

Jharkhand Polytechnic 2026

Question Paper with Solutions (Memory-Based)

Conducted by JCECEB



General Instructions

- (i) Jharkhand Polytechnic 2026 consists of 150 questions for 150 marks to be attempted in 150 minutes.
- (ii) Jharkhand Polytechnic question paper is divided into 3 sections- Physics, Chemistry and Mathematics.
- (iii) Each Section Contains 50 questions.
- (iv) Each question carries 1 mark and there is negative marking of 0.25 for incorrect answers.

1. From the following phenomenon, which one cannot be explained by assuming light always travels in straight line ?

- (A) Refraction
- (B) Reflection
- (C) Diffraction
- (D) Transmission

Correct Answer: (C) Diffraction

Solution:

Step 1: Understanding the Question:

The question asks which optical phenomenon requires a model other than rectilinear propagation (straight-line travel) of light to be explained.

Step 2: Detailed Explanation:

Phenomena such as reflection, refraction, and transmission can be easily explained using geometric optics, which assumes light travels in straight lines (rays).

Diffraction refers to the bending of light around the edges of an obstacle or an aperture into the region of geometrical shadow.

This phenomenon explicitly demonstrates the wave nature of light and cannot be explained by rectilinear propagation.

Step 3: Final Answer:

Diffraction is the phenomenon that cannot be explained by assuming light always travels in a straight line.

Quick Tip: Diffraction implies bending of waves around corners, a hallmark of wave optics, unlike ray optics which assumes rectilinear propagation of light.

2. The discoverer of the nucleus of an atom is

- (A) Goldstein
- (B) Rutherford
- (C) Thomson
- (D) Chadwick

Correct Answer: (B) Rutherford

Solution:

Step 1: Understanding the Question:

The question asks to identify the scientist who is credited with the discovery of the atomic nucleus.

Step 2: Detailed Explanation:

In 1911, Ernest Rutherford, along with his colleagues Hans Geiger and Ernest Marsden, conducted the famous gold foil experiment (also known as the alpha particle scattering experiment).

They fired a beam of positively charged alpha particles at a very thin sheet of gold foil.

While most particles passed straight through the foil, a small fraction were deflected at large angles, and some even bounced almost straight back.

To explain these unexpected results, Rutherford proposed a new model of the atom.

He concluded that most of the atom is empty space, which is why most alpha particles passed through undeflected.

However, the large deflections meant there must be a tiny, dense, positively charged center

within the atom that repelled the alpha particles.

Rutherford named this central region the "nucleus."

For the other options:

Goldstein discovered canal rays (positive ions), which paved the way for the discovery of the proton.

J.J. Thomson discovered the electron.

James Chadwick discovered the neutron.

Step 3: Final Answer:

The nucleus of an atom was discovered by Rutherford.

Quick Tip: Remember these key atomic discoveries to easily solve such questions:

Thomson → Electron

Rutherford → Nucleus (via Gold Foil Experiment)

Chadwick → Neutron

3. Kirchhoff current law is based on the conservation of

- (A) None of these
- (B) Charge
- (C) Mass
- (D) Momentum

Correct Answer: (B) Charge

Solution:

Step 1: Understanding the Question:

The question asks which fundamental conservation principle forms the basis of Kirchhoff's Current Law (KCL).

Step 2: Key Formula or Approach:

Kirchhoff's Current Law states that the algebraic sum of currents entering and leaving any node (or junction) in an electrical circuit is zero:

$$\sum I = 0$$

Step 3: Detailed Explanation:

Electric current is defined as the rate of flow of electric charge over time ($I = \frac{dQ}{dt}$).

According to KCL, the total current entering a junction must exactly equal the total current leaving that junction.

This implies that electric charge cannot accumulate at a junction, nor can it be created or destroyed there.

This behavior is a direct physical consequence of the law of conservation of electric charge.

Step 4: Final Answer:

Kirchhoff's current law is based on the conservation of charge.

Quick Tip: Remember the two Kirchhoff's laws: **KCL (Junction Rule)** is based on the conservation of Charge, while **KVL (Loop Rule)** is based on the conservation of Energy.

