

JEE Main 2024 Chemistry Question Paper Feb 1 Shift 1 with Solutions

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| Time Allowed :3 Hours | Maximum Marks :300 | Total Questions :90 |
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General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 90 questions, out of which 75 are to attempted. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. Each part (subject) has two sections.
 - (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and -1 mark for wrong answer.
 - (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and -1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer

Chemistry SECTION A

1. In Kjeldahl's estimation of nitrogen, CuSO_4 acts as

- (1) Oxidizing agent
- (2) Reducing agent
- (3) Catalyst
- (4) Reagent

Correct Answer: (3) Catalyst

Solution:

Step 1: Understanding the Kjeldahl Method.

In Kjeldahl's method of nitrogen estimation, CuSO_4 (Copper(II) sulfate) is used as a catalyst. It helps speed up the reaction without itself undergoing any permanent change. The method involves converting nitrogen in organic compounds into ammonia, which can then be measured.

Step 2: Analyzing the options.

- (1) **Oxidizing agent:** Incorrect. CuSO_4 is not used as an oxidizing agent in this method.
(2) **Reducing agent:** Incorrect. CuSO_4 does not act as a reducing agent in this case.
(3) **Catalyst:** Correct. CuSO_4 acts as a catalyst in the Kjeldahl method, facilitating the reaction without being consumed.
(4) **Reagent:** Incorrect. A reagent is consumed in the reaction, whereas CuSO_4 is only used to catalyze the reaction.

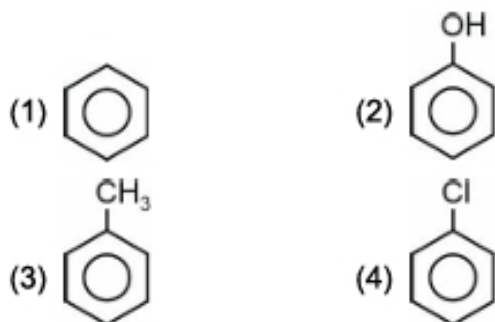
Step 3: Conclusion.

The correct answer is (3) **Catalyst** as CuSO_4 facilitates the reaction in the Kjeldahl method but is not consumed.

Quick Tip

In analytical chemistry, a catalyst speeds up a reaction without being consumed, while a reagent is involved in the reaction and may change during the process.

2. Which of the following is most likely attacked by an electrophile?



Correct Answer: (2) CH_3 group on benzene ring

Solution:

Step 1: Understanding Electrophilic Aromatic Substitution.

Electrophilic substitution occurs when an electrophile reacts with the electron-rich benzene ring. The groups attached to the benzene ring can either donate or withdraw electrons, affecting the reactivity towards electrophiles.

Step 2: Analyzing the options.

- (1) **OH group on benzene ring:** Incorrect. The OH group is an electron-donating group, which makes the benzene ring more reactive towards electrophiles. However, it's not the most reactive group in this case.
(2) **CH_3 group on benzene ring:** Correct. The CH_3 group is also an electron-donating

group, but it's more reactive than the OH group towards electrophiles due to its greater +M effect.

(3) Cl group on benzene ring: Incorrect. The Cl group is an electron-withdrawing group due to its inductive effect, making the ring less reactive towards electrophiles.

(4) None of the above: Incorrect. The CH₃ group is the most reactive towards electrophiles among the given options.

Step 3: Conclusion.

The correct answer is **(2) CH₃ group on benzene ring** as it is more reactive towards electrophiles due to its +M effect.

Quick Tip

The reactivity of the benzene ring towards electrophiles increases with electron-donating groups like CH₃ and OH, and decreases with electron-withdrawing groups like Cl.

3. Statement-I: PH₃ will have a lower boiling point than NH₃.

Statement-II: There are strong van der Waals forces in NH₃ and weak hydrogen bonding in PH₃.

- (1) Statement-I and Statement-II both are true
- (2) Statement-I and Statement-II both are false
- (3) Statement-I is true but Statement-II is false
- (4) Statement-I is false but Statement-II is true

Correct Answer: (3) Statement-I is true but Statement-II is false

Solution:

Step 1: Understanding the statements.

- Statement-I suggests that PH₃ has a lower boiling point than NH₃.
- Statement-II discusses van der Waals forces and hydrogen bonding, which are key factors affecting boiling points.

Step 2: Analyzing the statements.

