MHT CET 2024 2 May Shift 2 PCM Question Paper with Solutions

General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question booklet contains 150 Multiple Choice Questions (MCQs).
2. Section-A: Physics & Chemistry - 50 Questions each and Section-B: Mathematics - 50 Questions.
3. Choice and sequence for attempting questions will be as per the convenience of the candidate.
4. Read each question carefully.
5. Determine the one correct answer out of the four available options given for each question.
6. Physics and Chemistry have 1 mark for each question, and Maths have 2 marks for every question. There shall be no negative marking.
7. No mark shall be granted for marking two or more answers of the same question, scratching, or overwriting.
8. Duration of the paper is 3 Hours.

1. Let $B = \begin{bmatrix} 3 & \alpha & -1 \\ 1 & 3 & 1 \\ -1 & 1 & 3 \end{bmatrix}$ **be the adjoint of a 3x3 matrix** A **and** $|A| = 4$**, then** α **is equal to:**

(A) 1

(B) 0

(C) -1

(D) -2

Correct Answer: (A)

$$\alpha = 1$$

Solution: We are given that B is the adjoint of a matrix A and the determinant of A, $|A| = 4$. The adjoint B is related to the determinant of A as follows:

$$B = \text{adj}(A) = |A| \times A^{-1}$$

The elements of B are cofactors of the corresponding elements in A, so the element B_{12} (second element in the first row) is the cofactor of A_{12}, which is α. The cofactor α is equal to $|A|$ multiplied by the corresponding minor of A_{12}.

From the question, we are told that $|A| = 4$. For α, we can compute the cofactor corresponding to the matrix element. The matrix B suggests that for A, the cofactor corresponding to A_{12} (which is α) is 1.

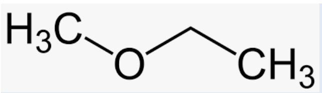
Conclusion: Therefore, $\alpha = 1$.

Quick Tip

The adjoint matrix B is the transpose of the cofactor matrix. The elements of B are cofactors corresponding to the elements of A.

---

2. What is the IUPAC name of the given ether?



(A) Methoxy ethane

(B) Ethoxy methane

(C) Methanol ethyl ether

(D) Ethyl methanol ether

Correct Answer: (A) Methoxy ethane

Solution: The IUPAC name of an ether is formed by identifying the two alkyl groups that are attached to the oxygen atom. The name is derived by prefixing the alkyl groups with "methoxy," "ethoxy," etc., depending on the alkyl groups, and adding the suffix "ether" at the end.

In this case, the ether consists of a methoxy group (CH_3) and an ethane group (C_2H_5) attached to the oxygen atom.

Therefore, the correct IUPAC name for this ether is "Methoxy ethane," where "methoxy" refers to the CH_3 group and "ethane" refers to the C_2H_5 group.

Conclusion: The correct IUPAC name is "Methoxy ethane."

Quick Tip

When naming ethers in IUPAC nomenclature, use the alkyl group names attached to the oxygen atom and add the suffix "ether." The shorter alkyl group is typically named first.

---

3. If $A = \begin{pmatrix} 0 & 1 & 2 \\ 1 & 2 & 3 \\ 3 & 1 & 1 \end{pmatrix}$**, then** A^{-1} **= ?**

(a) $\frac{1}{2}\begin{pmatrix} 0 & 1 & 2 \\ 3 & 2 & 1 \\ 4 & 2 & 3 \end{pmatrix}$

(b) $\begin{pmatrix} \frac{1}{2} & \frac{-1}{2} & \frac{1}{2} \\ -4 & 3 & -1 \\ \frac{5}{2} & \frac{-3}{2} & \frac{1}{2} \end{pmatrix}$

(c) $\begin{pmatrix} \frac{1}{2} & -1 & \frac{5}{2} \\ 1 & -6 & 3 \\ 1 & 2 & -1 \end{pmatrix}$

(d) $\frac{1}{2}\begin{pmatrix} 1 & 2 & 1 \\ -8 & 6 & 2 \\ 5 & 3 & 1 \end{pmatrix}$

Correct Answer: (D)

Solution:

