AP EAPCET 2026 May 13 Shift 2

Question Paper (Memory-Based) with Solutions

Conducted by National Testing Agency (NTA)

General Instructions

(i) The test is of 3 hours duration.

(ii) This test paper consists of 160 questions. The maximum marks are 160.

(iii) Physics and Chemistry contains 40 questions each and Mathematics contains 80 questions.

(iv) Each question carries +1 marks for correct answer and there is no negative marking for wrong answer.

1. If A and B are both 3×3 matrices, then which of the following statements are true?

(i) $AB = 0 \Rightarrow A = 0$ or $B = 0$

(ii) $AB = I_3 \Rightarrow A^{-1} = B$

(iii) $(A-B)^2 = A^2 - 2AB + B^2$

(A) (i) is false and (ii), (iii) are true

(B) (ii) is true (i), (iii) are false

(C) (i) and (ii) are true, (iii) is false

(D) All are true

Correct Answer: (B) (ii) is true (i), (iii) are false

Solution:

Concept: Matrix algebra features several distinct properties: the product of two non-zero matrices can be zero (zero divisors), and matrix multiplication is generally non-commutative ($AB \neq BA$). For square matrices, if their product is the identity matrix (I), then one is the inverse of the other.

Step 1: Checking statement (i) regarding zero divisors.

In matrix algebra, $AB = 0$ does not necessarily mean $A = 0$ or $B = 0$. There exist non-zero matrices whose product is zero. For example:

$$A = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}, B = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} \Rightarrow AB = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}$$

Since $A, B \neq 0$ but $AB = 0$, statement (i) is false.

Step 2: Checking statement (ii) regarding the matrix inverse.

By the definition of an invertible matrix, if A and B are square matrices of the same order such that $AB = I$, then A is non-singular and its inverse A^{-1} is equal to B. Thus, statement (ii) is true.

Step 3: Checking statement (iii) regarding the expansion of $(A-B)^2$.

We expand the square by multiplying the matrices:

$$(A-B)^2 = (A-B)(A-B) = A^2 - AB - BA + B^2$$

This expression only simplifies to $A^2 - 2AB + B^2$ if $AB = BA$. Because matrix multiplication is not generally commutative, statement (iii) is false.

Quick Tip: To avoid common pitfalls in matrix algebra, always treat the order of multiplication as fixed. Since AB is usually not equal to BA, standard algebraic identities like $(a-b)^2$ must be expanded manually as $A^2 - AB - BA + B^2$.

---

2. Let $A = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$ and $B = \begin{bmatrix} x & y \\ 1 & 2 \end{bmatrix}$ be two matrices such that $(A+B)(A-B) = A^2 - B^2$. If $C = \begin{bmatrix} x & 2 \\ 1 & y \end{bmatrix}$, then trace $(C) =$

(A) 3

(B) 5

(C) 7

(D) 9

Correct Answer: (A) 3

Solution:

Concept: For any two square matrices A and B, the expansion of $(A+B)(A-B)$ is given by $A^2 - AB + BA - B^2$. The identity $(A+B)(A-B) = A^2 - B^2$ holds true if and only if $AB = BA$, meaning the matrices commute. The trace of a matrix is the sum of the elements on its main diagonal.

Step 1: Using the commutativity condition $AB = BA$.

Expanding $(A+B)(A-B)$:

$$(A+B)(A-B) = A^2 - AB + BA - B^2$$

Given $(A+B)(A-B) = A^2 - B^2$, it implies:

$$-AB + BA = 0 \quad \Rightarrow \quad AB = BA$$

Step 2: Calculating products AB and BA.

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

$$BA = \begin{bmatrix} x & y \\ 1 & 2 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} = \begin{bmatrix} x+2y & 2x+y \\ 1+4 & 2+2 \end{bmatrix} = \begin{bmatrix} x+2y & 2x+y \\ 5 & 4 \end{bmatrix}$$

Step 3: Equating $AB = BA$ to find x and y.

