Tropospheric Ozone (D) is a key product and component of Photochemical interaction (II), which creates smog. This is also a strong link. (D $\rightarrow$ II)

Step 2: Check the options for these pairs.

We are looking for an option that contains both B-IV and D-II. - Option (A) has B-II.

Incorrect. - Option (B) has B-III. Incorrect. - Option (C) has B-IV and D-II. This is a potential match. - Option (D) has B-II. Incorrect.

Step 3: Evaluate the remaining matches in the potential option (C).
Option (C) suggests the complete matching: A-III, B-IV, C-I, D-II. - A (Nitrogen) $\rightarrow$ III (Greenhouse Effect). This is incorrect. Nitrogen is not a significant greenhouse gas. - C (Aerosols) $\rightarrow$ I (Hypnoxyotic...). The term in (I) is garbled and likely a typo. Despite the clear errors with A$\rightarrow$III and C$\rightarrow$I, option (C) is the only one that contains the two correct and unambiguous pairings (B$\rightarrow$IV and D$\rightarrow$II). Therefore, it is the intended answer, assuming errors in the other parts of the question.

Quick Tip

When faced with a flawed matching question, identify the most certain and unambiguous pairs first. Then, scan the options to see which one contains those correct pairs. This process of elimination can often lead to the intended answer even if other parts of the question are incorrect.

---

55. According to Koppen's climatic classification, _____ climate prevails in the Great Plains of India.

(A) Af

(B) Am

(C) BS

(D) Cwg

Correct Answer: (D)

Solution: Step 1: Analyze the climate of the Great Plains of India (Indo-Gangetic Plain). This region experiences hot summers, cool winters, and a strong monsoon season where most of the rainfall occurs. Winters are generally dry.

Step 2: Decode the Köppen climate classification codes. - A: Tropical climates. Af = Tropical rainforest, Am = Tropical monsoon. - B: Dry (arid and semi-arid) climates. BS = Semi-arid (steppe). - C: Temperate climates. w = dry winter, g = Ganges type (hottest month

before the summer monsoon). - Cwg: A temperate climate with dry winters and a hot, Ganges-type summer.

Step 3: Match the climate to the code. The description of a temperate climate with hot summers and a distinct dry season (winter) perfectly matches the Cwg classification. This is the code assigned to the majority of the Indo-Gangetic Plain.

Quick Tip

For the Köppen system in India: - Am: West coast (monsoon). - Aw: Most of the peninsula (tropical savanna). - BSh/BWh: Western arid regions (steppe/desert). - Cwg: Indo-Gangetic Plain. - E: Himalayas (polar/tundra).

---

56. Arrange the following in increasing order of their wavelength.

A. gamma radiations

B. X rays

C. UV radiations

D. microwave

E. Infrared radiations

(A) E, D, C, B, A

(B) B, A, C, D, E

(C) A, B, C, E, D

(D) A, B, C, D, E

Correct Answer: (C)

Solution: Step 1: Recall the electromagnetic spectrum.
The electromagnetic spectrum organizes different types of radiation by wavelength, frequency, and energy. Wavelength and frequency/energy are inversely related (short wavelength = high energy).

Step 2: List the main parts of the spectrum in order of increasing wavelength. The standard order is: Gamma rays $\rightarrow$ X-rays $\rightarrow$ Ultraviolet $\rightarrow$ Visible light $\rightarrow$ Infrared $\rightarrow$ Microwaves $\rightarrow$ Radio waves.

Step 3: Apply this order to the given radiations. 1. gamma radiations (A) - Shortest wavelength 2. X rays (B) 3. UV radiations (C) 4. Infrared radiations (E) 5. microwave (D) - Longest wavelength

Step 4: Form the final sequence. The correct sequence for increasing wavelength is A, B, C, E, D.

Quick Tip

A mnemonic for the EM spectrum in order of increasing wavelength is: "Good Xylophones Use Very Interesting Musical Rhythms" (Gamma, X-ray, UV, Visible, Infrared, Microwave, Radio).