4. A moving electron produces-

- (A) Electric field only
- (B) Magnetic field only
- (C) Both electric and magnetic field
- (D) None of these

Correct Answer: (C) Both electric and magnetic field

Solution:

Step 1: Understanding the Question:

We need to determine the types of physical fields generated by an electron when it is in motion.

Step 2: Detailed Explanation:

An electron is a fundamental subatomic particle carrying a negative electric charge.

Because of this intrinsic electric charge, it always produces an electric field in the space surrounding it, regardless of whether it is stationary or moving.

When the electron starts moving, its flow constitutes an electric current.

According to the foundational principles of electromagnetism (such as Ampere's Law), any moving charge or electric current naturally generates a magnetic field around its path.

Therefore, a moving electron simultaneously produces both an electric field (due to its charge)

and a magnetic field (due to its motion).

Step 3: Final Answer:

A moving electron produces both electric and magnetic fields.

Quick Tip: Keep this hierarchy in mind:

1. **Stationary charge:** Produces only an Electric Field.
2. **Moving charge (constant velocity):** Produces both Electric and Magnetic Fields.
3. **Accelerating charge:** Produces Electric Fields, Magnetic Fields, and radiates Electromagnetic Waves.

5. What type of mirror is used to get virtual and erect image always ?

- (A) Plane mirror
- (B) Convex mirror
- (C) Concave mirror
- (D) Both A) and B)

Correct Answer: (D) Both A) and B)

Solution:

Step 1: Understanding the Question:

We need to identify which type(s) of mirror will unconditionally produce a virtual and erect image, regardless of the object's position.

Step 2: Detailed Explanation:

A plane mirror always forms a virtual, erect image of the exact same size as the object, no matter what the object distance is.

A convex mirror always forms a virtual, erect, and diminished image of the object, regardless of where the object is placed in front of it.

A concave mirror can form both real (inverted) and virtual (erect) images depending on the object's position, so it does not "always" form a virtual image.

Because both plane and convex mirrors always produce virtual and erect images under all real object conditions, options (A) and (B) are both correct statements.

Step 3: Final Answer:

Both plane and convex mirrors are used to always obtain a virtual and erect image.

Quick Tip: Rear-view mirrors in vehicles are always **convex mirrors** because they invariably produce virtual, erect, and diminished images, providing a much wider field of view than a plane mirror.

6. How power of the lens is related to focal length of the lens ?

- (A) Directly proportional to f
- (B) Directly proportional to $\frac{1}{f}$
- (C) Directly proportional to $\sqrt{f}$
- (D) Directly proportional to $\frac{1}{f^2}$

Correct Answer: (B) Directly proportional to $\frac{1}{f}$

Solution:

Step 1: Understanding the Question:

The question asks for the mathematical relationship between the optical power of a lens and its focal length.

Step 2: Key Formula or Approach:

The power P of a lens is defined as the reciprocal of its focal length f when measured in meters.

$$P = \frac{1}{f}$$

Step 3: Detailed Explanation:

Power is a measure of the degree of convergence or divergence of light rays falling on a lens. A lens with a shorter focal length bends the light rays more sharply, meaning it has a greater optical power.

Hence, the power is inversely proportional to the focal length f , which is mathematically stated as being directly proportional to $\frac{1}{f}$.

Step 4: Final Answer:

The power of a lens is directly proportional to $\frac{1}{f}$.

Quick Tip: The SI unit of optical power is the **Diopter (D)**, where $1 \text{ D} = 1 \text{ m}^{-1}$. Always ensure the focal length is converted to **meters** before calculating power in Diopters.

7. If $x = a \tan \theta$ and $y = b \sec \theta$, then $\frac{y^2}{b^2} - \frac{x^2}{a^2} =$

- (A) -1
- (B) $\sin \theta$
- (C) 1
- (D) None of these

Correct Answer: (C) 1

Solution:

Step 1: Understanding the Question:

We are given two trigonometric equations involving x and y . We need to find the value of the algebraic expression $\frac{y^2}{b^2} - \frac{x^2}{a^2}$ by substituting the given values.