Comparing the elements: 1) $x+2 = x+2y \Rightarrow 2y = 2 \Rightarrow y = 1$ 2) $2y+2 = 4 \Rightarrow 2(1)+2 = 4$ (Consistent) 3) $2x+1 = 5 \Rightarrow 2x = 4 \Rightarrow x = 2$

Step 4: Finding the trace of matrix C.

Matrix $C = \begin{bmatrix} x & 2 \\ 1 & y \end{bmatrix} = \begin{bmatrix} 2 & 2 \\ 1 & 1 \end{bmatrix}$. The trace of C is the sum of the diagonal elements:

$$\text{trace}(C) = x + y = 2 + 1 = 3$$

Quick Tip: Whenever you see the identity $(A+B)(A-B) = A^2 - B^2$, immediately jump to the condition $AB = BA$. This is one of the most common ways matrix commutativity is tested in entrance exams.

---

3. If

$$A = \begin{bmatrix} 3 & 4 \\ 5 & 6 \end{bmatrix} \quad \textbf{and} \quad B = \begin{bmatrix} x & 0 \\ 0 & y \end{bmatrix},$$

where $x, y \in \mathbb{N}$**, then:**

(A) there is exactly one such matrix B such that $AB = I$

(B) there is no matrix B such that $AB = BA$

(C) there exist only a finite number of matrices B such that $AB = BA$

(D) there exist infinite number of matrices B such that $AB = BA$

Correct Answer: [(D)] there exist infinite number of matrices B such that $AB = BA$

Solution:

Concept: Two matrices A and B are said to commute if

$$AB = BA.$$

To check this condition, we calculate both products separately and compare the corresponding entries.
For diagonal matrices, multiplication becomes simpler because only the diagonal entries are non-zero.

Step 1: Compute the product AB.
Given:

$$A = \begin{bmatrix} 3 & 4 \\ 5 & 6 \end{bmatrix}, \qquad B = \begin{bmatrix} x & 0 \\ 0 & y \end{bmatrix}$$

Now,

$$AB = \begin{bmatrix} 3 & 4 \\ 5 & 6 \end{bmatrix} \begin{bmatrix} x & 0 \\ 0 & y \end{bmatrix}$$

Using matrix multiplication:

$$AB = \begin{bmatrix} 3x + 4(0) & 3(0) + 4y \\ 5x + 6(0) & 5(0) + 6y \end{bmatrix}$$

Hence,

$$AB = \begin{bmatrix} 3x & 4y \\ 5x & 6y \end{bmatrix}$$

Step 2: Compute the product BA.

$$BA = \begin{bmatrix} x & 0 \\ 0 & y \end{bmatrix} \begin{bmatrix} 3 & 4 \\ 5 & 6 \end{bmatrix}$$

Multiplying:

$$BA = \begin{bmatrix} 3x & 4x \\ 5y & 6y \end{bmatrix}$$

Step 3: Apply the condition $AB = BA$.

For two matrices to be equal, corresponding elements must be equal.

Thus,

$$\begin{bmatrix} 3x & 4y \\ 5x & 6y \end{bmatrix} = \begin{bmatrix} 3x & 4x \\ 5y & 6y \end{bmatrix}$$

Comparing corresponding entries:

From the $(1,2)$-entry:

$$4y = 4x$$

$$x = y$$

From the $(2,1)$-entry:

$$5x = 5y$$

$$x = y$$

Thus, the condition for commutativity is:

$$x = y$$

But since $x, y \in \mathbb{N}$, infinitely many choices are possible:

$$(1,1), (2,2), (3,3), \ldots$$

Hence, infinitely many matrices B satisfy

$$AB = BA.$$

Therefore, option (d) is correct.

Step 4: Check the validity of the given answer choices carefully.

Since infinitely many matrices satisfy $AB = BA$,

$$\boxed{\text{Option (d) is correct}}$$

and therefore options (a), (b), and (c) are incorrect.

Quick Tip: For a diagonal matrix

$$\begin{bmatrix} x & 0 \\ 0 & y \end{bmatrix},$$

matrix multiplication scales rows or columns separately.

