

KEAM 2026 Engineering April 18

Question Paper with Solutions

Conducted by CEE Kerala



General Instructions

- (i) **Duration:** The total duration of the examination is 3 hours (180 minutes).
- (ii) **Total Marks:** The complete paper carries a maximum of 600 marks.
- (iii) **Structure:** The paper has 3 Sections:
 - **Section A:** 45 Multiple Choice Questions (Physics).
 - **Section B:** 30 Multiple Choice Questions (Chemistry).
 - **Section B:** 75 Multiple Choice Questions (Mathematics).
- (iv) **Compulsory Questions:** All 150 questions are compulsory.
- (v) Each question has four options. Only **one** option is correct.
- (vi) **Correct Answer:** +4 marks.
- (vii) **Incorrect Answer:** -1 (Negative marking).
- (viii) **Unanswered/Marked for Review:** 0 marks.

PHYSICS

1. The acceleration of a moving body is found from the:

- (A) area under velocity-time graph
- (B) area under displacement-time graph
- (C) slope of distance-time graph
- (D) slope of velocity-time graph

(E) area under acceleration-time graph

Correct Answer: (D) slope of velocity-time graph

Solution:

Step 1: Understanding the Concept:

Acceleration is defined as the rate of change of velocity with respect to time.

In graphical analysis, the rate of change of one variable with respect to another is represented by the slope of the tangent to the curve at that point.

Step 2: Key Formula or Approach:

The mathematical definition of instantaneous acceleration is:

$$a = \frac{dv}{dt}$$

This derivative corresponds to the gradient or slope of a velocity (v) versus time (t) graph.

Step 3: Detailed Explanation:

In a velocity-time graph, the y-axis represents velocity and the x-axis represents time.

The slope ($\frac{dy}{dx}$) of this graph is $\frac{dv}{dt}$.

According to kinematics, this quantity is equal to the acceleration of the body.

For example, if the graph is a straight line, the acceleration is constant, and its value is given by the slope of that line.

Step 4: Final Answer:

The acceleration of a moving body is obtained from the slope of the velocity-time graph.

Quick Tip: To remember graphical relations:

Displacement $\rightarrow$ Velocity (Slope)

Velocity $\rightarrow$ Acceleration (Slope)

Acceleration $\rightarrow$ Velocity (Area)

Velocity $\rightarrow$ Displacement (Area).

2. The time period of an earth's satellite revolving at a height of 35,800 km is

- (A) 24 hours
- (B) 100 minutes
- (C) 12 hours
- (D) 48 hours
- (E) 52 hours

Correct Answer: (A) 24 hours

Solution:

Step 1: Understanding the Concept:

A satellite orbiting at an altitude of approximately 35,800 km above the Earth's equator is known as a geostationary or synchronous satellite.

Step 2: Key Formula or Approach:

The height of a geostationary orbit is specifically calculated so that the satellite's orbital period matches the Earth's rotational period.

$$T = 2\pi \sqrt{\frac{(R+h)^3}{GM}}$$

Step 3: Detailed Explanation:

The Earth rotates once on its axis every 24 hours.

For a satellite to appear stationary over a single point on Earth (geostationary), it must complete one revolution in exactly the same amount of time as Earth takes for one rotation.

The height of 35,800 km is the standard altitude for such geostationary satellites.

Therefore, its time period must be 24 hours.

Step 4: Final Answer:

The time period of the satellite is 24 hours.

Quick Tip: Communication satellites are placed in geostationary orbits so that ground-based antennas do not have to move to track them.

3. For most of the materials, Young's modulus (Y) and rigidity modulus (G) are related as

- (A) $G = 3Y$
- (B) $G = \frac{Y}{3}$
- (C) $G = \frac{3}{2}Y$
- (D) $G = \frac{Y}{8}$
- (E) $10G = 3Y$

Correct Answer: (B) $G = \frac{Y}{3}$

Solution:

Step 1: Understanding the Concept:

Elastic moduli like Young's modulus (Y), Rigidity modulus (G), and Bulk modulus (K) are interconnected through Poisson's ratio (ν).