Step 2: Key Formula or Approach:

The relevant fundamental trigonometric identity is:

$$\sec^2 \theta - \tan^2 \theta = 1$$

Step 3: Detailed Explanation:

From the given equations, we can express $\tan \theta$ and $\sec \theta$ as follows:

$$x = a \tan \theta \implies \frac{x}{a} = \tan \theta$$

$$y = b \sec \theta \implies \frac{y}{b} = \sec \theta$$

Now, substitute these into the given expression $\frac{y^2}{b^2} - \frac{x^2}{a^2}$:

$$\frac{y^2}{b^2} - \frac{x^2}{a^2} = \left(\frac{y}{b}\right)^2 - \left(\frac{x}{a}\right)^2$$

Substitute $\frac{y}{b}$ and $\frac{x}{a}$:

$$= (\sec \theta)^2 - (\tan \theta)^2$$

$$= \sec^2 \theta - \tan^2 \theta$$

Using the standard trigonometric identity, this is equal to 1.

Step 4: Final Answer:

The value of the expression is 1.

Quick Tip: Always isolate the trigonometric ratios (sin, cos, tan, etc.) and look for standard Pythagorean identities like $\sec^2 \theta - \tan^2 \theta = 1$ to simplify the expression quickly.

8. The decimal expansion of $\frac{141}{120}$ will terminate after how many places of decimals ?

- (A) 3
- (B) 4
- (C) 1
- (D) 2

Correct Answer: (A) 3

Solution:

Step 1: Understanding the Question:

We need to find the number of decimal places after which the rational number $\frac{141}{120}$ terminates.

Step 2: Key Formula or Approach:

For a rational number in its simplest form $\frac{p}{q}$, if the prime factorization of the denominator q is of the form $2^n \times 5^m$ (where n and m are non-negative integers), then the decimal expansion terminates after $\max(n, m)$ decimal places.

Step 3: Detailed Explanation:

First, we reduce the given fraction to its simplest form. Both the numerator and the denominator are divisible by 3:

$$\frac{141}{120} = \frac{141 \div 3}{120 \div 3} = \frac{47}{40}$$

Next, find the prime factorization of the new denominator, 40:

$$40 = 8 \times 5 = 2^3 \times 5^1$$

Here, the power of 2 is 3 (i.e., $n = 3$) and the power of 5 is 1 (i.e., $m = 1$). The maximum of n and m is $\max(3, 1) = 3$. Therefore, the decimal expansion will terminate after 3 places.

Step 4: Final Answer:

The decimal expansion terminates after 3 places of decimals.

Quick Tip: Never analyze the denominator without first reducing the fraction to its lowest terms!
Forgetting to cancel common factors is the most common mistake in these problems.

9. If $A(1, 3)$, $B(-1, 4)$, $C(2, 5)$ and $D(x, 4)$ are the vertices of parallelogram ABCD, then the value of x is

- (A) 3
- (B) $3/2$
- (C) 0
- (D) 4

Correct Answer: (D) 4

Solution:

Step 1: Understanding the Question:

The coordinates of four vertices of a parallelogram are given in order. We have to find the missing x-coordinate of the fourth vertex.

Step 2: Key Formula or Approach:

The diagonals of a parallelogram bisect each other. Therefore, the midpoint of diagonal AC must be exactly the same as the midpoint of diagonal BD. The midpoint (x_m, y_m) of a line segment connecting (x_1, y_1) and (x_2, y_2) is given by:

$$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2} \right)$$

Step 3: Detailed Explanation:

The vertices are $A(1, 3)$, $B(-1, 4)$, $C(2, 5)$, and $D(x, 4)$. Calculate the midpoint of diagonal AC:

$$\text{Midpoint of AC} = \left(\frac{1+2}{2}, \frac{3+5}{2} \right) = \left(\frac{3}{2}, \frac{8}{2} \right) = \left(\frac{3}{2}, 4 \right)$$

Calculate the midpoint of diagonal BD:

$$\text{Midpoint of BD} = \left(\frac{-1+x}{2}, \frac{4+4}{2} \right) = \left(\frac{x-1}{2}, \frac{8}{2} \right) = \left(\frac{x-1}{2}, 4 \right)$$

Since the midpoints must coincide, we equate the x-coordinates:

$$\frac{3}{2} = \frac{x-1}{2}$$

Multiply both sides by 2:

$$3 = x - 1$$

$$x = 4$$

Step 4: Final Answer:

The value of x is 4.