To verify $AB = BA$, always compare corresponding entries after multiplication.

---

4. If the system of equations

$$2x + 3y - 3z = 3, \qquad x + 2y + \alpha z = 1, \qquad 2x - y + z = \beta$$

has infinitely many solutions, then

$$\frac{\alpha}{\beta} - \frac{\beta}{\alpha} =$$

(A) $\frac{53}{14}$

(B) $\frac{45}{14}$

(C) $-\frac{53}{14}$

(D) $-\frac{45}{14}$

Correct Answer: (B) $\frac{45}{14}$

Solution:

Concept: A system of linear equations has infinitely many solutions when:

$$\text{Rank}(A) = \text{Rank}(A|B) < \text{number of variables}$$

This means one equation must be a linear combination of the others.
Hence, for infinitely many solutions, the third equation must be dependent on the first two equations.

Step 1: Write the given equations.

$$2x + 3y - 3z = 3 \qquad \cdots(1)$$

$$x + 2y + \alpha z = 1 \qquad \cdots(2)$$

$$2x - y + z = \beta \qquad \cdots(3)$$

Since infinitely many solutions exist, equation (3) must be obtainable from equations (1) and (2).
Assume:

$$(3) = \lambda(1) + \mu(2)$$

Step 2: Compare coefficients of x, y, and constants.
From coefficient of x:

$$2\lambda + \mu = 2 \qquad \cdots(4)$$

From coefficient of y:

$$3\lambda + 2\mu = -1 \qquad \cdots(5)$$

Solving (4) and (5):
From (4),

$$\mu = 2 - 2\lambda$$

Substitute into (5):

$$3\lambda + 2(2 - 2\lambda) = -1$$

$$3\lambda + 4 - 4\lambda = -1$$

$$-\lambda = -5$$

$$\lambda = 5$$

Then,

$$\mu = 2 - 2(5)$$

$$\mu = -8$$

Step 3: Find the value of α.

Compare coefficients of z:

From equation (3),

$$1 = \lambda(-3) + \mu(\alpha)$$

Substitute $\lambda = 5,\ \mu = -8$:

$$1 = 5(-3) - 8\alpha$$

$$1 = -15 - 8\alpha$$

$$16 = -8\alpha$$

$$\alpha = -2$$

Step 4: Find the value of β.

Compare constants:

$$\beta = 3\lambda + 1\mu$$

Substitute values:

$$\beta = 3(5) + (-8)$$

$$\beta = 15 - 8$$

$$\beta = 7$$

Step 5: Compute

$$\frac{\alpha}{\beta} - \frac{\beta}{\alpha}$$

Substitute:

$$\frac{-2}{7} - \frac{7}{-2}$$

$$= -\frac{2}{7} + \frac{7}{2}$$

Taking LCM $= 14$:

$$= \frac{-4+49}{14}$$

$$= \frac{45}{14}$$

Thus,

$$\boxed{\frac{\alpha}{\beta} - \frac{\beta}{\alpha} = \frac{45}{14}}$$

Hence, the correct option is:

$$\boxed{(B)\ \frac{45}{14}}$$

Quick Tip: For infinitely many solutions in a system of linear equations, one equation must be expressible as a linear combination of the others.

A quick method is to compare coefficients directly after assuming:

$$E_3 = \lambda E_1 + \mu E_2$$

---

5. The positive value of a for which the system of linear homogeneous equations

$$x + ay + z = 0, \qquad ax + 2y - z = 0, \qquad 2x + 3y + z = 0$$

has non-trivial solution is

(A) 0

(B) 1

(C) $\dfrac{1+\sqrt{5}}{2}$

(D) $\dfrac{\sqrt{5}-1}{2}$

Correct Answer: (C) $\dfrac{1+\sqrt{5}}{2}$

Solution:

Concept: A homogeneous system of linear equations has a non-trivial solution if and only if the determinant of the coefficient matrix is zero.

