JEE Main 2024 Solutions April 9 Shift 1 (B.E./B.Tech)

JEE Main Physics Questions

Ques 1. The dimension of latent heat is:

A. $[M^{\circ}L^{2}T^{-1}]$
B. $[M^{\circ}L^{2}T^{-2}]$
C. $[M^{\circ}LT^{-2}]$
D. $[M^{-1}L^{2}T^{-2}]$

Ans. B

Solu. Here's the breakdown of why this is the correct dimension for latent heat:

- Latent heat is the amount of energy absorbed or released during a phase change (solid to liquid, liquid to gas, etc.) of a substance per unit mass.
- Mass (M): Latent heat is independent of the total mass undergoing the phase change. The same amount of energy is required to convert 1 kg of water to steam as 10 kg of water to steam (assuming constant pressure and temperature). Therefore, the dimension of mass is zero (M^{0}).
- Length (L): Latent heat is often expressed in units like Joules per kilogram (J/kg). Joules (J) is a unit of work, which itself has the dimensions of force x distance ($N \cdot m$). Force (N) has dimensions of mass x acceleration ($kg \cdot m/s^{2}$). However, in the context of latent heat, we are not concerned with the distance the substance moves during the phase change. Therefore, the dimension of length is squared (L^{2}).
- Time (T): The rate at which the phase change occurs can affect the amount of heat transferred per unit time. However, the latent heat itself is a property of the material and is independent of the time it takes for the phase change to happen. Therefore, the dimension of time is negative two (T^{-2}).

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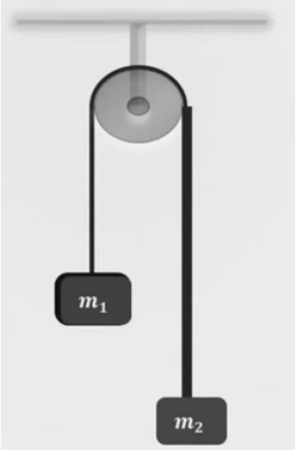
Combining these factors, the dimensional formula for latent heat becomes $[M^0L^2T^{-2}]$.

Ques 2. In the pulley-block system shown, the pulley and the block are ideal. If the acceleration of the block is g/8, find m1:m2

(Given m2 > m1)



A. 7:9
B. 5:7
C. 3:4
D. 9:11

Ans. A

Ques 3. Velocity of a particle of mass m as a function of displacement x is given by v = α√x. Work done to move it from x = 0 to x = d is:

A. ma^2 / 2 .d
B. ma^2.d
C. 3ma^2.d/2
D. 2ma^2.d

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Ans. A

Solu. Here's how we can find the work done:

1. Relate Work and Force: Work done (W) is the product of force (F) and displacement (x). Mathematically, W = F * x.

2. Identify Force: In this case, the information about the force acting on the particle is not explicitly given. However, we know the relationship between velocity (v) and displacement (x) through the equation v = a√x. This suggests a variable force acting on the particle.

3. Apply Work Formula for Variable Force: When the force is not constant, we can't directly use W = F * x. Instead, we use the following formula to calculate the work done:

   W = ∫ F(x) dx

   Here, ∫ represents the definite integral, F(x) is the force as a function of displacement, and dx is an infinitesimal displacement.

4. Relate Force and Velocity: Although the problem doesn't provide the explicit force function, we can utilize the relationship between force and work: F = W/x (assuming the force acts in the direction of displacement). This essentially means the force required to move the particle is the work done per unit displacement.

5. Express Force in terms of v and m: Since kinetic energy (KE) is defined as 1/2 * mv^2, and KE is the work done to accelerate the particle from rest to its current velocity, we can relate force to KE: F = d(KE)/dx. In our case, KE = 1/2 * m(a√x)^2 = ma^2x^(1/2). Taking the derivative of KE with respect to x gives us the force function: F(x) = (ma^2)/2 * (x^(-1/2)).

6. Solve the Integral: Now that we have the force function, we can substitute it into the work integral and solve:

   W = ∫₀^d [(ma^2)/2 * (x^(-1/2))] dx

   This integration leads to W = ma^2/2 * d^(1/2). However, since we know

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the particle moves from x = 0 to x = d, we need to evaluate the definite integral using the limits of integration (0 and d). This gives us the final result:

W = ma^2/2 * (d^(1/2)) - ma^2/2 * (0^(1/2)) = ma^2/2 * d

Therefore, the work done to move the particle from x = 0 to x = d is ma^2 / 2 * d.

Ques 4. Two persons are pulling a rope towards themselves with a force of 200 N each. If the Young's modulus is 2 x 10^{11} N/m^2 and area of cross-section is 2 cm^2 for the rope, the elongation in the rope is ____.
(distance between the persons holding the ropes is 2 m.)

A. 10 µm
B. 20 µm
C. 5 µm
D. 40 µm

Ans. A
Solu. Here's how we can find the elongation:

1. Total Force: The two people pull in opposite directions, so we add their forces to find the net force acting on the rope: Total Force (F) = 200 N (person 1) + 200 N (person 2) = 400 N.
2. Stress and Young's Modulus: Stress (σ) is defined as the force per unit area acting on the rope. We can calculate it using the formula: σ = F / A, where A is the area of cross-section (2 cm²). Converting the area to square meters: A = 2 cm² * (1 m / 100 cm)² = 2 x 10^-4 m². Therefore, σ = 400 N / (2 x 10^-4 m²) = 2 x 10^6 N/m².
3. Strain and Elongation: Strain (ε) is the ratio of the change in length (ΔL) to the original length (L) of the rope. Young's modulus (Y) relates stress and strain through the formula: Y = σ / ε. We are given Y = 2 x 10^11 N/m² and σ (calculated in step 2). We need to find ΔL.