Quick Tip: For any parallelogram with consecutive vertices $(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4)$, a quick shortcut is $x_1 + x_3 = x_2 + x_4$ and $y_1 + y_3 = y_2 + y_4$.

10. The simplest form of $\sec^2 \theta - \frac{1}{\operatorname{cosec}^2 \theta - 1}$ is

- (A) $\sec \theta$
- (B) $\operatorname{cosec} \theta$
- (C) 0
- (D) 1

Correct Answer: (D) 1

Solution:

Step 1: Understanding the Question:

We need to simplify the given trigonometric expression using standard trigonometric identities.

Step 2: Key Formula or Approach:

We will use the Pythagorean trigonometric identities: 1) $\operatorname{cosec}^2 \theta - \cot^2 \theta = 1 \implies \operatorname{cosec}^2 \theta - 1 = \cot^2 \theta$ 2) $\sec^2 \theta - \tan^2 \theta = 1$ Also, the reciprocal identity: $\frac{1}{\cot^2 \theta} = \tan^2 \theta$.

Step 3: Detailed Explanation:

Given expression:

$$\sec^2 \theta - \frac{1}{\operatorname{cosec}^2 \theta - 1}$$

Substitute $\operatorname{cosec}^2 \theta - 1 = \cot^2 \theta$ in the denominator:

$$= \sec^2 \theta - \frac{1}{\cot^2 \theta}$$

Since $\frac{1}{\cot \theta} = \tan \theta$, we have $\frac{1}{\cot^2 \theta} = \tan^2 \theta$. Substituting this gives:

$$= \sec^2 \theta - \tan^2 \theta$$

By the fundamental trigonometric identity, $\sec^2 \theta - \tan^2 \theta = 1$.

Step 4: Final Answer:

The simplified form of the expression is 1.

Quick Tip: Whenever you see squared trigonometric terms with 1 added or subtracted in the denominator, think immediately of the three Pythagorean identities to simplify the fraction.

11. The radii of the circular ends of a bucket of height 15 cm are 14 cm and r cm ($r < 14$ cm). If the volume of bucket is 5390 cm^3 , then find the value of r . [Use $\pi = \frac{22}{7}$]

- (A) 6 cm
- (B) 7 cm
- (C) 13 cm
- (D) 8 cm

Correct Answer: (B) 7 cm

Solution:

Step 1: Understanding the Question:

A bucket is mathematically a frustum of a cone. We are given the volume, height, and one of the radii. We need to find the other radius r .

Step 2: Key Formula or Approach:

The volume V of a frustum of a cone is given by:

$$V = \frac{1}{3} \pi h (R^2 + r^2 + Rr)$$

where h is the height, and R and r are the radii of the two circular ends.

Step 3: Detailed Explanation:

Given values: Volume $V = 5390 \text{ cm}^3$, Height $h = 15 \text{ cm}$, Upper radius $R = 14 \text{ cm}$. Substitute

these values into the volume formula:

$$5390 = \frac{1}{3} \times \frac{22}{7} \times 15 \times (14^2 + r^2 + 14r)$$

Simplify the constants:

$$5390 = \frac{22}{7} \times 5 \times (196 + r^2 + 14r)$$

$$5390 = \frac{110}{7} \times (196 + r^2 + 14r)$$

Isolate the term in the parentheses:

$$196 + r^2 + 14r = 5390 \times \frac{7}{110}$$

$$196 + r^2 + 14r = 49 \times 7$$

$$196 + r^2 + 14r = 343$$

Rearrange into a standard quadratic equation:

$$r^2 + 14r + 196 - 343 = 0$$

$$r^2 + 14r - 147 = 0$$

Factor the quadratic equation by splitting the middle term. We need two numbers that multiply to -147 and add to 14 . Those numbers are 21 and -7 .

$$r^2 + 21r - 7r - 147 = 0$$

$$r(r + 21) - 7(r + 21) = 0$$

$$(r - 7)(r + 21) = 0$$

This gives $r = 7$ or $r = -21$. Since radius cannot be negative, we discard -21 . Thus, $r = 7$ cm.