Statement-I: This is correct. PH₃ has a lower boiling point than NH₃ because NH₃ exhibits strong hydrogen bonding, which is absent in PH₃. The boiling point of NH₃ is 239.7 K, whereas PH₃ boils at 185.5 K.

Statement-II: This is incorrect. While NH₃ exhibits hydrogen bonding, PH₃ only has weaker van der Waals forces due to the absence of hydrogen bonding.

Step 3: Conclusion.

The correct answer is (3) Statement-I is true but Statement-II is false.

Quick Tip

Boiling points of molecules depend significantly on intermolecular forces like hydrogen bonding. Molecules with hydrogen bonding (like NH₃) have higher boiling points than those without (like PH₃).

4. Which of the following have a trigonal bipyramidal shape?

- (1) PF₅, PBr₅, [PtCl₄]²⁻, SF₆, BrF₅, PCl₅, [Fe(CO)₅] only
- (2) BrF₅, PF₅, PCl₅ and PBr₅ only
- (3) PF₅, PCl₅ and [Fe(CO)₅] only
- (4) [Fe(CO)₅], BrF₅, PF₅, PBr₅, PCl₅ only

Correct Answer: (1) PF₅, PBr₅, [PtCl₄]²⁻, SF₆, BrF₅, PCl₅, [Fe(CO)₅] only

Solution:

Step 1: Identifying the trigonal bipyramidal geometry.

Trigonal bipyramidal geometry occurs when there are five substituents around a central atom, resulting in two axial and three equatorial positions.

Step 2: Analyzing the given compounds.

- **PF₅, PBr₅, PCl₅:** These molecules are known to exhibit trigonal bipyramidal geometry due to five bonding atoms around the central phosphorus atom.
- **[PtCl₄]²⁻:** This complex also has a trigonal bipyramidal geometry.
- **SF₆:** This has an octahedral geometry, not trigonal bipyramidal.
- **[Fe(CO)₅]:** This complex shows a trigonal bipyramidal geometry with five CO ligands.

Step 3: Conclusion.

The correct answer is (1) PF₅, PBr₅, [PtCl₄]²⁻, SF₆, BrF₅, PCl₅, [Fe(CO)₅] only as these compounds

Quick Tip

Trigonal bipyramidal geometry typically occurs with five substituents around a central atom, while SF₆ has octahedral geometry.

5. Which of the following is correct for adiabatic free expansion against vacuum?

- (1) $q = 0, \Delta U = 0, W = 0$
- (2) $q = 0, \Delta U = 0$
- (3) $q = 0, \Delta U \neq 0, W = 0$
- (4) $q = 0, \Delta U \neq 0, W \neq 0$

Correct Answer: (1) $q = 0, \Delta U = 0, W = 0$

Solution:

Step 1: Understanding the adiabatic process.

An adiabatic process is one where no heat is exchanged with the surroundings, meaning $q = 0$. Additionally, since the system expands against a vacuum, no work is done on the surroundings, so $W = 0$. Therefore, the change in internal energy (ΔU) is zero as there is no heat or work involved.

Step 2: Analyzing the options.

- Option (1): Correct. Since it is an adiabatic process against a vacuum, $q = 0$, $W = 0$, and there is no change in internal energy, so $\Delta U = 0$.
- Option (2): Incorrect. It does not fully account for the fact that work is also zero.
- Option (3): Incorrect. The change in internal energy is zero as no work or heat is exchanged.
- Option (4): Incorrect. This is not possible in an adiabatic process against vacuum.

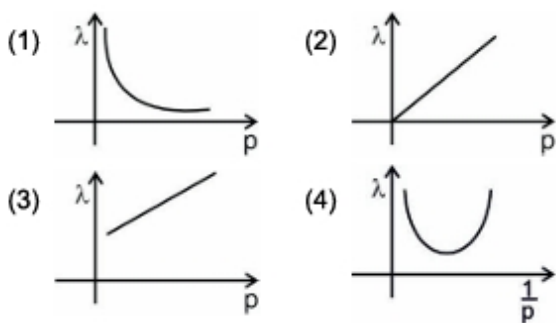
Step 3: Conclusion.

The correct answer is (1) $q = 0, \Delta U = 0, W = 0$.

Quick Tip

In an adiabatic expansion against vacuum, no heat or work is exchanged with the surroundings, and the internal energy remains constant.