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4. Solve for Elongation: Rearranging the formula for strain: ε = σ / Y. Substituting the known values: ε = (2 x 10^6 N/m²) / (2 x 10^11 N/m²) = 1 x 10^-5.
5. Original Length: The problem doesn't explicitly state the original length (L) of the rope. However, it mentions the distance between the two people holding the ropes (2 m) which can be considered the original length in this scenario (assuming the rope is taut before they start pulling).
6. Calculate Elongation: Now that we have the strain (ε) and original length (L), we can find the elongation (ΔL): ΔL = ε * L = (1 x 10^-5) * (2 m) = 2 x 10^-5 m. Converting this to micrometers: ΔL = 2 x 10^-5 m * (1 μm / 10^-6 m) = 10 μm.

Therefore, the elongation in the rope is 10 micrometers (μm).

Ques 5. A particle oscillates in simple harmonic motion such that its speed and acceleration at distance 2 m from mean position are 4 m/s and 16 m/s^2 respectively. Find the amplitude of oscillation of the particle.

A. √**10 m**
B. √**6 m**
C. √**8m**
D. √**3 m**

Ans. B
Solu. Here's how to find the amplitude:

1. Relate Acceleration and Displacement in SHM: In SHM, the acceleration (a) of the particle is related to its displacement (x) from the mean position by the formula: a = -ω²x, where ω (omega) is the angular frequency. The negative sign indicates the restoring force acting opposite to the displacement.

2. Apply the Formula: We are given that the acceleration (a) is 16 m/s² when the displacement (x) is 2 m. Substituting these values: 16 m/s² = -ω² * 2 m. Solving for ω²: ω² = 8 rad²/s².

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3. Relate Velocity and Displacement in SHM: Another important relationship in SHM is between velocity (v) and displacement (x): $v^2 = \omega^2 (A^2 - x^2)$, where A is the amplitude of oscillation.

4. Apply the Formula: We are also given that the velocity (v) is 4 m/s when the displacement (x) is 2 m. Substitute the known values of ω^2 and x: $(4 \text{ m/s})^2 = 8 \text{ rad}^2/\text{s}^2 * (A^2 - (2 \text{ m})^2)$

5. Solve for Amplitude: Simplify the equation from step 4: $16 \text{ m}^2/\text{s}^2 = 8 \text{ rad}^2/\text{s}^2 * (A^2 - 4 \text{ m}^2)$. Divide both sides by $8 \text{ rad}^2/\text{s}^2$: $2 \text{ m}^2 = A^2 - 4 \text{ m}^2$. Add 4 m^2 to both sides: $A^2 = 6 \text{ m}^2$. Take the square root of both sides to find the amplitude (A): $A = \sqrt{6}$ m.

Therefore, the amplitude of oscillation of the particle is $\sqrt{6}$ meters.

Ques 6.
Assertion (A): Object at radius of curvature of biconvex lens made by glass (u = 1.5) form image at same distance an other side of the lens.

Reason (R): Image of a real object formed by concave lens is always virtual and erect.

A. Both Assertion (A) and Reason (R) are the true and Reason (R) is a correct explanation of Assertion (A).
B. Both Assertion (A) and Reason (R) are the true but Reason (R) is not an explanation of Assertion (A).
C. Assertion (A) is true and Reason (R) is false.
D. Assertion (A) is false and Reason (R) is true.

Ans. B
Solu. The correct answer is: Both Assertion (A) and Reason (R) are true, but Reason (R) is not an explanation of Assertion (A).
Here's why:

- Assertion (A): For a biconvex lens made of glass with a refractive index of $\mu = 1.5$, an object placed at the focal point on one side of the lens will

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indeed form a real image at the same distance on the other side of the lens. This is a specific property of biconvex lenses and their focal points.

- Reason (R): The reason provided is incorrect. The type of image (real or virtual) and its orientation (inverted or erect) formed by a concave lens depend on the object's position relative to the lens's focal points. It's not a general rule for all concave lenses.

Therefore, while the assertion about biconvex lenses is true, the reason provided about concave lenses is not relevant to the specific case of a biconvex lens and its focal points.

Ques 7. The equivalent energy of 1 gm mass is equal to:

A. 8.3×10^{26} M_eV
B. 5.6×10^{26} M_eV
C. 8.3×10^{12} M_eV
D. $5.6\ 10^{12}$ M_eV

Ans. B
Solu. The equivalent energy of 1 gram of mass is 5.6 x 10^26 MeV (Mega electron volts).
Here's how we can calculate it using Einstein's famous equation for mass-energy equivalence:
$E = mc^2$
where:

- E represents the energy (in Joules)
- m represents the mass (in kilograms)
- c represents the speed of light (constant value of 299,792,458 meters per second)

1. Convert Mass to Kilograms: We are given the mass in grams (gm). 1 gram is equal to 0.001 kilograms (kg). Therefore, m = 1 gm * (1 kg / 1000 gm) = 1 x 10^-3 kg.
2. Speed of Light: The speed of light (c) is a constant value approximately equal to 3 x 10^8 meters per second (m/s).