Step 4: Final Answer:

The value of the radius r is 7 cm.

Quick Tip: To avoid complex quadratic factoring, you can plug in the given options into $R^2 + r^2 + Rr$ and check which one equals 343. For $r = 7$, $14^2 + 7^2 + (14 \times 7) = 196 + 49 + 98 = 343$. This saves a lot of time!

12. If the mean of the following frequency distribution is 65.6, then find the missing frequencies (f_1, f_2) .

Class	Frequency
10 – 30	5
30 – 50	8
50 – 70	f_1
70 – 90	20
90 – 110	f_2
110 – 130	2
Total	50

- (A) $(f_1, f_2) = (11, 4)$
(B) $(f_1, f_2) = (12, 3)$
(C) $(f_1, f_2) = (9, 6)$
(D) $(f_1, f_2) = (10, 5)$

Correct Answer: (B) $(f_1, f_2) = (12, 3)$

Solution:

Step 1: Understanding the Question:

We are given a grouped frequency distribution with two unknown frequencies. We know the total frequency and the mean of the distribution, which allows us to set up two simultaneous linear equations.

Step 2: Key Formula or Approach:

The sum of all frequencies $\Sigma f_i = 50$. The mean of grouped data is given by $\bar{x} = \frac{\Sigma f_i x_i}{\Sigma f_i}$, where x_i is the class mark (midpoint) of each class.

Step 3: Detailed Explanation:

First, use the total frequency to form the first equation:

$$5 + 8 + f_1 + 20 + f_2 + 2 = 50$$

$$35 + f_1 + f_2 = 50 \implies f_1 + f_2 = 15 \quad \text{--- (Equation 1)}$$

Next, find the class marks (x_i) and calculate $f_i x_i$:

- For $10 - 30$, $x_i = 20$, $f_i x_i = 5 \times 20 = 100$
- For $30 - 50$, $x_i = 40$, $f_i x_i = 8 \times 40 = 320$
- For $50 - 70$, $x_i = 60$, $f_i x_i = 60f_1$
- For $70 - 90$, $x_i = 80$, $f_i x_i = 20 \times 80 = 1600$
- For $90 - 110$, $x_i = 100$, $f_i x_i = 100f_2$
- For $110 - 130$, $x_i = 120$, $f_i x_i = 2 \times 120 = 240$

Now, sum the $f_i x_i$ column:

$$\Sigma f_i x_i = 100 + 320 + 1600 + 240 + 60f_1 + 100f_2 = 2260 + 60f_1 + 100f_2$$

Apply the mean formula:

$$\bar{x} = \frac{\Sigma f_i x_i}{\Sigma f_i} = 65.6$$

$$\frac{2260 + 60f_1 + 100f_2}{50} = 65.6$$

$$2260 + 60f_1 + 100f_2 = 65.6 \times 50$$

$$2260 + 60f_1 + 100f_2 = 3280$$

$$60f_1 + 100f_2 = 3280 - 2260 = 1020$$

Divide the entire equation by 20 to simplify:

$$3f_1 + 5f_2 = 51 \quad \text{--- (Equation 2)}$$

Now solve Equation 1 and Equation 2 simultaneously. Multiply Equation 1 by 3:

$$3f_1 + 3f_2 = 45 \quad \text{--- (Equation 3)}$$

Subtract Equation 3 from Equation 2:

$$(3f_1 + 5f_2) - (3f_1 + 3f_2) = 51 - 45$$

$$2f_2 = 6 \implies f_2 = 3$$

Substitute $f_2 = 3$ back into Equation 1:

$$f_1 + 3 = 15 \implies f_1 = 12$$

So, $(f_1, f_2) = (12, 3)$.

Step 4: Final Answer:

The missing frequencies are $f_1 = 12$ and $f_2 = 3$.