Step 2: Key Formula or Approach:

The fundamental relationship between Y and G is:

$$Y = 2G(1 + \nu)$$

Step 3: Detailed Explanation:

Poisson's ratio (ν) for most solid materials (metals, etc.) ranges between 0.25 and 0.35.

For an idealized incompressible material, the maximum theoretical value of ν is 0.5.

Substituting $\nu = 0.5$ into the formula:

$$Y = 2G(1 + 0.5) = 2G(1.5) = 3G$$

Rearranging for G :

$$G = \frac{Y}{3}$$

This is a common approximation used in many physics problems for isotropic materials.

Step 4: Final Answer:

For most materials, the relation is $G = \frac{Y}{3}$.

Quick Tip: Remember the three core relations:

1. $Y = 2G(1 + \nu)$
2. $Y = 3K(1 - 2\nu)$
3. $\frac{9}{Y} = \frac{1}{K} + \frac{3}{G}$

4. The pressure on an object of bulk modulus B undergoing hydraulic compression due to a stress exerted by surrounding fluid having volume strain $\frac{\Delta V}{V}$ is:

- (A) $B^2 \left(\frac{\Delta V}{V} \right)$
- (B) $B \left(\frac{\Delta V}{V} \right)^2$
- (C) $\frac{1}{B} \left(\frac{\Delta V}{V} \right)$
- (D) $\frac{1}{B^2} \left(\frac{\Delta V}{V} \right)$
- (E) $B \left(\frac{\Delta V}{V} \right)$

Correct Answer: (E) $B \left(\frac{\Delta V}{V} \right)$

Solution:

Step 1: Understanding the Concept:

Bulk modulus (B) measures the resistance of a substance to uniform compression. It is defined as the ratio of infinitesimal pressure increase to the resulting relative decrease of the volume.

Step 2: Key Formula or Approach:

The formula for Bulk Modulus is:

$$B = \frac{\text{Stress}}{\text{Strain}} = \frac{P}{\left(\frac{\Delta V}{V}\right)}$$

where P is the hydraulic pressure (stress).

Step 3: Detailed Explanation:

In the case of hydraulic compression, the stress applied is the pressure P exerted by the fluid.

The volume strain is given as $\frac{\Delta V}{V}$.

By rearranging the definition of Bulk Modulus:

$$P = B \times \text{Volume Strain}$$

Substituting the given strain:

$$P = B \times \left(\frac{\Delta V}{V}\right)$$

Step 4: Final Answer:

The pressure is given by $B \left(\frac{\Delta V}{V}\right)$.

Quick Tip: Bulk modulus always relates pressure and fractional volume change. Units of B are the same as pressure (Pascals or N/m^2) because strain is dimensionless.

5. When the displacement of a particle executing simple harmonic motion is half its amplitude, the ratio of its kinetic energy to potential energy is:

- (A) 1 : 3
- (B) 2 : 1
- (C) 3 : 1
- (D) 1 : 2
- (E) 2 : 3

Correct Answer: (C) 3 : 1

Solution:

Step 1: Understanding the Concept:

In Simple Harmonic Motion (SHM), the total energy is conserved and is the sum of Kinetic Energy (KE) and Potential Energy (PE).

Step 2: Key Formula or Approach:

Potential Energy: $PE = \frac{1}{2}ky^2$

Kinetic Energy: $KE = \frac{1}{2}k(A^2 - y^2)$

where A is amplitude and y is displacement.