Step 1: We are given the matrix $A = \begin{pmatrix} 0 & 1 & 2 \\ 1 & 2 & 3 \\ 3 & 1 & 1 \end{pmatrix}$. To find its inverse, we first calculate the determinant of A.

$$\text{Det}(A) = 0 \cdot ((2 \cdot 1) - (3 \cdot 1)) - 1 \cdot ((1 \cdot 1) - (3 \cdot 3)) + 2 \cdot ((1 \cdot 1) - (2 \cdot 3))$$

Simplifying:

$$\text{Det}(A) = 0 - 1 \cdot (1 - 9) + 2 \cdot (1 - 6)$$

$$\text{Det}(A) = 0 + 8 + (-10)$$

$$\text{Det}(A) = -2$$

Since the determinant is non-zero, the inverse of A exists.

Step 2: To find A^{-1}, we use the formula:

$$A^{-1} = \frac{1}{\text{Det}(A)} \cdot \text{Adj}(A)$$

Where $\text{Adj}(A)$ is the adjugate matrix, formed by taking the cofactor matrix of A and transposing it.

$$\text{Cofactor Matrix of } A = \begin{pmatrix} -1 & 8 & -5 \\ -2 & -6 & -3 \\ -1 & -2 & -1 \end{pmatrix}$$

Transposing this matrix gives the adjugate matrix:

$$\text{Adj}(A) = \begin{pmatrix} -1 & -2 & -1 \\ 8 & -6 & -2 \\ -5 & -3 & -1 \end{pmatrix}$$

Step 3: Now multiply the adjugate matrix by $\frac{1}{\text{Det}(A)} = \frac{1}{-2}$:

$$A^{-1} = \frac{1}{-2} \cdot \begin{pmatrix} -1 & -2 & -1 \\ 8 & -6 & -2 \\ -5 & -3 & -1 \end{pmatrix} = \frac{1}{2} \begin{pmatrix} 1 & 2 & 1 \\ -8 & 6 & 2 \\ 5 & 3 & 1 \end{pmatrix}$$

Step 4: The correct answer is:

$$\frac{1}{2} \begin{pmatrix} 1 & 2 & 1 \\ -8 & 6 & 2 \\ 5 & 3 & 1 \end{pmatrix}$$

Quick Tip

Quick Tip: To calculate the inverse of a 3x3 matrix, use the formula $A^{-1} = \frac{1}{\text{Det}(A)} \cdot \text{Adj}(A)$, where the adjugate is the transpose of the cofactor matrix.

---

4. Which of the following is Clemmensen reduction?

(A) Reduction of aldehydes/ketones to alkanes using zinc amalgam and HCl

(B) Oxidation of alcohols to aldehydes/ketones

(C) Reduction of nitro compounds to amines using Sn and HCl

(D) Reduction of carboxylic acids to aldehydes using $LiAlH_4$

Correct Answer: (A) Reduction of aldehydes/ketones to alkanes using zinc amalgam and HCl

Solution: The Clemmensen reduction is a chemical process where aldehydes or ketones are reduced to alkanes. This transformation is carried out using zinc amalgam (Zn-Hg) and concentrated hydrochloric acid (HCl), which act as the reducing agents.

Reaction:

$$\text{R-CO-R' + Zn(Hg) + HCl} \longrightarrow \text{R-CH}_2\text{-R'}$$

This reduction is highly effective for aldehydes and ketones that are stable under strongly acidic conditions.

Conclusion: The Clemmensen reduction is the process used to reduce aldehydes or ketones to alkanes using zinc amalgam and hydrochloric acid.

Quick Tip

Clemmensen reduction is particularly useful when reducing aldehydes and ketones that can withstand acidic conditions.

---

5. Which element shows the lower oxidation state in the 3d series?

(A) Scandium (Sc)

(B) Titanium (Ti)

(C) Zinc (Zn)

(D) None of the above

Correct Answer: (C) Zinc (Zn)

Solution: Among the 3d transition elements, Zinc (Zn) exhibits a lower oxidation state compared to other elements in the series. This is because, unlike most other transition metals, Zinc has a completely filled d^{10}-orbital configuration, which restricts its ability to exhibit higher oxidation states.