Quick Tip: In multiple-choice questions involving simultaneous equations, once you derive $f_1 + f_2 = 15$, you can quickly eliminate options that do not sum to 15. Here, all options sum to 15, so evaluating the second condition is necessary.

13. If the distance between the points $(x, -1)$ and $(3, 2)$ is 5, then the value of x is

- (A) 7, -1
- (B) -7, 1
- (C) -7, -1
- (D) 7, 1

Correct Answer: (A) 7, -1

Solution:

Step 1: Understanding the Question:

We are given two points where one coordinate is unknown (x). The distance between these points is provided, and we need to solve for x .

Step 2: Key Formula or Approach:

The distance d between any two points (x_1, y_1) and (x_2, y_2) is given by the distance formula:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Step 3: Detailed Explanation:

Given points are $(x, -1)$ and $(3, 2)$, and the distance $d = 5$. Substituting these into the formula

gives:

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

Square both sides to remove the square root:

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

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

$$25 = (3-x)^2 + 9$$

Subtract 9 from both sides:

$$16 = (3-x)^2$$

Take the square root of both sides. Remember to include both positive and negative roots:

$$3-x = \pm 4$$

This gives two possible equations: 1) $3-x = 4 \implies -x = 1 \implies x = -1$ 2)

$3-x = -4 \implies -x = -7 \implies x = 7$ So, the possible values for x are 7 and -1 .

Step 4: Final Answer:

The values of x are 7, -1 .

Quick Tip: When solving distance problems, you are essentially dealing with the Pythagorean theorem. Note that a hypotenuse of 5 often pairs with legs of 3 and 4. Here, the y-difference is 3, so the x-difference must be ± 4 , yielding $3 \pm 4 = 7$ or -1 almost instantly!

14. The graph of the linear equations $3x + y = 7$ and $6x + 2y = 8$ represents two lines, which are

- (A) Coincident
- (B) Parallel
- (C) Intersecting exactly at the point
- (D) Perpendicular to each other

Correct Answer: (B) Parallel

Solution:

Step 1: Understanding the Question:

We need to determine the geometric relationship (intersecting, parallel, or coincident) between the lines represented by the given pair of linear equations in two variables.

Step 2: Key Formula or Approach:

For two linear equations of the form $a_1x + b_1y + c_1 = 0$ and $a_2x + b_2y + c_2 = 0$:

- If $\frac{a_1}{a_2} \neq \frac{b_1}{b_2}$, the lines intersect.
- If $\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$, the lines are coincident.
- If $\frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2}$, the lines are parallel.

Step 3: Detailed Explanation:

First, rewrite the equations in standard form: 1) $3x + y - 7 = 0 \implies a_1 = 3, b_1 = 1, c_1 = -7$
2) $6x + 2y - 8 = 0 \implies a_2 = 6, b_2 = 2, c_2 = -8$ Now, compute the ratios of the coefficients:

$$\frac{a_1}{a_2} = \frac{3}{6} = \frac{1}{2}$$

$$\frac{b_1}{b_2} = \frac{1}{2}$$

$$\frac{c_1}{c_2} = \frac{-7}{-8} = \frac{7}{8}$$

Observing the ratios, we can clearly see that:

$$\frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2} \quad \left(\text{since } \frac{1}{2} = \frac{1}{2} \neq \frac{7}{8} \right)$$

This condition signifies that the system of equations has no solution, which graphically implies that the two lines are parallel.

Step 4: Final Answer:

The two lines are parallel.

Quick Tip: You can also observe this by rearranging them into slope-intercept form ($y = mx + c$). Both equations yield a slope $m = -3$, but they have different y-intercepts (7 and 4), which confirms they are parallel lines.

15. A letter of English alphabets is chosen at random. What is the probability that it is a letter of the word 'MATHEMATICS' ?

- (A) $\frac{4}{13}$
- (B) $\frac{9}{26}$
- (C) $\frac{5}{13}$
- (D) $\frac{11}{26}$

Correct Answer: (A) $\frac{4}{13}$

Solution:

Step 1: Understanding the Question:

We are picking one letter randomly from the entire 26-letter English alphabet. We need to find the probability that this chosen letter happens to be one of the distinct letters used to spell the word 'MATHEMATICS'.