Step 3: Detailed Explanation:

Given $y = \frac{A}{2}$.

$$PE = \frac{1}{2}k\left(\frac{A}{2}\right)^2 = \frac{1}{2}k\frac{A^2}{4} = \frac{1}{8}kA^2$$

$$KE = \frac{1}{2}k\left(A^2 - \left(\frac{A}{2}\right)^2\right) = \frac{1}{2}k\left(A^2 - \frac{A^2}{4}\right) = \frac{1}{2}k\left(\frac{3A^2}{4}\right) = \frac{3}{8}kA^2$$

Calculating the ratio $\frac{KE}{PE}$:

$$\frac{KE}{PE} = \frac{\frac{3}{8}kA^2}{\frac{1}{8}kA^2} = \frac{3}{1}$$

Step 4: Final Answer:

The ratio is 3 : 1.

Quick Tip: At $y = A/2$, PE is 25% of total energy and KE is 75% of total energy. Thus the ratio is $75 : 25 = 3 : 1$.

6. When a magnetic field is applied on a stationary electron, it

- (A) remains stationary
- (B) spins about its own axis
- (C) moves in the direction of the field
- (D) moves perpendicular to the direction of the field
- (E) moves opposite to the direction of the field

Correct Answer: (A) remains stationary

Solution:

Step 1: Understanding the Concept:

A magnetic field exerts a force on a charged particle only when the particle is in motion relative to the magnetic field.

Step 2: Key Formula or Approach:

The Magnetic Lorentz Force is given by:

$$\vec{F} = q(\vec{v} \times \vec{B})$$

In magnitude: $F = qvB \sin \theta$

Step 3: Detailed Explanation:

For a stationary electron, the velocity $v = 0$.

Substituting $v = 0$ into the force equation:

$$F = q(0)B \sin \theta = 0$$

Since there is no magnetic force acting on the stationary electron, there is no change in its state of rest.

Therefore, the electron will remain stationary.

Step 4: Final Answer:

The electron remains stationary.

Quick Tip: Magnetic fields do not perform work on charges because the force is always perpendicular to velocity. If velocity is zero, there is no force at all.

7. The resistors $R_1 = 3\Omega$ and $R_2 = 1\Omega$ are connected in parallel to a 20 V battery. Find the heat developed in the resistor R_1 in one minute.

- (A) 600 J
- (B) 800 J
- (C) 6000 J
- (D) 8000 J
- (E) 7000 J

Correct Answer: (D) 8000 J

Solution:

Step 1: Understanding the Concept:

In a parallel circuit, the potential difference (voltage) across each resistor is the same and equal to the supply voltage.

Step 2: Key Formula or Approach:

Heat produced (H) in a resistor is given by:

$$H = \frac{V^2}{R} \times t$$

where V is voltage, R is resistance, and t is time in seconds.

Step 3: Detailed Explanation:

Given: $V = 20 \text{ V}$, $R_1 = 3\Omega$, and $t = 1 \text{ minute} = 60 \text{ s}$.

The heat developed in R_1 is:

$$H = \frac{20^2}{3} \times 60$$

$$H = \frac{400}{3} \times 60$$

$$H = 400 \times 20$$

$$H = 8000 \text{ J}$$

Step 4: Final Answer:

The heat developed is 8000 J.

Quick Tip: For parallel circuits, use $H = \frac{V^2}{R}t$ because V is constant. For series circuits, use $H = I^2Rt$ because I is constant.

CHEMISTRY

8. Among the following, the molecule that will have the highest dipole moment is:

- (A) H_2
- (B) HI
- (C) HBr
- (D) HCl
- (E) HF

Correct Answer: (E) HF

Solution:

Step 1: Understanding the Concept:

Dipole moment depends on the electronegativity difference between the bonded atoms and the distance between them.

Step 2: Key Formula or Approach:

Dipole moment (μ) = charge (q) $\times$ distance (d).

For hydrogen halides, q depends on the electronegativity difference.

Step 3: Detailed Explanation:

H_2 is non-polar, so $\mu = 0$.

For HX (where X is a halogen), the electronegativity decreases in the order: $F > Cl > Br > I$.

The electronegativity difference (ΔEN) is highest for HF.