That is,

$$|A| = 0$$

For the system:

$$AX = 0$$

non-trivial solutions exist when the coefficient matrix is singular.

Step 1: Write the coefficient matrix.

The given equations are:

$$x + ay + z = 0$$

$$ax + 2y - z = 0$$

$$2x + 3y + z = 0$$

Therefore, the coefficient matrix is:

$$A = \begin{bmatrix} 1 & a & 1 \\ a & 2 & -1 \\ 2 & 3 & 1 \end{bmatrix}$$

For non-trivial solution:

$$|A| = 0$$

Step 2: Evaluate the determinant.

$$\begin{vmatrix} 1 & a & 1 \\ a & 2 & -1 \\ 2 & 3 & 1 \end{vmatrix} = 0$$

Expand along the first row:

$$1\begin{vmatrix} 2 & -1 \\ 3 & 1 \end{vmatrix} - a\begin{vmatrix} a & -1 \\ 2 & 1 \end{vmatrix} + 1\begin{vmatrix} a & 2 \\ 2 & 3 \end{vmatrix} = 0$$

Now compute each minor.

First minor:

$$\begin{vmatrix} 2 & -1 \\ 3 & 1 \end{vmatrix} = (2)(1) - (-1)(3)$$

$$= 2 + 3 = 5$$

Second minor:

$$\begin{vmatrix} a & -1 \\ 2 & 1 \end{vmatrix} = a(1) - (-1)(2)$$

$$= a + 2$$

Third minor:

$$\begin{vmatrix} a & 2 \\ 2 & 3 \end{vmatrix} = 3a - 4$$

Substituting:

$$5 - a(a+2) + (3a - 4) = 0$$

Step 3: Simplify the equation.

$$5 - a^2 - 2a + 3a - 4 = 0$$

$$1 - a^2 + a = 0$$

Multiply by -1:

$$a^2 - a - 1 = 0$$

Step 4: Solve the quadratic equation.

Using quadratic formula:

$$a = \frac{-(-1) \pm \sqrt{(-1)^2 - 4(1)(-1)}}{2(1)}$$

$$a = \frac{1 \pm \sqrt{1+4}}{2}$$

$$a = \frac{1 \pm \sqrt{5}}{2}$$

Since positive value is required:

$$\boxed{a = \frac{1 + \sqrt{5}}{2}}$$

Hence, the correct option is:

$$\boxed{(c)\ \frac{1 + \sqrt{5}}{2}}$$

Quick Tip: For a homogeneous system:

$$AX = 0$$

non-trivial solutions exist only when:

$$|A| = 0$$

Always form the coefficient matrix first and then evaluate its determinant carefully.

---

6. Escape velocity on a planet is 10 km/s. If the radius remains same but the mass becomes 4 times, the new escape velocity is:

(A) 10 km/s

(B) 20 km/s

(C) 5 km/s

(D) 40 km/s

Correct Answer: (B) 20 km/s

Solution:

Concept: Escape velocity is the minimum velocity required for an object to escape completely from the gravitational field of a planet without further propulsion.

The formula for escape velocity is:

:contentReference[oaicite:0]index=0

where:

$$v_e = \text{escape velocity}$$

$$G = \text{gravitational constant}$$

$$M = \text{mass of the planet}$$

$$R = \text{radius of the planet}$$

From the formula:

$$v_e \propto \sqrt{M}$$

when radius remains constant.

Step 1: Write the relation between old and new escape velocity.

Initial escape velocity:

$$v_1 = 10 \text{ km/s}$$

New mass:

$$M_2 = 4M_1$$

Since radius remains same:

$$\frac{v_2}{v_1} = \sqrt{\frac{M_2}{M_1}}$$

Substitute:

$$\frac{v_2}{10} = \sqrt{\frac{4M_1}{M_1}}$$

$$\frac{v_2}{10} = \sqrt{4}$$

$$\frac{v_2}{10} = 2$$

$$v_2 = 20 \text{ km/s}$$

Step 2: Write the final answer.