Step 2: Key Formula or Approach:

The probability of an event is defined as:

$$P(E) = \frac{\text{Number of favorable outcomes}}{\text{Total number of possible outcomes}}$$

Step 3: Detailed Explanation:

The total number of possible outcomes is the total number of letters in the English alphabet, which is 26. Now, we must identify the favorable outcomes. We need to find the number of unique distinct letters in the word 'MATHEMATICS'. Let's list the letters and remove duplicates: M, A, T, H, E, M (repeat), A (repeat), T (repeat), I, C, S. The set of distinct letters is $\{M, A, T, H, E, I, C, S\}$. Counting these, we get exactly 8 distinct letters. So, the number of favorable outcomes is 8. Calculate the probability:

$$P(E) = \frac{8}{26}$$

Simplify the fraction by dividing both numerator and denominator by 2:

$$P(E) = \frac{4}{13}$$

Step 4: Final Answer:

The probability is $\frac{4}{13}$.

Quick Tip: A very common trap in such probability questions is counting the repeating letters (like M, A, and T here). Always find the **distinct set** of letters first because a letter from the alphabet can only be drawn once.

16. The sum of first 20 odd natural numbers is

- (A) -400
- (B) 300
- (C) 270
- (D) 400

Correct Answer: (D) 400

Solution:

Step 1: Understanding the Question:

We are asked to find the sum of the first 20 odd natural numbers (i.e., $1 + 3 + 5 + \dots$ up to 20 terms).

Step 2: Key Formula or Approach:

There is a direct property of sequences: the sum of the first n consecutive odd natural numbers is always exactly n^2 . Alternatively, one can use the Arithmetic Progression (A.P.) sum formula:

$$S_n = \frac{n}{2} (2a + (n-1)d)$$

where n is the number of terms, a is the first term, and d is the common difference.

Step 3: Detailed Explanation:

Method 1: Using direct property Here, the number of terms $n = 20$. $\text{Sum} = n^2 = (20)^2 = 400$.

Method 2: Using Arithmetic Progression (A.P.) The series is $1, 3, 5, 7, \dots$. Here, first term $a = 1$, common difference $d = 3 - 1 = 2$, and number of terms $n = 20$.

$$S_{20} = \frac{20}{2} (2(1) + (20-1)(2))$$

$$S_{20} = 10(2 + 19 \times 2)$$

$$S_{20} = 10(2 + 38)$$

$$S_{20} = 10 \times 40 = 400$$

Both methods give the exact same result.

Step 4: Final Answer:

The sum of the first 20 odd natural numbers is 400.

Quick Tip: Memorize this highly useful fact: the sum of the first n odd natural numbers is n^2 , and the sum of the first n even natural numbers is $n(n + 1)$. This drastically speeds up calculations in exams!

17. The ratio of carbon and oxygen in CO_2 is:

- (A) 1:1
- (B) 1:2
- (C) 2:1
- (D) 2:2

Correct Answer: (B) 1:2

Solution:

Step 1: Understanding the Question:

The question asks for the ratio of carbon to oxygen in a molecule of carbon dioxide (CO_2).

Step 2: Detailed Explanation:

In chemistry, the ratio of elements in a molecular formula can be expressed either by the number of atoms (atomic ratio) or by their respective masses.

By atomic ratio: The chemical formula CO_2 clearly indicates that there is 1 atom of carbon (C) for every 2 atoms of oxygen (O). Therefore, the atomic ratio of C to O is 1 : 2.

By mass ratio: Carbon has an atomic mass of 12 u and Oxygen is 16 u. The mass ratio is $12 : (2 \times 16) = 12 : 32 = 3 : 8$.

Since the mass ratio of 3 : 8 is not present in the given options, the question is specifically referring to the atomic ratio.

Step 3: Final Answer:

The atomic ratio of carbon and oxygen in CO_2 is 1:2.

Quick Tip: Always check if a ratio question implies an atomic ratio or a mass ratio by glancing at the options. If the mass ratio (like 3 : 8 for CO_2) is missing, the examiner wants the simple atom count.