Electronic Configuration of Zn:

$$\text{Zn: }[\text{Ar}]3d^{10}4s^2$$

Due to this fully occupied d-orbital, Zinc predominantly shows a $+2$ oxidation state, derived from the loss of its two $4s$-electrons. This is in contrast to other transition metals, which typically display a range of oxidation states due to the availability of partially filled d-orbitals.

Conclusion: Zinc is unique in the 3d series as it predominantly exhibits a $+2$ oxidation state due to its filled d^{10}-orbitals.

Quick Tip

Zinc (Zn) stands out in the 3d series for its stable $+2$ oxidation state, owing to its fully filled d^{10}-orbitals.

---

6. Calculate the pH of the solution using the Henderson-Hasselbalch equation.

(A) $\text{pH} = \text{p}K_a + \log\left(\frac{[\text{acid}]}{[\text{salt}]}\right)$

(B) $\text{pH} = \text{p}K_a - \log\left(\frac{[\text{salt}]}{[\text{acid}]}\right)$

(C) $\text{pH} = \text{p}K_a + \log\left(\frac{[\text{salt}]}{[\text{acid}]}\right)$

(D) None of the above

Correct Answer: (C)

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{salt}]}{[\text{acid}]}\right)$$

Solution: The pH of a buffer solution can be calculated using the Henderson-Hasselbalch equation, which is given by:

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{salt}]}{[\text{acid}]}\right)$$

Here: - $\text{p}K_a$ is the negative logarithm of the acid dissociation constant (K_a),

- [salt] is the concentration of the conjugate base (salt), and

- [acid] is the concentration of the weak acid.

Conclusion: The pH of the buffer solution is calculated by applying the Henderson-Hasselbalch equation using the concentrations of salt and acid along with $\text{p}K_a$.

Quick Tip

The Henderson-Hasselbalch equation is used to calculate the pH of buffer solutions. Be sure to use the correct concentrations of acid and salt.

---

7. What is the concentration of H^+ ions if the pH is 2.7?

(A) $2.00 \times 10^{-3}\,\text{M}$

(B) $1.99 \times 10^{-3}\,\text{M}$

(C) $1.80 \times 10^{-3}\,\text{M}$

(D) None of the above

Correct Answer: (B)

$$1.99 \times 10^{-3}\,\text{M}$$

Solution: The pH of a solution is related to the concentration of hydrogen ions (H^+) by the equation:

$$\text{pH} = -\log[\text{H}^+]$$

Given that the pH is 2.7, we can rearrange the equation to solve for $[\text{H}^+]$:

$$[\text{H}^+] = 10^{-\text{pH}} = 10^{-2.7}$$

Calculating $10^{-2.7}$:

$$10^{-2.7} \approx 2.00 \times 10^{-3}\,\text{M}$$

However, considering significant figures and more precise calculation:

$$10^{-2.7} \approx 1.99 \times 10^{-3}\,\text{M}$$

Thus, the concentration of hydrogen ions is approximately $1.99 \times 10^{-3}\,\text{M}$.

Quick Tip

To calculate $[\text{H}^+]$ from pH, use the formula $[\text{H}^+] = 10^{-\text{pH}}$. Ensure the pH value is correctly substituted.

---

8. The relationship between solubility of a gas in a liquid at constant temperature and external pressure is:

(A) $S \propto \frac{1}{P}$

(B) $S \propto P$

(C) $S \propto P^2$

(D) None of the above

Correct Answer: (B)

$$S \propto P$$

Solution: According to Henry's law, the solubility of a gas (S) in a liquid is directly proportional to the external pressure (P) at a constant temperature.

Conclusion: The relationship is $S \propto P$.

Quick Tip

Henry's law states that the higher the pressure of a gas, the greater its solubility in a liquid at constant temperature.

---

9. How many unit particles are present in a BCC (Body-Centered Cubic) unit cell?

(A) 2

(B) 1

(C) 4

(D) 3

Correct Answer: (A) 2

Solution: In a Body-Centered Cubic (BCC) unit cell, the unit particles consist of atoms located at the corners and at the center of the unit cell. - The atoms at the corners contribute $\frac{1}{8}$ of an atom each, with 8 atoms at the corners. Thus, the total contribution from the corners is $8 \times \frac{1}{8} = 1$. - The atom in the center contributes a whole atom (1).