Greater electronegativity difference results in greater partial charges, and thus a higher dipole moment.

Even though bond length increases down the group, the magnitude of charge dominates the

trend in this case.

Step 4: Final Answer:

HF has the highest dipole moment.

Quick Tip: Trend for dipole moment: $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$. Always check the electronegativity difference for diatomic molecules.

9. An odd electron molecule among the following is (2015)

- (A) CO
- (B) SO_2
- (C) CO_2
- (D) NO
- (E) O_2

Correct Answer: (D) NO

Solution:

Step 1: Understanding the Concept:

An odd electron molecule is one that has an odd total number of valence electrons. Such molecules often do not follow the octet rule.

Step 2: Key Formula or Approach:

Calculate total valence electrons = sum of valence electrons of all atoms in the molecule.

Step 3: Detailed Explanation:

(A) CO: $4(\text{C}) + 6(\text{O}) = 10$ (Even)

(B) SO_2 : $6(\text{S}) + 2 \times 6(\text{O}) = 18$ (Even)

(C) CO_2 : $4(\text{C}) + 2 \times 6(\text{O}) = 16$ (Even)

(D) NO: $5(\text{N}) + 6(\text{O}) = 11$ (Odd)

(E) O_2 : $2 \times 6(\text{O}) = 12$ (Even)

Since NO has 11 valence electrons, it is an odd electron molecule.

Step 4: Final Answer:

The odd electron molecule is NO.

Quick Tip: Common odd electron molecules to remember: NO, NO_2 , ClO_2 . They are typically paramagnetic.

10. Which one of the following is the correct relation between C_p and C_V for one mole of an ideal gas? (R is molar gas constant)

(A) $C_p = C_V - R$

(B) $C_p = C_V + R$

(C) $C_p = R - C_V$

(D) $C_p = C_V \times R$

(E) $C_p = C_V / R$

Correct Answer: (B) $C_p = C_V + R$

Solution:

Step 1: Understanding the Concept:

C_p is molar heat capacity at constant pressure, and C_V is molar heat capacity at constant volume. For an ideal gas, they are related via the gas constant R .

Step 2: Key Formula or Approach:

The relation is known as Mayer's relation:

$$C_p - C_V = R$$

Step 3: Detailed Explanation:

Heat added at constant volume increases internal energy only.

Heat added at constant pressure increases internal energy AND does expansion work ($P\Delta V$).

For 1 mole of an ideal gas, $P\Delta V = R\Delta T$.

Thus, $C_p\Delta T = C_v\Delta T + R\Delta T$.

Dividing by ΔT gives $C_p = C_v + R$.

Step 4: Final Answer:

The correct relation is $C_p = C_v + R$.

Quick Tip: Always remember C_p is greater than C_v because work is done during constant pressure heating.

11. Which of the following is a Lewis acid?

- (A) HCl
- (B) HO^-
- (C) H_2O
- (D) Co^{3+}
- (E) NH_3

Correct Answer: (D) Co^{3+}

Solution:**Step 1: Understanding the Concept:**

A Lewis acid is defined as a chemical species that can accept an electron pair.

Step 2: Key Formula or Approach:

Look for species that are electron deficient or have vacant orbitals (like metal cations or molecules with incomplete octets).

Step 3: Detailed Explanation:

(A) HCl is a Bronsted acid (proton donor).

(B) HO^- and (E) NH_3 have lone pairs and are Lewis bases (electron donors).

(C) H_2O has lone pairs and usually acts as a Lewis base.

(D) Co^{3+} is a transition metal ion with a high positive charge and vacant d-orbitals. It can readily accept electron pairs from ligands.

Therefore, Co^{3+} acts as a Lewis acid.

Step 4: Final Answer:

The Lewis acid is Co^{3+} .

Quick Tip: All simple cations (like H^+ , Cu^{2+} , Fe^{3+}) and molecules with incomplete octets (like BF_3 , AlCl_3) are Lewis acids.