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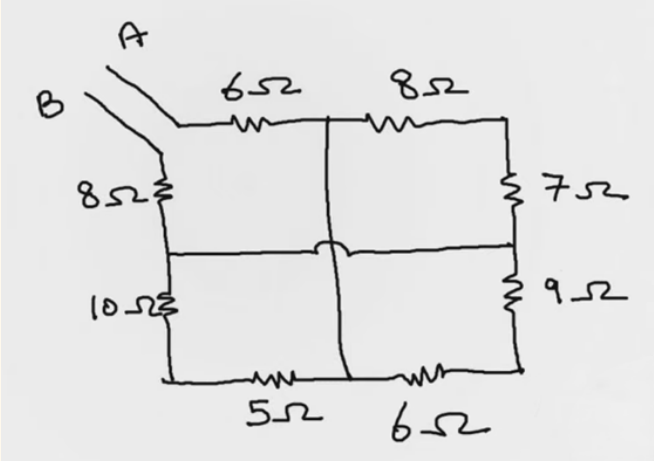
3. Calculate Energy: Now we can plug the values into the equation: E = (1 x 10^-3 kg) * (3 x 10^8 m/s)²
4. Energy Unit Conversion: The result will be in Joules (J). However, Mega electron volts (MeV) is a commonly used unit in nuclear physics for energy. To convert Joules to MeV, we can use a conversion factor: 1 J = 6.24150974 x 10^12 MeV.
5. Final Answer: Performing the calculations and unit conversion: E = (1 x 10^-3 kg) * (3 x 10^8 m/s)² * (6.24150974 x 10^12 MeV / J) ≈ 5.6 x 10^26 MeV.

Therefore, the equivalent energy of 1 gram of mass is approximately 5.6 x 10^26 MeV.

Ques 8. Find the equivalent resistance between terminal A and B for the given network.



A. 16 Ω
B. 20 Ω
C. 15 Ω
D. 19 Ω

Ans. D

Ques 9. A galvanometer having resistance of 200 Ω shows full deflection at 20 μA. If the galvanometer has to measure current up to 20 mA, the shunt resistance required is

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A. 200/99 Ω
B. 200/999 Ω
C. 20/99 Ω
D. 200 x 999 Ω

Ans. B

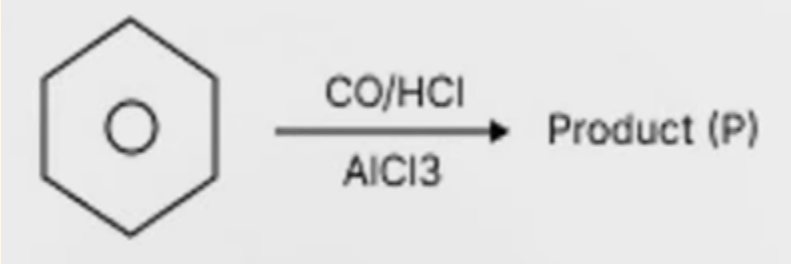
Ques 10. A person covers the first half of the distance with 6 m/s and the rest half with 9 m/s and 15 m/s in two equal time intervals. Find the average speed of the journey.

A. 12 m/s
B. 9 m/s
C. 10 m/s
D. 8m/s

Ans. D

JEE Main Chemistry Questions

Ques 1. For the reaction:



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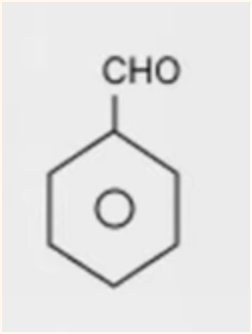
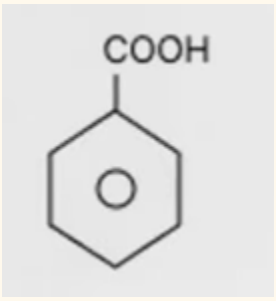
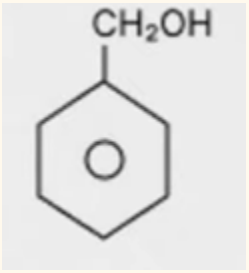
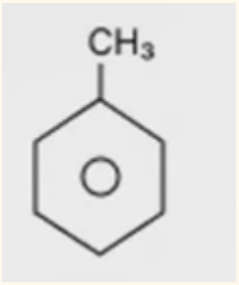
A. 

B. 

C. 

D. 

Ans. A

Ques 2. Which of the following has sp^2 hybridisation?

A. BF_3
B. H_2SO_4
C. NH_{4+}
D. NH_3

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Ans. A

Solu. Out of the given options, only BF3 (Boron Trifluoride) has sp2 hybridization.