---

57. Half life of a radioactive material during radioactive decay is _____.

(A) directly proportional to the initial concentration

(B) inversely proportional to the initial concentration and directly proportional to decay constant

(C) directly proportional to the final concentration and inversely proportional to decay constant

(D) independent of the initial concentration and inversely proportional to decay constant

Correct Answer: (D)

Solution: Step 1: Define radioactive half-life ($t_{1/2}$).

The half-life is the time required for a quantity of a radioactive substance to be reduced to half of its initial value.

Step 2: State the formula relating half-life and the decay constant.

Radioactive decay is a first-order process. The relationship between the half-life and the decay constant (λ) is:

$$t_{1/2} = \frac{\ln(2)}{\lambda}$$

Step 3: Analyze the relationship.

From the formula, we can see two things: 1. The half-life ($t_{1/2}$) is inversely proportional to the decay constant (λ). 2. The formula does not contain any terms for the initial or final concentration/amount of the substance. This means the half-life is independent of these quantities.

Conclusion: The half-life is independent of the initial concentration and inversely proportional to the decay constant.

Quick Tip

A key feature of first-order kinetics (which includes radioactive decay) is that the half-life is constant. It doesn't matter if you start with 1 kg or 1 gram of a substance; the time it takes for half of it to decay is always the same.

---

58. The amount of groundwater is estimated to be _____.

(A) nearly equal to the amount of surface water on the planet Earth

(B) less than the amount of surface water on the planet Earth

(C) twice the amount of surface water on the planet Earth

(D) twenty five times the amount of surface water on the planet Earth

Correct Answer: (D) (Represents the correct order of magnitude difference)

Solution: Step 1: Compare the major reservoirs of Earth's freshwater.
The vast majority of Earth's water is saline (in oceans). Of the small percentage that is freshwater, most is locked up in glaciers and ice caps.

Step 2: Compare liquid freshwater reservoirs.
Of the liquid freshwater, the two main reservoirs are groundwater and surface water (lakes, rivers, swamps, etc.).

Step 3: Estimate the relative amounts.
Groundwater constitutes approximately 30

Step 4: Calculate the approximate ratio and evaluate the options. The ratio of groundwater to surface water is roughly 30Therefore, the amount of groundwater is approximately 25

times the amount of surface freshwater. Option (D) correctly captures this significant difference in magnitude.

Quick Tip

Remember the freshwater distribution: most is frozen in ice caps (∼69

---

59. Match LIST-I with LIST-II

LIST-I (Disease)

(A) Blue baby syndrome

(B) Keshan disease

(C) Gas bubble disease

(D) Itai itai

LIST-II (Cause)

(I) Excess dissolved oxygen in drinking water

(II) Excess Cd in drinking water

(III) Excess nitrate ions in drinking water

(IV) Selenium deficiency

(A) A - I, B - II, C - III, D - IV

(B) A - I, B - III, C - IV, D - II

(C) A - III, B - IV, C - I, D - II

(D) A - III, B - IV, C - II, D - I

Correct Answer: (C)

Solution: Step 1: Analyze Blue baby syndrome (A)

This condition (methemoglobinemia) is caused by decreased oxygen-carrying capacity of hemoglobin. In infants, it is classically linked to high concentrations of nitrate in drinking water. Thus, **A matches with (III)**.

Step 2: Analyze Keshan disease (B)

Keshan disease is a congestive cardiomyopathy (a heart condition) caused by a dietary deficiency of the mineral selenium. Thus, **B matches with (IV)**.

Step 3: Analyze Gas bubble disease (C)

This is a condition primarily affecting aquatic organisms like fish, caused by environmental supersaturation with gases, typically nitrogen or oxygen. This can be considered as ”Excess dissolved oxygen”. Thus, **C matches with (I)**.

Step 4: Analyze Itai-itai disease (D)

”Itai-itai” (Japanese for ”it hurts, it hurts”) is a painful bone disease caused by chronic poisoning from excess cadmium (Cd) in drinking water and food, first identified in Japan. Thus, **D matches with (II)**.

Conclusion: The correct matching is A-III, B-IV, C-I, D-II.