Hence, the new escape velocity is:

$$\boxed{20 \text{ km/s}}$$

Therefore, the correct option is:

$$\boxed{(B)\ 20 \text{ km/s}}$$

Quick Tip: Escape velocity depends on both mass and radius:

$$v_e \propto \sqrt{\frac{M}{R}}$$

If mass becomes n times and radius remains constant, escape velocity becomes:

$$\sqrt{n} \times \text{original escape velocity}$$

---

7. At what depth inside Earth does g become half of its surface value? (Earth radius $= R$)

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

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

(C) $\frac{3R}{4}$

(D) R

Correct Answer: (A) $\frac{R}{2}$

Solution:

Concept: The acceleration due to gravity decreases linearly with depth inside the Earth.

The relation between gravity at depth d and gravity on the surface is:

where:

$$g_d = \text{gravity at depth } d$$

$$g = \text{gravity at Earth's surface}$$

$$R = \text{radius of Earth}$$

Step 1: Use the given condition.

It is given that gravity becomes half of its surface value.

Therefore:

$$g_d = \frac{g}{2}$$

Using the formula:

$$\frac{g}{2} = g\left(1 - \frac{d}{R}\right)$$

Step 2: Simplify the equation.

Divide both sides by g:

$$\frac{1}{2} = 1 - \frac{d}{R}$$

Rearranging:

$$\frac{d}{R} = 1 - \frac{1}{2}$$

$$\frac{d}{R} = \frac{1}{2}$$

Hence:

$$d = \frac{R}{2}$$

Step 3: Write the final answer.

Therefore, the required depth is:

$$\boxed{\frac{R}{2}}$$

Hence, the correct option is:

$$\boxed{(A)\ \frac{R}{2}}$$

Quick Tip: Inside the Earth, acceleration due to gravity decreases linearly with depth:

$$g_d = g\left(1 - \frac{d}{R}\right)$$

At the center of Earth ($d = R$),

$$g = 0$$

---

8. A mass m is taken from Earth's surface to infinity. Work done is:

(A) $+\frac{GMm}{R}$
(B) $-\frac{GMm}{R}$
(C) 0
(D) $\frac{GMm}{2R}$

Correct Answer: (A) $+\frac{GMm}{R}$

Solution:

Concept: Work done by an external agent in moving a mass in a gravitational field is equal to the change in the gravitational potential energy of the system. The gravitational potential energy U of a mass m at a distance r from the center of the Earth (mass M) is given by:

$$U = -\frac{GMm}{r}$$

The work done (W) is calculated as $W = U_{\text{final}} - U_{\text{initial}}$.

Step 1: Identify the initial and final states

Initial position: On the Earth's surface, so $r_1 = R$. Final position: At infinity, so $r_2 = \infty$.

Step 2: Calculate the initial and final potential energy.

Initial potential energy, $U_i = -\frac{GMm}{R}$.

Final potential energy, $U_f = -\frac{GMm}{\infty} = 0$.

Step 3: Calculate the work done by the external agent.

Work done $W = U_f - U_i$

$$W = 0 - \left(-\frac{GMm}{R}\right)$$

$$W = +\frac{GMm}{R}$$

Quick Tip: To move a mass away from a massive body, an external agent must do positive work to overcome the attractive gravitational force. Thus, the work done in taking a mass to infinity from a surface will always be positive.

---

9. A wire of length 2 m and area $1 \times 10^{-6}\,m^2$ stretches by 1 mm under force 200 N. Young's modulus is:

(A) $2 \times 10^{11}\,Pa$
(B) $4 \times 10^{11}\,Pa$
(C) $1 \times 10^{11}\,Pa$
(D) $5 \times 10^{10}\,Pa$

Correct Answer: (B) $4 \times 10^{11}\,Pa$

Solution:

Concept: Young's modulus (Y) is a measure of the stiffness of a solid material. It is defined as the ratio of longitudinal stress to longitudinal strain within the elastic limit of the material:

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{F/A}{\Delta L/L} = \frac{F \cdot L}{A \cdot \Delta L}$$

where F is the applied force, A is the cross-sectional area, L is the original length, and ΔL is the change in length.