12. The average oxidation state of sulphur in the tetrathionate ion is:

(A) +3

(B) +2.5

(C) +5

(D) +3.5

(E) +1.5

Correct Answer: (B) +2.5

Solution:**Step 1: Understanding the Concept:**

Oxidation state is the formal charge assigned to an atom. The average oxidation state in a polyatomic ion is found using the overall charge.

Step 2: Key Formula or Approach:

The formula for tetrathionate ion is $\text{S}_4\text{O}_6^{2-}$.

Sum of oxidation states = Net charge.

Step 3: Detailed Explanation:

Let the oxidation state of sulphur be x .

Oxidation state of oxygen is typically -2 .

For $\text{S}_4\text{O}_6^{2-}$:

$$4(x) + 6(-2) = -2$$

$$4x - 12 = -2$$

$$4x = 10$$

$$x = \frac{10}{4} = +2.5$$

Structurally, two S atoms have 0 and two have +5 oxidation states, averaging to +2.5.

Step 4: Final Answer:

The average oxidation state is +2.5.

Quick Tip: Fractional oxidation states often indicate that the element exists in different bonding environments within the same molecule.

13. Which of the following is an electron donating group?

- (A) NO_2
- (B) $-\text{CH}_3$
- (C) $-\text{COOH}$
- (D) $-\text{CN}$
- (E) $-\text{OC}_6\text{H}_5$

Correct Answer: (B) $-\text{CH}_3$

Solution:

Step 1: Understanding the Concept:

Electron donating groups (EDGs) increase the electron density in a molecule (like a benzene ring) via inductive (+I) or resonance (+R) effects.

Step 2: Key Formula or Approach:

Identify groups with positive inductive effects (like alkyls) or lone pairs for resonance donation.

Step 3: Detailed Explanation:

(A) NO_2 , (C) COOH , and (D) CN are all electron-withdrawing groups (EWGs) because they have electronegative atoms or multiple bonds that pull density away.

(B) $-\text{CH}_3$ is an alkyl group. Alkyl groups donate electron density through the +I effect and hyperconjugation.

(E) $-\text{OC}_6\text{H}_5$ is a phenoxy group which is complex but alkyls are the most standard EDGs in such lists.

Step 4: Final Answer:

The electron donating group is $-\text{CH}_3$.

Quick Tip: Alkyl groups are activating groups in electrophilic aromatic substitution due to their electron-donating nature.

MATHS

14. If $ay = x + b$ is the equation of the line passing through the points $(-5, -2)$ and $(4, 7)$, then the value of $2a + b$ is equal to:

- (A) 1
- (B) 3
- (C) 5

(D) -3

(E) -1

Correct Answer: (C) 5

Solution:

Step 1: Understanding the Concept:

A line's equation can be found using two points. Once found, its coefficients can be compared to the given form $ay = x + b$.

Step 2: Key Formula or Approach:

$$\text{Slope } m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\text{Point-slope form: } y - y_1 = m(x - x_1)$$

Step 3: Detailed Explanation:

Points: $(-5, -2)$ and $(4, 7)$.

$$m = \frac{7 - (-2)}{4 - (-5)} = \frac{9}{9} = 1.$$

$$\text{Equation: } y - 7 = 1(x - 4) \Rightarrow y - 7 = x - 4 \Rightarrow y = x + 3.$$

Comparing $1 \cdot y = x + 3$ with $ay = x + b$:

$$a = 1, b = 3.$$

$$\text{Value of } 2a + b = 2(1) + 3 = 5.$$

Step 4: Final Answer:

The value of $2a + b$ is 5.

Quick Tip: If the slope is 1, the equation is simply $y = x + (\text{y-intercept})$. Here $7 = 4 + 3$, so intercept is 3.