Quick Tip

Associate keywords with these environmental diseases: - Blue Baby $\rightarrow$ Nitrate - Keshan $\rightarrow$ Selenium - Itai-Itai $\rightarrow$ Cadmium - Minamata $\rightarrow$ Mercury

---

60. Choose the correct statements.

A. Dissolution of oxygen in surface water changes with change in temperature during extreme summer and winters.

B. Dissolved oxygen and BOD have inverse relationship in sewage water.

C. Chemical oxygen demand is always higher than BOD in sewage water.

D. More saline water will have less conductivity.

(A) A and B only

(B) A, B and D only

(C) A, B, C and D

(D) A, B and C only

Correct Answer: (D)

Solution: Step 1: Analyze statement A.

The solubility of gases in water is temperature-dependent. Cold water can hold more dissolved oxygen than warm water. Therefore, dissolved oxygen levels change with the seasons. Statement A is correct.

Step 2: Analyze statement B.

Biochemical Oxygen Demand (BOD) is the amount of oxygen consumed by bacteria while decomposing organic waste. In water with high sewage content (high BOD), the decomposition process consumes a large amount of dissolved oxygen, leading to low DO levels. Thus, they have an inverse relationship. Statement B is correct.

Step 3: Analyze statement C.

Chemical Oxygen Demand (COD) measures the oxygen required to oxidize all organic matter (both biodegradable and non-biodegradable) chemically. BOD only measures the biodegradable portion. Therefore, for sewage water, COD is always greater than or equal to BOD. The statement says COD is higher, which is generally true. Statement C is correct.

Step 4: Analyze statement D.

Electrical conductivity in water is due to the presence of dissolved ions (salts). Saline water has a high concentration of dissolved salts, and therefore has a higher conductivity than less saline water. The statement says it will have less conductivity. Statement D is incorrect.

Conclusion: Statements A, B, and C are correct.

Quick Tip

Remember these key water quality relationships: - Temperature & DO: Inverse (Hot water, less oxygen). - BOD & DO: Inverse (High waste, less oxygen). - COD vs BOD: COD $\geq$ BOD (COD measures more stuff). - Salinity & Conductivity: Direct (More salt, more conductive).

---

61. Which of the following is dominantly responsible for buffering capacity of natural water?

(A) carbonate ions

(B) dissolved oxygen

(C) bicarbonate ions

(D) phosphate ions

Correct Answer: (C)

Solution: Step 1: Define buffering capacity.

The buffering capacity of water is its ability to resist changes in pH upon the addition of an acid or a base.

Step 2: Identify the primary buffering system in natural waters.

The most important buffering system in natural aquatic environments is the carbonate system. This system involves the equilibrium between dissolved carbon dioxide (CO_2), carbonic acid (H_2CO_3), bicarbonate ions (HCO_3^-), and carbonate ions (CO_3^{2-}).

Step 3: Determine the dominant species in this system.

In the typical pH range of natural waters (6.5 to 8.5), the bicarbonate ion (HCO_3^-) is the dominant species in the carbonate system. It can neutralize added acids by accepting H^+ to form carbonic acid, and neutralize added bases by donating H^+ to form carbonate ions. This makes it the primary agent responsible for the water's buffering capacity.

Quick Tip

For water chemistry, the carbonate-bicarbonate system is key. Think of bicarbonate (HCO_3^-) as the main workhorse that keeps the pH of rivers and lakes stable.

---

62. Soil acidity can be introduced by _____.

A. Mine tailings rich in pyrites

B. Extraction of Al from its ore

C. Use of nitrogen-rich fertilizers

D. Use of limestone

(A) A, B and D only

(B) A and C only

(C) A, B and C only

(D) A, B, C and D

Correct Answer: (B)

Solution: Step 1: Analyze statement A.

Pyrite (FeS_2) is a sulfide mineral. When exposed to air and water, it oxidizes to form sulfuric acid (H_2SO_4), a strong acid. This process, known as acid mine drainage, drastically increases soil and water acidity. Statement A is a cause of acidity.