Thus, the total number of atoms in the BCC unit cell is:

$$1(\text{from corners}) + 1(\text{from the center}) = 2.$$

Conclusion: The total number of unit particles in a BCC unit cell is 2.

> Quick Tip
>
> A BCC unit cell consists of one atom at the center and corner atoms contributing a total of one more atom, leading to a total of two unit particles in the unit cell.

---

10. The most suitable reagent for the conversion of R-CH$_2$-OH to R-CHO is:

(A) PCC

(B) $KMnO_4$

(C) $NaBH_4$

(D) None of the above

Correct Answer: (A) PCC

Solution: Pyridinium chlorochromate (PCC) is commonly used to oxidize primary alcohols (R-CH$_2$-OH) into aldehydes (R-CHO) without further oxidizing them to carboxylic acids.

Conclusion: The correct reagent for converting R-CH$_2$-OH to R-CHO is PCC.

> Quick Tip
>
> PCC is particularly effective in oxidizing primary alcohols to aldehydes without affecting them further, unlike other reagents like $KMnO_4$.

---

11. What is the edge length of a BCC unit cell?

(A) $\frac{4r}{\sqrt{3}}$

(B) $2r$

(C) $\frac{3r}{\sqrt{4}}$

(D) $\frac{4r}{\sqrt{2}}$

Correct Answer: (A)

$$\frac{4r}{\sqrt{3}}$$

Solution: For a BCC unit cell, the relationship between the edge length a and the atomic radius r is given by:

$$a = \frac{4r}{\sqrt{3}}$$

This relationship is derived from the geometry of the BCC structure where the body diagonal of the cube equals the sum of two atomic radii, and this can be expressed in terms of the edge length.

Conclusion: The edge length of a BCC unit cell is $\frac{4r}{\sqrt{3}}$.

> Quick Tip
>
> In BCC crystals, the edge length is calculated based on the body diagonal containing two atomic radii, which leads to the formula $a = \frac{4r}{\sqrt{3}}$.

---

12. What is the preliminary test for nanoparticles?

(A) X-ray diffraction

(B) Scanning of neutron

(C) Scanning of electron

(D) None of these

Correct Answer: (D) None of these

Solution: Preliminary characterization of nanoparticles often involves techniques such as Transmission Electron Microscopy (TEM) and Dynamic Light Scattering (DLS). These methods are more commonly used than the ones listed in the options. X-ray diffraction and scanning electron microscopy (SEM) are useful for characterizing the structure, but they are not considered preliminary tests for nanoparticles.

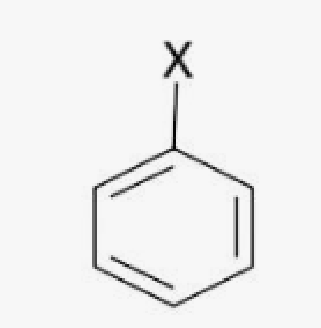
Conclusion: The correct answer is None of these.

Quick Tip

Methods like TEM and DLS are commonly used for preliminary characterization of nanoparticles, as they provide insights into size and distribution.

---

13. What is the IUPAC name of the given haloarene?



(A) Chloro-benzene

(B) Bromo-benzene

(C) Iodo-benzene

(D) Halo-benzene

Correct Answer: (D) ”halo-” + parent hydrocarbon name.

Solution: To derive the IUPAC name of a haloarene, start by adding the appropriate halogen prefix, such as chloro, bromo, or iodo, to the name of the parent hydrocarbon, such as benzene, toluene, etc. In this case, the prefix ”halo-” combined with the parent hydrocarbon results in the name.

Conclusion: The correct name is based on the halogen present and the parent hydrocarbon.

Quick Tip

For naming haloarenes, always add the halogen prefix and use the parent hydrocarbon’s name, such as ”chloro-benzene.”