15. The equation of perpendicular bisector of the line segment joining the points $(10, 0)$ and $(0, -4)$ is

- (A) $5x + 2y = 21$
- (B) $5x + 2y = 0$
- (C) $2x - 5y = 21$
- (D) $5x - 2y = 21$
- (E) $2x + 3y = 21$

Correct Answer: (A) $5x + 2y = 21$

Solution:

Step 1: Understanding the Concept:

The perpendicular bisector passes through the midpoint of the segment and has a slope that is the negative reciprocal of the segment's slope.

Step 2: Key Formula or Approach:

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

$$\text{Slope } m_{\perp} = -\frac{1}{m_{\text{line}}}$$

Step 3: Detailed Explanation:

$$\text{Midpoint of } (10, 0) \text{ and } (0, -4) \text{ is } M = \left(\frac{10+0}{2}, \frac{0-4}{2} \right) = (5, -2).$$

$$\text{Slope of segment} = \frac{-4-0}{0-10} = \frac{2}{5}.$$

$$\text{Slope of perpendicular bisector} = -\frac{5}{2}.$$

$$\text{Equation: } y - (-2) = -\frac{5}{2}(x - 5)$$

$$2(y + 2) = -5(x - 5) \Rightarrow 2y + 4 = -5x + 25 \Rightarrow 5x + 2y = 21.$$

Step 4: Final Answer:

The equation is $5x + 2y = 21$.

Quick Tip: Check which option is satisfied by the midpoint $(5, -2)$.

(A): $5(5) + 2(-2) = 25 - 4 = 21$. Correct.

16. The end-points of a diameter of a circle are $(1, 4)$ and $(5, 4)$. Then the equation of the circle is

- (A) $(x-3)^2 + y^2 = 9$
 (B) $(x-3)^2 + (y+4)^2 = 3$
 (C) $(x-2)^2 + (y-4)^2 = 9$
 (D) $(x+3)^2 + (y+4)^2 = 9$
 (E) $(x-3)^2 + (y-4)^2 = 4$

Correct Answer: (C) $(x-2)^2 + (y-4)^2 = 9$

Solution:

Step 1: Understanding the Concept:

The equation of a circle in standard center-radius form is $(x-h)^2 + (y-k)^2 = r^2$, where (h, k) is the center and r is the radius. The center of the circle is the midpoint of its diameter.

Step 2: Key Formula or Approach:

1. Center $(h, k) = \left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$. 2. Radius r is half the diameter length or the distance from the center to one of the endpoints.

Step 3: Detailed Explanation:

Let the given diameter endpoints be $A(-1, 4)$ and $B(5, 4)$.

First, calculate the center (h, k) :

$$h = \frac{-1+5}{2} = \frac{4}{2} = 2$$

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

So, the center is $(2, 4)$.

Next, calculate the radius r as the distance from center $(2, 4)$ to endpoint $B(5, 4)$: Since the y-coordinates are the same, the distance is horizontal:

$$r = \sqrt{(5-2)^2 + (4-4)^2} = \sqrt{3^2} = 3$$

Now substitute the center and radius into the circle equation:

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

$$(x - 2)^2 + (y - 4)^2 = 3^2$$

$$(x - 2)^2 + (y - 4)^2 = 9$$

Step 4: Final Answer:

The correct equation is $(x - 2)^2 + (y - 4)^2 = 9$.

Quick Tip: Diametric form: $(x - x_1)(x - x_2) + (y - y_1)(y - y_2) = 0$.

$$(x + 1)(x - 5) + (y - 4)(y - 4) = 0 \Rightarrow x^2 - 4x - 5 + (y - 4)^2 = 0 \Rightarrow (x - 2)^2 - 4 - 5 + (y - 4)^2 = 0.$$

17. The foci of a hyperbola are (8,3) and (0,3) and eccentricity is $\frac{4}{3}$. Then the length of the transverse axis is:

- (A) $\frac{32}{3}$
- (B) 4
- (C) 8
- (D) $\frac{8}{3}$
- (E) 6

Correct Answer: (E) 6

Solution:

Step 1: Understanding the Concept:

In a hyperbola, the distance between the foci is $2ae$, where a is the length of the semi-transverse axis.