Step 2: Analyze statement B.

The primary process for extracting aluminum (Bayer process) involves digesting bauxite ore in a hot solution of sodium hydroxide (a strong base). The waste product, red mud, is highly alkaline, not acidic. Statement B is not a cause of acidity.

Step 3: Analyze statement C.

Ammonium-based nitrogen fertilizers can cause soil acidity through nitrification. Soil bacteria convert ammonium (NH_4^+) to nitrate (NO_3^-), releasing hydrogen ions (H^+) in the process, which lowers the soil pH. Statement C is a cause of acidity.

Step 4: Analyze statement D.

Limestone is calcium carbonate ($CaCO_3$). It is an alkaline material used to neutralize soil acidity by reacting with H^+ ions. It is a treatment for acidity, not a cause. Statement D is not a cause of acidity.

Conclusion: A and C are causes of soil acidity.

Quick Tip

To remember causes of soil acidity, think: - Acid Rain: From industrial pollutants (SOx, NOx). - Mining: Oxidation of sulfides like pyrite. - Fertilizers: Nitrification of ammonium. Limestone (lime) is the cure, not the cause.

---

63. Match LIST I with LIST II

LIST I (Metal)

(A) Manganese

(B) Zinc

(C) Aluminium

(D) Lithium

LIST II (Ore)

(I) Sinsilfuoride (typo)

(II) Gibbsite

(III) Lepidolite

(IV) Psilomelane

(A) A-I, B-II, C-III, D-IV

(B) A-I, B-III, C-II, D-IV

(C) A-IV, B-I, C-II, D-III

(D) A-III, B-IV, C-I, D-II

Correct Answer: (C)

Solution: Step 1: Analyze Aluminium (C)

The primary ore of aluminium is bauxite, which is a rock composed mainly of aluminium hydroxide minerals, the most common of which is Gibbsite. Thus, **C matches with (II)**.

Step 2: Analyze Lithium (D)

Lithium is commercially extracted from several minerals, including spodumene and Lepidolite, which is a lithium-bearing mica. Thus, **D matches with (III)**.

Step 3: Analyze Manganese (A)

Major ores of manganese include pyrolusite and Psilomelane. Thus, **A matches with (IV)**.

Step 4: Analyze Zinc (B)

The main ore of zinc is sphalerite (zinc sulfide). ”Sinsilfuoride” (I) is not a recognized mineral and is likely a typo. By elimination based on the other correct matches, B is paired with I.

Conclusion: The matching is A-IV, C-II, D-III. Option (C) contains this pattern (A-IV, B-I, C-II, D-III).

Quick Tip

Focus on the definite pairs first when matching: - Aluminium $\rightarrow$ Bauxite/Gibbsite - Lithium $\rightarrow$ Lepidolite/Spodumene - Manganese $\rightarrow$ Psilomelane/Pyrolusite - Iron $\rightarrow$ Hematite/Magnetite

64. Arrange the following soil horizons as they occur from top to bottom in a typical soil profile.

A. A horizon

B. B horizon

C. R horizon

D. O horizon

E. C horizon

(A) A, B, C, D, E

(B) D, A, B, E, C

(C) C, E, B, D, A

(D) A, B, E, C, D

Correct Answer: (B)

Solution: Step 1: Define the master soil horizons.
Soil scientists classify soil into layers or horizons. The main (master) horizons are designated by letters.

Step 2: List the horizons in order from the surface downward. 1. O horizon (D): The surface layer, rich in organic matter (leaf litter, humus). 2. A horizon (A): Topsoil, a mix of minerals and humus. Zone of leaching. 3. E horizon (not in this specific list, but often present below A): Zone of eluviation (leaching). 4. B horizon (B): Subsoil, zone of accumulation (illuviation) where minerals and clays from above are deposited. 5. C horizon (E): Parent material, weathered bedrock from which the soil is formed. 6. R horizon (C): Bedrock, the unweathered parent rock.

Step 3: Form the sequence based on the given letters. The correct order from top to bottom is D (O horizon), A (A horizon), B (B horizon), E (C horizon), C (R horizon).