Step 1: Extracting given values and converting to SI units.

Original length $(L) = 2$ m
Cross-sectional area $(A) = 1 \times 10^{-6}\,m^2$
Force $(F) = 200$ N
Extension $(\Delta L) = 1$ mm $= 1 \times 10^{-3}$ m

Step 2: Substituting the values into the Young's modulus formula.

$$Y = \frac{200 \times 2}{(1 \times 10^{-6}) \times (1 \times 10^{-3})}$$

Step 3: Simplifying the calculation.

$$Y = \frac{400}{1 \times 10^{-9}}$$

$$Y = 400 \times 10^9$$

$$Y = 4 \times 10^{11}\, Pa$$

Quick Tip: Always double-check your units! In elasticity problems, extensions are often given in mm or cm. Converting them to meters (10^{-3} or 10^{-2}) immediately prevents power-of-ten errors in your final answer.

---

10. A wire is stretched by 2 mm under force 100 N. Elastic energy stored is:

(A) 0.05 J

(B) 0.1 J

(C) 0.2 J

(D) 0.01 J

Correct Answer: (B) 0.1 J

Solution:

Concept: Elastic potential energy is the energy stored as a result of applying a force to deform an elastic object. For a stretched wire, the work done by the stretching force is stored as elastic potential energy (U). If the deformation is within the elastic limit, the formula is:

$$U = \frac{1}{2} \times \text{Force} \times \text{Extension}$$

This formula represents the area under the Force-Extension graph.

Step 1: Extracting given values from and converting to SI units.

Force (F) $= 100$ N

Extension (ΔL) $= 2$ mm $= 2 \times 10^{-3}$ m

Step 2: Substituting values into the elastic energy formula.

$$U = \frac{1}{2} \times F \times \Delta L$$

$$U = \frac{1}{2} \times 100 \times (2 \times 10^{-3})$$

Step 3: Calculating the final result.

$$U = 100 \times 10^{-3}$$

$$U = 0.1\,J$$

Quick Tip: The factor of $\frac{1}{2}$ is crucial because the force increases linearly from 0 to F as the wire stretches. Think of it as using the average force $(F/2)$ over the total distance of the stretch.

---

11. The IUPAC name of an element with atomic number 119 is:

(A) Ununennium

(B) Unnilennium

(C) Unununium

(D) ununoctium

Correct Answer: (A) Ununennium

Solution:

Concept: For elements with atomic numbers greater than 100, IUPAC established a systematic naming convention based on the numerical roots of the digits in the atomic number. The roots are:

0	1	2	3	4	5	6	7	8	9
nil	un	bi	tri	quad	pent	hex	sept	oct	enn

The name is constructed by putting the roots together in order of the digits and adding the suffix "-ium".

Step 1: Identify the digits of the atomic number

The atomic number given is 119. The digits are: 1, 1, and 9.

Step 2: Match each digit to its corresponding IUPAC numerical root.

* Digit 1: **un** * Digit 1: **un** * Digit 9: **enn**

Step 3: Assemble the name and add the suffix.

Combining the roots: **un** + **un** + **enn** Adding the suffix: **un** + **un** + **enn** + **ium** Final Name: **Ununennium**

Quick Tip: To remember the rules: if a root ends in 'n' (like enn) and the suffix is 'ium', you keep both 'n's. However, if a root ends in 'i' (like bi or tri) and is followed by 'ium', you drop one 'i' (e.g., Ununtrium, not Ununtriiium).

---

12. Consider the following:

a) 0.0025

b) 500.0

c) 2.0034

Number of significant figures in A, B and C respectively are

(A) 5, 4, 4

(B) 2, 4, 2

(C) 4, 3, 2

(D) 2, 4, 5

Correct Answer: (D) 2, 4, 5

Solution:

Concept: Significant figures are the digits in a number that carry meaningful information about its precision. The rules are:

1. All non-zero digits are significant.
2. Zeros between non-zero digits are significant (captive zeros).
3. Leading zeros (to the left of the first non-zero digit) are NOT significant.
4. Trailing zeros in a number containing a decimal point are significant.