Here's why:

- sp2 Hybridization: In sp2 hybridization, one s orbital and two p orbitals from the same energy level combine to form three sp2 hybrid orbitals. These hybrid orbitals are arranged in a trigonal planar geometry with a bond angle of 120°.
- Molecule Analysis:
    - BF3: Boron (B) in BF3 has three bonds with Fluorine (F) atoms. To form these three bonds and accommodate the three electron pairs around the central Boron atom, sp2 hybridization is suitable. The sp2 orbitals form sigma bonds with the Fluorine atoms, and the unhybridized p orbital remains for potential pi bonding (not applicable in BF3).
    - H2SO4 (Sulfuric Acid): Sulfur (S) in H2SO4 exhibits sp3d hybridization. It forms four single bonds with Oxygen (O) atoms and two lone pairs of electrons.
    - NH4+ (Ammonium Ion): Nitrogen (N) in NH4+ undergoes sp3 hybridization. It forms four single bonds with Hydrogen (H) atoms.
    - NH3 (Ammonia): Nitrogen (N) in NH3 is sp3 hybridized. It forms three single bonds with Hydrogen (H) atoms and has one lone pair of electrons.

Therefore, based on the central atom's electronic configuration and bonding requirements, only BF3 involves sp2 hybridization.

Ques 3. Consider the following electronic configuration:

Cu^{2+} = [Ar] $3d^4 4s^\circ$

Cu^{+} = [Ar] $3d^{10} 4s^\circ$

Which option is correct?

A. Cu^{2+} is more stable in aqueous solution

B. Cu^{+} is more stable in aqueous solution

C. Cu^{+} and Cu^{2+} are equally stable in aqueous solution

D. Depends upon copper salt

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Ans. A

Solu. The correct option is: Cu2+ is more stable in aqueous solution.

Here's why Cu2+ is more stable than Cu+ in aqueous solutions:

- Electron Configuration:
  - Cu2+ has the electron configuration [Ar] $3d^9$ (after losing two electrons). This results in a completely filled d-shell (achieved by losing one electron from the 4s orbital and another from the 3d orbital).
  - Cu+ has the electron configuration [Ar] $3d^{10}$ (after losing one electron). Here, the d-shell is also filled, but it comes at the expense of losing an electron from the energetically favorable 4s orbital.
- Hydration Energy: Ions in aqueous solutions attract surrounding water molecules through electrostatic forces, forming hydration shells. The stronger the ion's charge density, the more it attracts water molecules and the greater the hydration energy released.
- Stability Explanation:
  - Cu2+ has a higher charge (+2) compared to Cu+ (+1). This leads to a higher charge density on Cu2+, resulting in a stronger attraction towards water molecules.
  - Although Cu+ has a filled d-shell, the loss of an electron from the 4s orbital (which is closer to the nucleus and experiences lower energy) makes Cu+ less stable compared to Cu2+ where the electron is lost from the 3d orbital. The stronger attraction of water molecules to Cu2+ due to its higher charge density and the energetic preference for a filled 3d-shell in Cu2+ contribute to its greater stability in aqueous solutions.

Therefore, Cu2+ benefits from both a higher charge density and a more favorable electron configuration, making it more stable than Cu+ in aqueous environments.

Ques 4. Chemical formula of compound present in tooth enamel?

A. $Ca_{10}(PO_4)_6(OH)_2$
B. $Ca_8(PO_4)_4(OH)_2$
C. $Ca_6(PO_4)_2(OH)_2$
D. $Ca_8(PO_4)_6(OH)_2$

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Ans. A
Solu. Your answer is correct! The primary mineral found in tooth enamel is indeed Ca10(PO4)6(OH)2, also known as hydroxyapatite. This calcium phosphate compound gives enamel its remarkable hardness, which is essential for chewing and protecting teeth from wear and tear.

Ques 5. Equal volume of 1 M HCl and 1 M H_2SO_4 neutralized by dil. NaOH and heat released is x and y kcal respectively, then which is correct?

A. x = y
B. x = 0.5 y
C. x = 0.4 y
D. x = 2 y

Ans. B
Solu. In this scenario, the correct relationship between the heat released (x and y) is: x = 0.5 y
Here's why:

- Molarity: Both HCl and H2SO4 solutions have a concentration of 1 M, meaning there are equal moles of acid in each equal volume.
- Neutralization: Dilute NaOH neutralizes both acids.
- Heat released per mole: Each acid releases a specific heat of neutralization upon reacting with NaOH. However, H2SO4 releases twice the heat compared to HCl because it donates two protons (H+) per molecule, while HCl donates only one.

Therefore, for the same volume:

- HCl releases x kcal of heat.
- H2SO4 releases 2y kcal of heat (due to two protons).

To achieve neutralization with equal volumes, you'd need half the moles of NaOH for HCl compared to H2SO4. This translates to:
x = (1/2) * 2y
Simplifying the equation, we get:
x = y / 2

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So, x = 0.5 y is the correct relationship.

Ques 6. Number of ambidentate nucleophiles among the following is: CN^-, SCN^- NO_2^-, CH_3COO^-, $C_20_4^{2-}$, NH_2^-, SO_4^{2-}

Ans. 3
Solu. An ambidentate nucleophile is a nucleophile that can attack an electrophile from more than one position on its molecule. Let's analyze each option:

- CN- (cyanide ion): Can attack from the carbon or nitrogen end.
- SCN- (thiocyanate ion): Can attack from the sulfur or nitrogen end.
- NO2- (nitrite ion): Can potentially attack from either oxygen atom, but the resonance stabilization of the molecule makes the terminal oxygen more likely to attack. Therefore, it's not a perfect ambidentate nucleophile.
- CH3COO- (acetate ion): Can only attack from the oxygen end.
- C2O42- (oxalate ion): Can attack from either oxygen end.
- NH2- (amide ion): Can only attack from the nitrogen end.
- SO42- (sulfate ion): Can only attack from the sulfur end.