Quick Tip

A simple mnemonic for the main soil horizons from top to bottom is ”Old Ants Eat Big Crumbs of Rock”. (O, A, E, B, C, R).

65. Choose the correct statement.

(A) Excessive nutrient inputs to lakes maintains the high dissolved oxygen of the lakes.

(B) Lakes with extensive algal blooms will have the good health of the lakes.

(C) Eutrophic lakes have high BOD.

(D) Oligotrophic lakes have high BOD compared to eutrophic lakes.

Correct Answer: (C)

Solution: Step 1: Analyze statement A.

Excessive nutrient inputs (eutrophication) cause massive algal blooms. When these algae die, they are decomposed by bacteria, a process that consumes large amounts of dissolved oxygen, leading to hypoxia or anoxia (low or no oxygen). Thus, the statement is incorrect.

Step 2: Analyze statement B.

Extensive algal blooms are a primary symptom of eutrophication, which is a state of poor ecological health for a lake, often leading to fish kills and loss of biodiversity. Thus, the statement is incorrect.

Step 3: Analyze statement C.

Eutrophic lakes are rich in nutrients and have high biological productivity. This leads to a large amount of organic matter (dead algae, etc.) that needs to be decomposed. This decomposition requires a lot of oxygen, meaning the lake has a high Biochemical Oxygen Demand (BOD). This statement is correct.

Step 4: Analyze statement D.

Oligotrophic lakes are nutrient-poor and have low biological productivity. There is little organic matter to decompose, so they have a very low BOD. The statement claims they have high BOD compared to eutrophic lakes, which is the exact opposite of the truth. Thus, the statement is incorrect.

Quick Tip

- Oligotrophic: ”Oligo” = few. Low nutrients, low algae, low BOD, high clarity, high oxygen. Good health. - Eutrophic: ”Eu” = true/good (at growing things). High nutrients, high algae, high BOD, low clarity, low oxygen. Poor health.

---

66. Which one of the following statements is incorrect?

(A) Nitrogen is one of the top five elements found in plants and animals.

(B) Industrial and biological nitrogen fixation require the input of substantial amount of energy.

(C) Nitrogen in organisms is only found in nucleic acids, i.e. DNA and RNA.

(D) Nitrogen is plentiful in the earth’s atmosphere in relatively inert forms.

Correct Answer: (C)

Solution: Step 1: Analyze statement A.

The most abundant elements in living organisms are Oxygen, Carbon, Hydrogen, and Nitrogen. It is a key component, making this statement correct.

Step 2: Analyze statement B.

Breaking the strong triple bond in atmospheric nitrogen (N_2) is an extremely energy-intensive process. Both the industrial Haber-Bosch process and biological nitrogen fixation by bacteria require massive energy inputs. This statement is correct.

Step 3: Analyze statement C.

Nitrogen is a fundamental component of all amino acids, which are the building blocks of proteins. It is also a component of the nitrogenous bases in nucleic acids (DNA and RNA), as well as in other molecules like ATP and chlorophyll. The statement that it is only found in nucleic acids is incorrect.

Step 4: Analyze statement D.

The Earth’s atmosphere is approximately 78

Conclusion: Statement C is the incorrect one.

Quick Tip

Remember the two main biological macromolecules containing nitrogen: Proteins (via amino acids) and Nucleic Acids (via nitrogenous bases). Any statement limiting nitrogen to just one of these is incorrect.

---

67. Condensation of water vapors in atmosphere actually _____.

(A) cools the surrounding

(B) sometime cools and sometimes warms the surrounding

(C) warms the surrounding

(D) neither cools nor warms the surrounding

Correct Answer: (C)

Solution: Step 1: Understand phase changes and energy.

Changing the phase of a substance requires an input or release of energy, known as latent heat. - Melting (solid to liquid) and evaporation (liquid to gas) are endothermic processes; they absorb heat from the surroundings, causing cooling. - Freezing (liquid to solid) and condensation (gas to liquid) are exothermic processes; they release heat into the surroundings, causing warming.