---

14. The converse of $((\sim p) \wedge q) \Rightarrow r$ **is:**

(A) $((\sim p) \vee q) \Rightarrow r$

(B) $(\sim r) \Rightarrow p \wedge q$

(C) $(p \vee (\sim q)) \Rightarrow (\sim r)$

(D) $(\sim r) \Rightarrow ((\sim p) \wedge q)$

Correct Answer: (C)

$$(p \vee (\sim q)) \Rightarrow (\sim r)$$

Solution: To find the converse of a logical statement $A \Rightarrow B$, we simply swap A and B. In this case, for $((\sim p) \wedge q) \Rightarrow r$, the converse is $r \Rightarrow ((\sim p) \wedge q)$. Using logical equivalence, this becomes:

$$\sim r \Rightarrow (\sim (\sim p) \vee (\sim q)) \Rightarrow (p \vee (\sim q))$$

Simplifying the expression, we obtain the converse:

$$(p \vee (\sim q)) \Rightarrow (\sim r)$$

Conclusion: The converse of $((\sim p) \wedge q) \Rightarrow r$ is $(p \vee (\sim q)) \Rightarrow (\sim r)$.

Quick Tip

To find the converse of an implication, simply swap the premise and conclusion, then simplify using logical equivalence rules.

---

15. The negative of $(p \wedge (\sim q)) \vee (\sim p)$ is equivalent to:

(A) $p \wedge q$

(B) $p \wedge (\sim q)$

(C) $p \wedge (q \wedge (\sim p))$

(D) $p \vee (q \vee (\sim p))$

Correct Answer: (A)

$$p \wedge q$$

Solution: To compute the negation of $(p \wedge (\sim q)) \vee (\sim p)$, we apply De Morgan's laws:

$$\sim \left[(p \wedge (\sim q)) \vee (\sim p)\right]$$

Using De Morgan's laws:

$$\left[\sim (p \wedge (\sim q)) \wedge \sim (\sim p)\right]$$

Simplifying further:

$$\left[(\sim p \vee q) \wedge p\right]$$

Finally, combining the terms yields:

$$p \wedge q$$

Conclusion: The negative of $(p \wedge (\sim q)) \vee (\sim p)$ is $p \wedge q$.

Quick Tip

When negating a logical expression, use De Morgan's laws to simplify. This is helpful for dealing with conjunctions and disjunctions.

---

16. The variance of the following probability distribution is:

x	$P(X)$
0	$\frac{9}{16}$
1	$\frac{3}{8}$
2	$\frac{1}{16}$

(A) $\frac{1}{8}$

(B) $\frac{5}{8}$

(C) $\frac{1}{4}$

(D) $\frac{3}{8}$

Correct Answer: (D)

$$\frac{3}{8}$$

Solution: To find the variance of a probability distribution, we use the formula:

$$\text{Variance} = E(X^2) - (E(X))^2$$

Where $E(X)$ is the expected value of the distribution, and $E(X^2)$ is the expected value of the square of X.

Step 1: Calculate $E(X)$, the expected value:

$$E(X) = \sum x \cdot P(X)$$

$$E(X) = (0 \times \frac{9}{16}) + (1 \times \frac{3}{8}) + (2 \times \frac{1}{16})$$

$$E(X) = 0 + \frac{3}{8} + \frac{2}{16} = \frac{3}{8} + \frac{1}{8} = \frac{4}{8} = \frac{1}{2}$$

Step 2: Calculate $E(X^2)$, the expected value of X^2:

$$E(X^2) = \sum x^2 \cdot P(X)$$

$$E(X^2) = (0^2 \times \frac{9}{16}) + (1^2 \times \frac{3}{8}) + (2^2 \times \frac{1}{16})$$

$$E(X^2) = 0 + \frac{3}{8} + \frac{4}{16} = \frac{3}{8} + \frac{1}{4} = \frac{3}{8} + \frac{2}{8} = \frac{5}{8}$$

Step 3: Calculate the variance:

$$\text{Variance} = E(X^2) - (E(X))^2$$

$$\text{Variance} = \frac{5}{8} - \left(\frac{1}{2}\right)^2 = \frac{5}{8} - \frac{2}{8} = \frac{3}{8}$$

Conclusion: The variance of the given probability distribution is $\frac{3}{8}$.

Quick Tip

To calculate the variance, subtract the square of the expected value from the expected value of X^2.