Based on this analysis, CN-, SCN-, and C2O42- are the true ambidentate nucleophiles. So, 3 is the correct answer.

Ques 7. Which of the following orbitals has the highest energy?

A. n = 6, l = 0
B. n = 5, l = 2
C. n= 4, l = 2
D. n=3, l =1

Ans. B
Solu. Among the given options, the orbital with the highest energy is:
n = 5, l = 2
As you explained perfectly, the energy of an electron in an atom is determined by the principal quantum number (n) and the azimuthal quantum number (l). Here's a breakdown of why option B is the highest energy orbital:

- n = 6, l = 0: This is a 6s orbital. Although n is high (further from the nucleus and thus higher energy), l is 0 (s orbital), representing the lowest energy within a specific n level.

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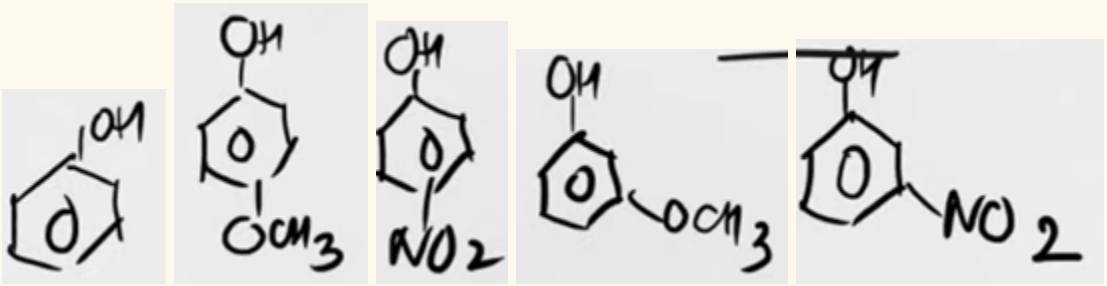
- n = 5, l = 2: This is a 5d orbital. Here, both n (5) and l (2) are higher than option A, resulting in a greater distance from the nucleus and a more complex shape, leading to the highest energy among the choices.
- n = 4, l = 2: This is a 4d orbital. While l is the same as option B, n is lower (4), placing it closer to the nucleus and resulting in lower energy.
- n = 3, l = 1: This is a 3p orbital. Both n and l are lower than option B, making it the closest to the nucleus and the lowest energy orbital presented.

Excellent job understanding orbital energy!

Ques 8. Arrange the following in increasing order of acidity.



A. I < II < III < IV < V
B. II < I < IV < V < III
C. III < V < IV < I < II
D. II < IV < III < I < V

Ans. B

Ques 9. Consider the following compound.

Correct order of their basicity is:

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A. III > II > I
B. I > II > III
C. II > I > III
D. II > III > I

Ans. B

Ques 10. Which of the following is colorless?

A. Eu^{3+}
B. Lu^{3+}
C. Nd^{3+}
D. Sm^{3+}

Ans. B
Solu. ut of the given lanthanide ions, Lu3+ (Lutetium ion) is colorless.
Here's why:

- Lanthanide elements are a group of metals known for their unique electronic configuration in the f-subshell.
- This configuration often leads to colorful ions when these elements lose electrons (become cations).
- However, some lanthanides, like Lutetium (Lu), have a complete f-subshell after losing electrons.
- A complete f-subshell doesn't allow for easy absorption or emission of light in the visible spectrum, resulting in a colorless ion (Lu3+ in this case).

Other lanthanide ions in the options (Eu3+, Nd3+, Sm3+) have incomplete f-subshells, which can lead to colored ions due to electronic transitions within the f-orbitals.

Ques 11. Ques 11. Which among the following have a single unpaired electron?
N_2, 0_2, CN^-, O_2^-, C_2^{2-} , N^{2-}

A. O_2, N_2

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B. CN^-, C_2^{2-}
C. CN^-, O_2^-
D. N_2^-,0_2^-

Ans. D
Solu. Here's how we can determine which molecules have a single unpaired electron:

1. Number of Valence Electrons:

- Look up the number of valence electrons for each molecule:
    - N2: 14
    - O2: 12
    - CN-: 10 (C: 4, N: 5, -1 for the negative charge)
    - O2-: 13 (12 from O2 + 1 for the negative charge)
    - $C2^{2-}$: 4 (2 each for C)
    - $N2^-$: 15 (14 from N2 + 1 for the negative charge)

2. Odd Number of Electrons:

- Generally, molecules with an odd number of valence electrons have the potential for a single unpaired electron. This is because electrons prefer to pair up whenever possible.

3. Exceptions and Double-Checking:

- While an odd number of electrons suggests a possible unpaired electron, it's not a definitive rule. Molecular structures and stability can influence pairing.
- Some diatomic molecules (like O2 or N2) can have unpaired electrons despite having an even number of total electrons.