Step 2: Apply this to condensation.

When water vapor (a gas) condenses into liquid water droplets to form clouds, it must release the energy that was required to turn it into a gas in the first place. This released energy is called the latent heat of condensation. This energy is transferred to the surrounding air molecules.

Conclusion: The release of latent heat during condensation warms the surrounding atmosphere. This is a crucial process in the development of storms like hurricanes.

Quick Tip

Think about how you feel when you get out of a pool. The evaporating water on your skin takes heat from your body, making you feel cold. Condensation is the exact opposite process; it releases heat.

---

68. The Prime Minister of India introduced mission LiFE in UN climate change conference of parties (COP) _____ held at _____ in the year _____.

(A) COP-26, Paris, 2021

(B) COP-26, Glasgow, 2020

(C) COP-29, Dubai, 2022

(D) COP-26, Glasgow, 2021

Correct Answer: (D)

Solution: Step 1: Identify the event.

The concept of Mission LiFE (Lifestyle for Environment) was introduced by Indian Prime Minister Narendra Modi.

Step 2: Identify the venue and conference.

This introduction took place at the 2021 United Nations Climate Change Conference, which is also known as COP26.

Step 3: Identify the location and year.

COP26 was held in Glasgow, Scotland, in the year 2021.

Conclusion: The correct combination is COP-26, Glasgow, 2021.

Quick Tip

Associate ”Mission LiFE” with India’s major announcement at the Glasgow COP26 climate summit in 2021.

---

69. Which of the following are criteria pollutants under national ambient air quality standards?

A. $PM_{2.5}$

B. NO_x

C. Lead

D. Methane

E. Sulphur dioxide

(A) A, B and D only

(B) A, B and C only

(C) A, C and E only

(D) A, B, C and E only

Correct Answer: (D)

Solution: Step 1: Define ”Criteria Pollutants”.
Criteria air pollutants are a set of common air pollutants that are regulated by national environmental agencies because they can harm public health and the environment.

Step 2: List the criteria pollutants in India (under NAAQS).
India’s National Ambient Air Quality Standards (NAAQS) regulate 12 pollutants: PM_{10}, $PM_{2.5}$ (A), Sulphur Dioxide (SO_2) (E), Nitrogen Dioxide (NO_2) (B, as part of NO_x), Ozone (O_3), Carbon Monoxide (CO), Lead (Pb) (C), Ammonia (NH_3), Benzene, Benzo(a)Pyrene, Arsenic, and Nickel.

Step 3: Evaluate the given options against the list. - A ($PM_{2.5}$), B (NO_x), C (Lead), and E (Sulphur dioxide) are all on the list. - D (Methane) is a major greenhouse gas but is not regulated as a criteria pollutant for direct ambient air quality in the same way.

Conclusion: The correct combination from the options is A, B, C, and E.

Quick Tip

The main six criteria pollutants focused on globally are CO, Pb, NO_2, O_3, PM ($PM_{2.5}$/PM_{10}), and SO_2. Methane is usually discussed in the context of climate change, not direct air quality standards.

70. Which one of the following states in India is known to have the highest Chromium pollution of water and soils due to tanning industry?

(A) Uttar Pradesh

(B) Andhra Pradesh

(C) Tamil Nadu

(D) Maharashtra

Correct Answer: (C)

Solution: Step 1: Identify the link between tanning and chromium.
Chromium, particularly hexavalent chromium, is extensively used in the leather tanning process. Improper disposal of tannery effluent is a major source of chromium contamination in soil and water.

Step 2: Identify major leather tanning hubs in India.
India has several major centers for the leather industry. The most prominent are Kanpur in Uttar Pradesh and a large cluster in Tamil Nadu (including cities like Vellore, Ambur, and Dindigul).

Step 3: Evaluate the states known for pollution from this industry.
While Kanpur (Uttar Pradesh) is also heavily polluted, the state of Tamil Nadu has a massive concentration of tanneries and a long-documented history of severe and widespread chromium pollution in the Palar river basin, making it the most cited example for this specific environmental issue in India.