Step 1: Analyze value (a) 0.0025

In 0.0025, the zeros to the left of 2 are leading zeros. According to Rule 3, leading zeros are not significant. Only the digits 2 and 5 are significant.

Significant figures = 2.

Step 2: Analyze value (b) 500.0.

In 500.0, there is a decimal point. According to Rule 4, trailing zeros after a non-zero digit in a decimal number are significant. Here, the zeros between 5 and the decimal, as well as the zero after the decimal, are all significant.

Significant figures = 4.

Step 3: Analyze value (c) 2.0034.

In 2.0034, the zeros are between the non-zero digits 2 and 3. According to Rule 2, these captive zeros are significant. All digits $(2, 0, 0, 3, 4)$ carry meaning.

Significant figures = 5.

Quick Tip: To easily identify significant figures, try writing the number in scientific notation. For example, 0.0025 becomes 2.5×10^{-3} (2 digits), and 500.0 becomes 5.000×10^2 (4 digits). The digits in the coefficient are always the significant ones!

---

13. Identify the correct set of molecules with zero dipole moment.

(A) CO_2, NH_3, H_2O

(B) NH_3, NF_3, BF_3

(C) PF_3, NH_3, CH_4

(D) CH_4, BF_3, CO_2

Correct Answer: (D) CH_4, BF_3, CO_2

Solution:

Concept: Dipole moment measures the separation of positive and negative charges in a molecule.

A molecule has:

- **Zero dipole moment** when the bond dipoles cancel each other due to symmetrical geometry.
- **Non-zero dipole moment** when the molecular shape is unsymmetrical and dipoles do not cancel.

Thus, molecular geometry plays a very important role in determining dipole moment.

Step 1: Examine the molecules in option (A).

$$CO_2$$

has linear geometry:

$$O = C = O$$

The two bond dipoles are equal and opposite, so:

$$\mu = 0$$

$$NH_3$$

has trigonal pyramidal geometry due to one lone pair on nitrogen. Dipoles do not cancel completely.
Hence:

$$\mu \neq 0$$

$$H_2O$$

has bent geometry because of two lone pairs on oxygen. Therefore:

$$\mu \neq 0$$

Thus, option (A) is incorrect.

Step 2: Examine the molecules in option (B).

$$NH_3$$

is polar:

$$\mu \neq 0$$

$$NF_3$$

also has trigonal pyramidal geometry and possesses a small but non-zero dipole moment.

$$\mu \neq 0$$

$$BF_3$$

has trigonal planar symmetrical structure. Bond dipoles cancel completely.

$$\mu = 0$$

Since all molecules do not have zero dipole moment, option (B) is incorrect.

Step 3: Examine the molecules in option (C).

$$PF_3$$

has trigonal pyramidal geometry and is polar.

$$\mu \neq 0$$

$$NH_3$$

is also polar.

$$\mu \neq 0$$

$$CH_4$$

has tetrahedral symmetrical geometry. Dipoles cancel completely.

$$\mu = 0$$

Hence, option (C) is incorrect.

Step 4: Examine the molecules in option (D).

$$CH_4$$

has tetrahedral symmetrical geometry.

$$\mu = 0$$

$$BF_3$$

has trigonal planar symmetrical geometry.

$$\mu = 0$$

$$CO_2$$

has linear symmetrical geometry.

$$\mu = 0$$

Thus, all molecules in option (D) have zero dipole moment.

Therefore:

$$\boxed{\text{Option (D) is correct}}$$

Quick Tip: Symmetrical molecules generally have zero dipole moment because individual bond dipoles cancel each other.

Examples:

$$CO_2, \ CH_4, \ BF_3, \ CCl_4$$

Molecules containing lone pairs often become asymmetrical and usually possess non-zero dipole moment.