Step 2: Key Formula or Approach:

Distance between foci $= 2ae$.

Length of transverse axis $= 2a$.

Step 3: Detailed Explanation:

Foci: $(8, 3)$ and $(0, 3)$.

Distance $= 8 - 0 = 8$ (horizontal).

So, $2ae = 8$.

Given $e = 4/3$.

$$2a \times (4/3) = 8$$

$$2a = 8 \times (3/4) = 6.$$

The length of the transverse axis is $2a = 6$.

Step 4: Final Answer:

The length of the transverse axis is 6.

Quick Tip: Always identify if the transverse axis is horizontal or vertical. Here, $y = 3$ is constant, so it is horizontal.

18. A set contains 9 elements. Then the number of subsets of the set which contains at most 4 elements is:

- (A) 32
- (B) 64
- (C) 128
- (D) 256
- (E) 512

Correct Answer: (D) 256

Solution:

Step 1: Understanding the Concept:

The number of subsets with exactly k elements from a set of n elements is given by the binomial coefficient $\binom{n}{k}$.

Step 2: Key Formula or Approach:

Required number = $\binom{n}{0} + \binom{n}{1} + \cdots + \binom{n}{4}$ for $n = 9$.

Step 3: Detailed Explanation:

Total subsets for $n = 9$ is $2^9 = 512$.

Sum of all coefficients: $\sum_{k=0}^9 \binom{9}{k} = 512$.

By symmetry: $\binom{9}{0} = \binom{9}{9}$, $\binom{9}{1} = \binom{9}{8}$, $\binom{9}{2} = \binom{9}{7}$, $\binom{9}{3} = \binom{9}{6}$, $\binom{9}{4} = \binom{9}{5}$.

Thus, $\binom{9}{0} + \cdots + \binom{9}{4}$ is exactly half of the total sum.

Result = $512/2 = 256$.

Step 4: Final Answer:

The number of subsets is 256.

Quick Tip: For odd n , the sum of the first half of binomial coefficients is always 2^{n-1} . Here $2^{9-1} = 2^8 = 256$.

19. If x^{22} is in the $(r + 1)^{\text{th}}$ term of the binomial expansion of $(3x^3 - x^2)^9$, then the value of r is equal to

- (A) 3
- (B) 4
- (C) 5
- (D) 6
- (E) 7

Correct Answer: (C) 5

Solution:**Step 1: Understanding the Concept:**

We must find the specific term in a binomial expansion that contains a given power of x . The

general formula for the $(r + 1)^{\text{th}}$ term in the expansion of $(a + b)^n$ is used.

Step 2: Key Formula or Approach:

The general term T_{r+1} is given by:

$$T_{r+1} = \binom{n}{r} a^{n-r} b^r$$

Here, $a = 3x^3$, $b = -x^2$, and $n = 9$.

Step 3: Detailed Explanation:

Substitute the given terms into the general formula:

$$T_{r+1} = \binom{9}{r} (3x^3)^{9-r} (-x^2)^r$$

Now, separate the constants from the variables:

$$T_{r+1} = \binom{9}{r} (3^{9-r}) (x^{3(9-r)}) (-1)^r (x^{2r})$$

$$T_{r+1} = \binom{9}{r} 3^{9-r} (-1)^r x^{27-3r} x^{2r}$$

Combine the exponents of x by adding them together:

$$\text{Power of } x = (27 - 3r) + 2r = 27 - r$$

The problem states that this term must contain x^{22} . Therefore, set the combined exponent of x equal to 22:

$$27 - r = 22$$

Solve for r :

$$r = 27 - 22 = 5$$

Step 4: Final Answer:

The value of r is 5.

Quick Tip: Always check the sign. $(-x^2)^r$ will affect the sign of the term but not the power of x .