Quick Tip

When thinking about industrial pollution in India, associate: - Tanneries/Chromium: Tamil Nadu (Vellore), Uttar Pradesh (Kanpur) - Textile Dyes: Tamil Nadu (Tiruppur) - Mercury: Kodaikanal (from a specific factory)

---

71. Arrange the following layers of atmosphere starting from earth's surface.

A. Troposphere

B. Stratosphere

C. Tropopause

D. Stratopause

E. Mesosphere

(A) A, B, C, D, E

(B) A, D, B, C, E

(C) A, C, B, D, E

(D) A, C, B, E, D

Correct Answer: (C)

Solution: Step 1: Identify the main atmospheric layers.
The atmosphere is divided into layers based on temperature profiles. The main layers from the ground up are the Troposphere, Stratosphere, Mesosphere, and Thermosphere.

Step 2: Identify the boundary regions ('pauses').
The 'pauses' are the boundaries that separate the main layers. The tropopause separates the troposphere and stratosphere. The stratopause separates the stratosphere and mesosphere.

Step 3: Construct the sequence from the Earth's surface upwards. 1. Troposphere (A): The lowest layer, where we live and weather occurs. 2. Tropopause (C): The boundary at the top of the troposphere. 3. Stratosphere (B): The layer above the troposphere, containing the ozone layer. 4. Stratopause (D): The boundary at the top of the stratosphere. 5. Mesosphere (E): The layer above the stratosphere.

Conclusion: The correct order from the surface up is A, C, B, D, E.

Quick Tip

A mnemonic for the layers is "Trust Me in The Exam": Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere. The 'pauses' are the ceilings of the layers below them (e.g., Tropopause is the top of the Troposphere).

---

72. Match LIST-I with LIST-II

LIST-I (Person)

(A) Anna Hazare

(B) Rajender Singh

(C) Chandi Prasad Bhatt

(D) Medha Patkar

LIST-II (Movement)

(I) Narmada Bachao Andolan

(II) Tarun Bharat Sangh

(III) Chipko movement

(IV) Ralegan Siddhi Watershed Development

(A) A-IV, B-II, C-III, D-I

(B) A-I, B-III, C-II, D-IV

(C) A-I, B-II, C-IV, D-III

(D) A-III, B-IV, C-I, D-II

Correct Answer: (A)

Solution: Step 1: Analyze Anna Hazare (A)

While famous for his anti-corruption activism, Anna Hazare's foundational work was in transforming his drought-prone village, Ralegan Siddhi, through community-based watershed development. Thus, **A matches with (IV)**.

Step 2: Analyze Rajender Singh (B)

Rajender Singh, known as the "waterman of India," is renowned for his water conservation efforts in Rajasthan, primarily through the NGO Tarun Bharat Sangh. Thus, **B matches with (II)**.

Step 3: Analyze Chandi Prasad Bhatt (C)

Chandi Prasad Bhatt is an Indian environmentalist and social activist, who was one of the pioneers of the Chipko movement in the 1970s. Thus, **C matches with (III)**.

Step 4: Analyze Medha Patkar (D)

Medha Patkar is a social activist best known as a founding member of the large-scale social movement, Narmada Bachao Andolan (Save the Narmada Movement). Thus, **D matches with (I)**.

Conclusion: The correct matching is A-IV, B-II, C-III, D-I.

Quick Tip

Associate these key figures with their movements: - Medha Patkar → Narmada River - Chandi Prasad Bhatt / Sunderlal Bahuguna → Chipko (Hugging Trees) - Rajender Singh → Water / Tarun Bharat Sangh - Anna Hazare → Ralegan Siddhi / Anti-corruption

---

73. Match LIST-I with LIST-II

LIST-I (Type of Rock)

(A) Non-foliated metamorphic rock

(B) Foliated metamorphic rock

(C) Igneous rock

(D) Sedimentary rock

LIST-II (Characteristics/example)

(I) Dolomite

(II) Rhyolite

(III) Ornate Gneiss (Gneiss)

(IV) Quartzite

(A) A-II, B-IV, C-III, D-I

(B) A-I, B-III, C-IV, D-II

(C) A-IV, B-III, C-II, D-I

(D) A-IV, B-II, C-III, D-I

Correct Answer: (C)

Solution: Step 1: Analyze Non-foliated metamorphic rock (A)

These rocks lack a layered or banded appearance. Quartzite, formed from sandstone, is a classic example. Thus, **A matches with (IV)**.