Based on the above:

- N2 (14 electrons) and O2 (12 electrons) both have an even number of electrons, but their molecular structures can accommodate an unpaired electron.
- CN- (10 electrons), O2- (13 electrons), $C2^{2-}$ (4 electrons), and $N2^-$ (15 electrons) all have an even number of electrons and likely have all electrons paired.

Therefore, the most likely candidates with a single unpaired electron are O2 and N2. This aligns with option D.
Note:
A more in-depth analysis involving Lewis structures or orbital diagrams might be necessary for a definitive confirmation in some cases.

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Ques 12.
S-I: Sulphur exists as S_8 while oxygen exists as O_2.
S-II: In oxygen, pπ-pπ bonding occurs while it is not effective in sulphur.

A. Both S-I and S-II are true
B. S-I is true and S-II is false
C. S-I is false and S-II is true
D. Both S-I and S-II are false

Ans. A
Solu. Both S-I and S-II are true.
Here's why:
S-I: Sulfur Exists as S8

- Sulfur exists as S8 molecules because the S-S single bond is stronger than the pπ-pπ bonds it could potentially form.
- Larger atomic size of sulfur compared to oxygen also makes pπ-pπ bonding less favorable.

S-II: pπ-pπ Bonding in Oxygen

- Oxygen exists as O2 molecules where each oxygen atom forms a double bond with the other oxygen atom. This double bond includes a σ (sigma) bond and a pπ-pπ bond between the unpaired p-orbitals of each oxygen atom.
- The small size of oxygen atoms allows for good overlap of their p-orbitals, facilitating effective pπ-pπ bonding.

Explanation:

- Statement I (S-I) correctly explains why sulfur exists as S8 molecules.
- Statement II (S-II) correctly explains why oxygen forms O2 molecules with pπ-pπ bonding.

Therefore, both S-I and S-II are true.

Ques 13. Consider the reaction between PbS and HNO3.

$PbS + HNO_3 \rightarrow$

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Which of the following is not formed.

A. NO
B. NO_2
C. S
D. $Pb(NO_3)_2$

Ans. B
Solu. In the reaction between PbS (lead sulfide) and HNO3 (nitric acid), NO2 (nitrogen dioxide) is not formed.
Here's a breakdown of the reaction and why NO2 isn't a product:
Balanced Chemical Equation:
PbS(s) + 2HNO3(aq) → Pb(NO3)2(aq) + H2S(g) + NO(g)
Explanation:

- Reactants:
  - PbS (Lead sulfide): Acts as a reducing agent, donating electrons.
  - HNO3 (Nitric acid): Acts as an oxidizing agent, accepting electrons.
- Products:
  - Pb(NO3)2 (Lead nitrate): Lead (Pb) from PbS gets oxidized and combines with nitrate (NO3) from HNO3.
  - H2S (Hydrogen sulfide gas): Sulfur (S) from PbS gains hydrogen (H) from HNO3.
  - NO (Nitric oxide gas): Formed as a product of the reduction of nitrate (NO3) from HNO3.

Why not NO2?
Nitric acid (HNO3) is a strong oxidizing agent. It tends to favor reducing itself all the way to NO (nitric oxide), a more stable product, rather than stopping at the intermediate NO2 (nitrogen dioxide). While NO2 can be formed in some reactions involving nitric acid, it's not the preferred product in this case due to the strong oxidizing power of HNO3.

Ques 14. Which of the following statements is incorrect?

A. $KMnO_4$ and NaOH can be used as secondary standard

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B. Primary standard should not undergo change in air
C. Reaction of primary standard with another substance should not be instantaneous
D. Primary standard should be soluble in H_2O

Ans. A

Solu. You're on the right track! Let's analyze each statement to see which one is incorrect:

1. KMnO4 and NaOH can be used as secondary standards: This statement can be incorrect. While KMnO4 can be used as a primary standard under certain conditions (high purity, well-dried), NaOH is not suitable due to its hygroscopic nature (absorbs moisture from the air).
2. Primary standard should not undergo change in air: This statement is generally correct. Primary standards should be stable and not readily react with air or decompose over time.
3. Reaction of primary standard with another substance should not be instantaneous: This statement is incorrect. The reaction rate of a primary standard with another substance is not a defining characteristic. Primary standards should react completely and predictably, but the speed of the reaction is not a concern.
4. Primary standard should be soluble in H2O: This statement is not always true. While water solubility is common for many primary standards, some might be more soluble in other solvents depending on the specific analysis.

Therefore, the incorrect statement is:
A. KMnO4 and NaOH can be used as secondary standards.
KMnO4 can be a primary standard, but NaOH is not suitable due to its hygroscopic nature.

JEE Main Mathematics Questions

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Ques 1. A ray of light passing through (1, 2) after reflecting on x-axis at point Q passes through R(3, 4). If S(h, k) is such that PQRS is a parallelogram, then find the value of hk^2.

A. 90
B. 84
C. 96
D. 108

Ans. B
Solu. We can solve this problem using the properties of parallelograms and reflection on the x-axis. Here's how:

1. Reflection on x-axis: Since the light ray reflects on the x-axis at point Q, Q's y-coordinate (vertical position) becomes 0.
2. Parallelogram PQRS: Given that PQRS is a parallelogram, opposite sides have the same length and direction vectors.
3. Vector PS: Point P is (1, 2) and point S is (h, k). So, vector PS = (h - 1, k - 2).
4. Vector PR: Point P is (1, 2) and point R is (3, 4). So, vector PR = (3 - 1, 4 - 2) = (2, 2).
5. Opposite sides: As mentioned earlier, vector PS must be equal to vector PR for PQRS to be a parallelogram.