---

14. Calculate the amount of CO_2 gas produced, when 32g of CH_4 is burned with sufficient amount of oxygen (Given atomic weight of $C = 12, O = 16$ and $H = 1$)

(A) 132g

(B) 44g

(C) 88g

(D) 176g

Correct Answer: (C) 88g

Solution:

Concept: Stoichiometry allows us to calculate the masses of reactants and products in a chemical reaction. The combustion of methane (CH_4) in excess oxygen is a complete combustion reaction. To solve this, we must first write the balanced chemical equation and then use the mole concept to relate the mass of the reactant to the mass of the product.

Step 1: Write the balanced chemical equation for the combustion of methane.

Methane reacts with oxygen to produce carbon dioxide and water:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

From the equation, 1 mole of CH_4 produces 1 mole of CO_2.

Step 2: Calculate the number of moles of CH_4

Molar mass of $CH_4 = 12 + (4 \times 1) = 16$ g/mol.

$$\text{Moles of } CH_4 = \frac{\text{Given mass}}{\text{Molar mass}} = \frac{32\text{ g}}{16\text{ g/mol}} = 2\text{ moles}$$

Step 3: Determine the mass of CO_2 produced.

Since the molar ratio of CH_4 to CO_2 is 1 : 1, 2 moles of CH_4 will produce 2 moles of CO_2.

Molar mass of $CO_2 = 12 + (2 \times 16) = 44$ g/mol.

$$\text{Mass of } CO_2 = \text{Moles} \times \text{Molar mass} = 2\text{ moles} \times 44\text{ g/mol} = 88\text{ g}$$

Quick Tip: In stoichiometry, always "bridge" through moles. Convert the given mass to moles, use the coefficients from the balanced equation to find the moles of the desired product, and then convert those moles back to mass.

---

15. Which of the following pairs of gases contains the same number of molecules?

(A) 11 g of CO_2 and 7 g of N_2

(B) 44 g of CO_2 and 14 g of N_2

(C) 22 g of CO_2 and 28 g of N_2

(D) All the above pairs of gases

Correct Answer: (A) 11 g of CO_2 and 7 g of N_2

Solution:

Concept: The number of molecules in a substance depends on the number of moles.

The relation is:

$$\text{Number of moles} = \frac{\text{Given mass}}{\text{Molar mass}}$$

If two gas samples have equal number of moles, then they contain equal number of molecules.

Step 1: Find the molar masses of the gases.

For carbon dioxide:

$$CO_2 = 12 + 2(16) = 44 \text{ g/mol}$$

For nitrogen gas:

$$N_2 = 2(14) = 28 \text{ g/mol}$$

Step 2: Check option (A).

For 11 g of CO_2:

$$\text{Moles} = \frac{11}{44} = \frac{1}{4}$$

For 7 g of N_2:

$$\text{Moles} = \frac{7}{28} = \frac{1}{4}$$

Both contain:

$$\frac{1}{4} \text{ mole}$$

Hence, both have the same number of molecules.

Step 3: Check option (B).

For 44 g of CO_2:

$$\text{Moles} = \frac{44}{44} = 1$$

For 14 g of N_2:

$$\text{Moles} = \frac{14}{28} = \frac{1}{2}$$

Since the number of moles are not equal, the number of molecules are not equal.

Thus, option (B) is incorrect.

Step 4: Check option (C).

For 22 g of CO_2:

$$\text{Moles} = \frac{22}{44} = \frac{1}{2}$$

For 28 g of N_2:

$$\text{Moles} = \frac{28}{28} = 1$$

Again, the number of moles are not equal.

Thus, option (C) is incorrect.

Step 5: Write the final answer.

Only option (A) contains equal number of moles and therefore equal number of molecules.

Hence:

$$\boxed{\text{Option (A) is correct}}$$

Quick Tip: Equal number of molecules means equal number of moles.

Always compare:

$$\text{Moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

If moles are equal, the number of molecules will also be equal.