Step 2: Analyze Foliated metamorphic rock (B)

These rocks have a layered appearance due to the parallel alignment of minerals. Gneiss is a high-grade foliated rock with distinct banding. Thus, **B matches with (III)**.

Step 3: Analyze Igneous rock (C)

Igneous rocks are formed from the cooling of magma or lava. Rhyolite is a volcanic (extrusive) igneous rock. Thus, **C matches with (II)**.

Step 4: Analyze Sedimentary rock (D)

Sedimentary rocks are formed from the accumulation of sediments. Dolomite (or Dolostone) is a sedimentary carbonate rock. Thus, **D matches with (I)**.

Conclusion: The correct matching is A-IV, B-III, C-II, D-I.

Quick Tip

Remember key examples for each rock type: - Igneous: Granite (intrusive), Basalt/Rhyolite (extrusive). - Sedimentary: Sandstone, Limestone, Shale, Dolomite. - Metamorphic: Marble (from limestone), Quartzite (from sandstone), Slate (from shale), Gneiss (foliated).

---

74. Mohorovicic discontinuity is commonly defined as the depth at which _____.

(A) the p-wave velocity decreases to 5.6 km/sec

(B) the p-wave velocity exceeds 7.6 km/sec

(C) the s-wave velocity exceeds 3.57 km/sec

(D) the p and s waves exceed 5.6 km/sec and 3.57 km/sec respectively

Correct Answer: (B)

Solution: Step 1: Define the Mohorovičić Discontinuity (Moho).

The Moho is the boundary surface between the Earth's crust and the mantle.

Step 2: Describe how it is identified.

It is identified by a distinct and rapid increase in the velocity of seismic waves (both P-waves and S-waves). This is because the mantle below is significantly denser and more rigid than the crust above.

Step 3: Quantify the velocity change.

P-wave (primary wave) velocity in the lower crust is typically 6.7–7.2 km/s. Upon crossing the Moho into the mantle, it abruptly increases to 7.6–8.6 km/s. Therefore, the depth where the P-wave velocity sharply increases to over 7.6 km/s is the defining characteristic of the Moho.

Conclusion: Option (B) provides the best description of this seismic velocity jump.

Quick Tip

Moho = Boundary between Crust and Mantle. It's defined by seismic waves suddenly speeding up. Specifically, P-waves jump from ∼7 km/s to ∼8 km/s.

---

75. Ozone in the stratosphere captures _____ and protects us from harmful effects.

(A) UV A, UV B and UV C radiations completely

(B) UV A and UV B radiations completely

(C) UV B partially and UV C radiations completely

(D) UV A completely and UV B and UV C radiations partially

Correct Answer: (C)

Solution: Step 1: Identify the types of UV radiation.
Ultraviolet radiation from the sun is classified into three types based on wavelength: UV-A (longest wavelength), UV-B (medium), and UV-C (shortest wavelength, most energetic).

Step 2: Describe the interaction of each type with the ozone layer.
- UV-C: This is the most harmful type of UV radiation. The stratospheric ozone layer is extremely effective at absorbing it, so virtually none reaches the Earth's surface. It is absorbed completely. - UV-B: This radiation is also very harmful. The ozone layer absorbs a significant portion (around 95- UV-A: This is the least energetic type of UV radiation. The ozone layer absorbs very little of it, and most of it reaches the surface.

Conclusion: The most accurate description is that the ozone layer absorbs UV-C completely and UV-B partially.

Quick Tip

Remember the ozone layer's effectiveness: - UV-C: Completely blocked. - UV-B: Mostly Blocked (partially absorbed). - UV-A: Allows through (mostly unabsorbed).