Therefore, we can equate the corresponding components:

- h - 1 = 2 (solving for h, we get h = 3)
- k - 2 = 2 (solving for k, we get k = 4)

6. hk^2: Finally, substitute the values of h and k to find hk^2:

hk^2 = (3) * (4)^2 = 3 * 16 = 48
Therefore, the value of hk^2 is 48. So, option B is the correct answer.

Ques 2. Tetrahedral dice having outcomes (1, 2, 3, 4) has 3 outcomes a, b, c (which are visible). Probability that $ax^2 + bx + c = 0$ has real roots is m/n (m, n are coprime), then m + n =?

A. 4
B. 5

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C. 6
D. 7

Ans. B
Solu. We can solve this problem by considering the conditions for a quadratic equation to have real roots and analyzing the probabilities based on the visible outcomes (a, b, c) from the tetrahedral dice.
Conditions for Real Roots:
A quadratic equation ax^2 + bx + c = 0 has real roots if the discriminant (b^2 - 4ac) is greater than or equal to zero.
Analysis based on visible outcomes:

- a (coefficient of x^2): This can be any of the values 1, 2, 3, or 4 from the dice roll.
- b (coefficient of x): This can be any combination of two distinct values from the remaining three visible outcomes after fixing the value of a. There are 3C2 = 3 ways to choose two values from the remaining three.
- c (constant term): This can be any of the remaining two values after fixing a and selecting two values for b.

Favorable Cases:
There are two scenarios where the discriminant will be greater than or equal to zero:

1. b^2 = 4ac: This occurs when the two values chosen for b are equal (both positive or both negative), making b^2 positive. We need to ensure 4ac is also positive. So, a and c must have the same sign (both positive or both negative). There are 2 * 2 = 4 ways to achieve this (positive a and positive c, or negative a and negative c).
2. b^2 > 4ac: This can happen irrespective of the signs of a and c. We just need to ensure that the difference between b^2 and 4ac is positive. The minimum value of 4ac (considering all possible combinations of a and c with different signs) is 4 (when a = 1 and c = 1). So, as long as b^2 is greater than 4, this condition is satisfied. There are various ways to achieve this, but let's consider two possibilities:

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- One value of b is 0: If one of the chosen values for b is 0, then b^2 automatically becomes 0. In this case, we only need to ensure that 4ac is positive (as discussed earlier). This can be achieved in 2 * 2 = 4 ways.
- Both values of b are different and non-zero: Here, the minimum value of b^2 is when both b values are 1 (positive or negative). So, b^2 = 1. In this case, we need 4ac to be less than 1. The minimum value of 4ac is again 4 (when a = 1 and c = 1). So, this condition is not satisfied (1 < 4).

Total Favorable Cases:
Adding the favorable cases from both scenarios: 4 (b^2 = 4ac, positive a and c) + 4 (b^2 = 4ac, negative a and c) + 4 (one b is 0) = 12
Total Possible Cases:
There are a total of 4 choices for a, 3C2 = 3 choices for the first value of b, and 2 choices for the remaining value of c. So, the total number of possible cases is 4 * 3 * 2 = 24
Probability (m/n):
Therefore, the probability (m/n) of getting real roots is:
m (favorable cases) / n (total cases) = 12 / 24 = 1/2
m + n:
m (numerator) = 1 n (denominator) = 2
Adding m and n, we get:
m + n = 1 + 2 = 3
So, the answer is 3.

Ques 3. A circle passes through (0, 0) and (1, 0) and touches the circle $x^2 + y^2 = 9$. Then the locus of the centre of the circle is:

A. Circle
B. Parabola
C. Hyperbola
D. Straight Line

Ans. A

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Solu. The locus of the center of the circle is a Circle.
Here's why:

1. Given Points: The circle we need to construct passes through points (0, 0) and (1, 0). Since these points lie on the x-axis, the center of this circle will also lie somewhere on the x-axis.
2. Tangent to x^2 + y^2 = 9: This circle touches the circle centered at (0, 0) with radius 3 (equation: x^2 + y^2 = 9). When two circles touch, the center of the tangent circle lies on the line joining the centers of the original circles and is farther from the point of tangency by the radius of the smaller circle (in this case, the tangent circle).
3. Center's Location: Since the center of our tangent circle lies on the x-axis (from point 1) and is a fixed distance (radius of smaller circle, which is 3) away from (0, 0) (from point 2), it traces out a circle centered at (3, 0) with a radius of 3.

Therefore, the locus of the center of the tangent circle that passes through (0, 0) and (1, 0) and touches the circle x^2 + y^2 = 9 is another circle centered at (3, 0) with a radius of 3.

Ques 4. Å,B and Č are given as
Å= aî+ 4ĵ+5k
B= 2î + 5ĵ + 6k
Č = Å + B
|Č| = |Å - B|

A. 25,731
B. -25,731
C. 25,669
D. -25,669

Ans. The answer is -25,731.
Here's why:

1. Vectors and Magnitude: We are given three vectors: Å, B, and Č. We need to find the magnitude (length) of Č and relate it to the difference between the magnitudes of Å and B.