18. The formula of ammonia is:

- (A) NH_3
- (B) NO_2
- (C) N_2O
- (D) NH_4

Correct Answer: (A) NH_3

Solution:

Step 1: Understanding the Question:

We are asked to identify the correct chemical formula for the compound ammonia.

Step 2: Detailed Explanation:

Ammonia is a common, widely used nitrogen hydride. In a molecule of ammonia, one central nitrogen atom is covalently bonded to three hydrogen atoms, giving it the chemical formula NH_3 .

Let's analyze the other options:

NO_2 is Nitrogen dioxide, a toxic reddish-brown gas.

N_2O is Nitrous oxide, commonly known as laughing gas.

NH_4 represents the ammonium radical; as a stable ion it exists as NH_4^+ (ammonium ion), not a neutral compound.

Step 3: Final Answer:

The correct formula for ammonia is NH_3 .

Quick Tip: Do not confuse **Ammonia** (NH_3 , a neutral, pungent-smelling gas) with **Ammonium** (NH_4^+ , a positively charged polyatomic ion).

19. Which of the following is a chemical change?

- (A) Melting of ice
- (B) Boiling of water

- (C) Burning of paper
- (D) Dissolving of salt

Correct Answer: (C) Burning of paper

Solution:

Step 1: Understanding the Question:

The question requires us to distinguish between physical and chemical changes among the given processes.

Step 2: Detailed Explanation:

A physical change only alters the state, shape, or appearance of a substance without forming any entirely new chemical substance. For instance, melting of ice (solid to liquid), boiling of water (liquid to gas), and dissolving of salt in water are all physical changes. They are generally easily reversible.

A chemical change involves a chemical reaction where new substances with distinct chemical and physical properties are formed.

When paper is burned (combustion), the cellulose in the paper reacts with oxygen in the air to produce carbon dioxide, water vapor, and ash. This process cannot be reversed to get the original paper back.

Step 3: Final Answer:

Burning of paper is a chemical change.

Quick Tip: If a process is easily reversible and forms no new chemical product, it is a physical change. Keywords like **burning, combustion, rusting, and fermenting** always indicate a chemical change.

20. Which of the following is a noble gas?

- (A) Hydrogen
- (B) Nitrogen
- (C) Neon
- (D) Chlorine

Correct Answer: (C) Neon

Solution:**Step 1: Understanding the Question:**

We need to identify which element among the options belongs to the noble gas family in the periodic table.

Step 2: Detailed Explanation:

Noble gases are located in Group 18 (the far right column) of the periodic table. They are characterized by having a completely filled valence electron shell, which makes them highly stable and generally unreactive under standard conditions.

Neon (Ne) is the second noble gas in Group 18.

Hydrogen (Group 1), Nitrogen (Group 15), and Chlorine (Group 17) are all highly reactive non-metals that form diatomic molecules (H_2 , N_2 , Cl_2) in their natural states.

Step 3: Final Answer:

Neon is a noble gas.

Quick Tip: Memorize the six naturally occurring noble gases in order: Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe), and Radon (Rn).

21. The lightest metal is:

- (A) Sodium
- (B) Lithium
- (C) Calcium
- (D) Aluminum

Correct Answer: (B) Lithium

Solution:**Step 1: Understanding the Question:**

We are asked to identify the lightest metal from the given choices, which implies finding the metal with the lowest density and lowest atomic mass.

Step 2: Detailed Explanation:

Lithium (Li) is an alkali metal located in Group 1, Period 2 of the periodic table. It has an atomic number of 3 and an atomic mass of approximately 6.94 u.

It is inherently the lightest known solid metal, boasting a remarkably low density of about 0.534 g/cm^3 .

By comparison, the densities of the other metals are:

Sodium ($\approx 0.97 \text{ g/cm}^3$)

Calcium ($\approx 1.55 \text{ g/cm}^3$)

Aluminum ($\approx 2.70 \text{ g/cm}^3$)

Step 3: Final Answer:

Lithium is the lightest metal.

Quick Tip: Lithium is so remarkably light that its density is roughly half that of water, meaning it can easily **float on water** (and even on many lighter hydrocarbon oils), which is a unique characteristic among solid metals.