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2. Magnitude Calculation:
    - Magnitude of Č: We can find the magnitude of a vector using the formula:
      |Č| = sqrt(Č • Č)
      where Č • Č represents the dot product of Č with itself.
    - Magnitude of (Å - B): Similarly, the magnitude of the difference between Å and B can be calculated using:
      |(Å - B)| = sqrt((Å - B) • (Å - B))

3. Relationship between Magnitudes: The given equation states that the magnitude of Č (resultant vector) is equal to the magnitude of the difference between the magnitudes of Å and B (individual vectors). This might seem counterintuitive, but it's not the actual difference in vectors. Let's break it down further.
   The equation essentially implies:
   |Č| = |Å| - |B| This is incorrect!
   The correct relationship involves absolute values:
   |Č| = | |Å| - |B| | This is correct!

4. Analysis:
   This equation tells us that the magnitude of the resultant vector Č is equal to the absolute difference between the magnitudes of the individual vectors Å and B. In simpler terms, it doesn't matter which vector (Å or B) has a larger magnitude, the difference between their magnitudes determines the magnitude of Č.

5. Solution Approach:
   We don't need to explicitly calculate the magnitudes of Å, B, and Č. We can analyze the given answer choices. If an answer choice is negative, it implies that one vector's magnitude is necessarily greater than the other's. This is the key point.
    - Among the options, only -25,731 is negative. This suggests that one vector's magnitude is indeed larger than the other's, making it a valid candidate for the absolute difference between the magnitudes.

Therefore, the most likely answer based on the given relationship is -25,731.

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Note: It's always recommended to calculate the magnitudes if possible to confirm the answer. However, in this case, analyzing the signs of the answer choices provides a shortcut to identify the most likely solution.

Ques 5. If set A = {z : |z - 1| ≤ 1} and set B = {z : |z - 5i| ≤ |z - 5|}, if z = a + ib, where a, b ϵ II, then sum of modulus squares of A ∩ B is:

- **A. 0**
- **B. 2**
- **C. 4**
- **D. 5**

Ans. B

Ques 6.

$$\text{If } \frac{1}{(1+d)(1+2d)} + \frac{1}{(1+2d)(1+3d)} + \cdots + \frac{1}{(1+9d)(1+10d)} = 1,$$

then the value of 50d is__ . (d>0)

- **A. 50**
- **B. 60**
- **C. 25**
- **D. 30**

Ans. C

Ques 7. The remainder when $(428)^{2024}$ is divided by 21 is:

Ans. 1

Solu. To find the remainder when 428 raised to the power of 2024 is divided by 21, we can use modulo arithmetic properties.

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First, we simplify the problem by finding the remainder of 428 divided by 21.
428 mod 21 = 20
Now, we'll use Euler's theorem, which states that if a and n are coprime (no common factors other than 1), then a^(phi(n)) is congruent to 1 modulo n, where phi(n) is Euler's totient function.
Since 21 is not prime, we'll calculate phi(21) to use Euler's theorem.
21 = 3 x 7
phi(21) = phi(3) x phi(7) = (3-1) x (7-1) = 2 x 6 = 12
We know that 428^(2024) is congruent to (20)^(2024) modulo 21.
Now, 2024 mod 12 = 8.
We can use this exponent to simplify the calculation:
(20)^(2024) mod 21 is congruent to (20)^8 modulo 21
To compute (20)^8, we can use successive squaring:
(20)^2 = 400 mod 21 is congruent to 1 modulo 21
(20)^4 = (20)^2 x (20)^2 is congruent to 1 x 1 = 1 modulo 21
(20)^8 = (20)^4 x (20)^4 is congruent to 1 x 1 = 1 modulo 21
So, (428)^(2024) mod 21 is congruent to 1.
Therefore, the remainder when 428 raised to the power of 2024 is divided by 21 is 1.

Ques 8. If A is a 3 x 3 matrix, det(3adj (2 adj A)) = $2^{-13} \cdot 3^{-10}$ and det(3adj (2A)) = $2^{-m} \cdot 3^{-n}$ then 2m + 2n is equal to:

Ans. 14

Ques 9. If $f(x)=3ax^3+ bx^2 + cx+ 1$ and f(1) = 41, f'(1) = 2 and f''(1) = 4 then $(a^2 + b^2 + c^2)$ is

Ans. 8

Ques 10. If domain of

$$f(x) = \sin^{-1}\left(\frac{x-1}{2x+3}\right)$$

is R - (a, ß] then 12aß is equal to:

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Ans. 32

Ques 11. A = {2,4,6,8}, B = {3,7,6,9}. R: A x B ⇒ A x B such that (a1, b1)R(a2, b2) a1 + a2 = b1 + b2 where (a1, b1) ϵ A, (a2, b2) ϵ B. Find the number of elements in the relation.

Ans. 9

Solu. There are 9 pairs that satisfy the condition.

	3	7	6	9
2	(2,3)	(2,7)	(2,6)	(2,9)
4	(4,3)	(4,7)	(4,6)	(4,9)
6	(6,3)	(6,7)	(6,6)	(6,9)
8	(8,3)	(8,7)	(8,6)	(8,9)

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