6. Which of the following is the correct plot between λ (de Broglie wavelength) and p (momentum)?



Correct Answer: (1) Curve decreasing exponentially

Solution:

Step 1: Understanding the de Broglie relation.

The de Broglie wavelength λ is related to the momentum p of a particle by the equation:

$$\lambda = \frac{h}{p}$$

where h is Planck's constant and p is the momentum of the particle. This shows that λ is inversely proportional to p . As p increases, λ decreases.

Step 2: Analyzing the plot.

- Option (1): Correct. Since λ is inversely proportional to p , the plot between λ and p will show a curve that decreases as p increases. This matches the expected relationship.
- Option (2): Incorrect. A linear increasing relationship does not match the inverse proportionality of λ and p .
- Option (3): Incorrect. A linear decreasing relationship also does not fit the inverse relation between λ and p .
- Option (4): Incorrect. The plot with a minimum at $\frac{1}{p}$ does not match the inverse proportionality.

Step 3: Conclusion.

The correct answer is (1) Curve decreasing exponentially, as the relationship between λ and p follows an inverse proportionality.

Quick Tip

The de Broglie wavelength decreases as the momentum of the particle increases. This inverse relationship is crucial in understanding the wave-like properties of matter.

7. Balance the following reaction and find x , y , and A :



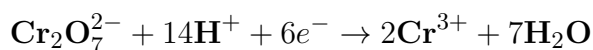
- (1) $x = 7, y = 6, A = 14$
- (2) $x = 14, y = 6, A = 7$
- (3) $x = 14, y = 3, A = 7$
- (4) $x = 8, y = 2, A = 1$

Correct Answer: (2) $x = 14, y = 6, A = 7$

Solution:

Step 1: Balancing the reaction.

The balanced reaction is:



Thus, $x = 14, y = 6$, and $A = 7$.

Step 2: Conclusion.

The correct answer is (2) as the reaction balances with these values for x, y , and A .

Quick Tip

In redox reactions, always balance the elements first, followed by hydrogen and oxygen atoms, and lastly the charges.

8. The complementary strand of DNA for ATGCTTCA is:

- (1) TACGAAGA
- (2) TACGAAGT
- (3) TAGCAACA
- (4) TAGTCACT

Correct Answer: (2) TACGAAGT

Solution:

Step 1: Understanding complementary base pairing.

In DNA, adenine (A) pairs with thymine (T), and cytosine (C) pairs with guanine

(G). The complementary strand follows these base pairing rules.

Step 2: Analyzing the options.

The given strand is ATGCTTCA. Using complementary base pairing: - A pairs with T

- T pairs with A
- G pairs with C
- C pairs with G
- T pairs with A
- T pairs with A
- C pairs with G
- A pairs with T

Thus, the complementary strand is TACGAAGT.

Step 3: Conclusion.

The correct answer is (2).

Quick Tip

Adenine pairs with thymine, and cytosine pairs with guanine in DNA. This complementary base pairing is crucial for the accurate replication and transcription of genetic material.

9. What is the pH of $\text{CH}_3\text{COO-NH}_4^+$ salt?

Given K_a of $\text{CH}_3\text{COOH} = 1.8 \times 10^{-5}$

Given K_b of $\text{NH}_4\text{OH} = 1.8 \times 10^{-5}$

(At 25°C)

- (1) 7
- (2) 9
- (3) 8.9
- (4) 7.8

Correct Answer: (1) 7

Solution:

Step 1: Understanding the salt.

The salt $\text{CH}_3\text{COO-NH}_4^+$ is formed from the neutralization of acetic acid (CH_3COOH) and ammonium hydroxide (NH_4OH). In solution, CH_3COO^- acts as a weak base and NH_4^+ acts as a weak acid. The pH of the solution depends on the hydrolysis

of NH_4^+ .

Step 2: Using the relationship between K_a and K_b .

The relationship between the acid dissociation constant (K_a) of CH_3COOH and the base dissociation constant (K_b) of NH_4OH can be expressed using the equation:

$$K_a \times K_b = K_w = 1 \times 10^{-14}$$

Since $K_a = 1.8 \times 10^{-5}$ and $K_b = 1.8 \times 10^{-5}$, we can calculate the pH of the solution.

Step 3: Calculation of pH.

The solution will be neutral since the acid and base strengths are comparable, meaning that the salt $\text{CH}_3\text{COO-NH}_4^+$ will not significantly alter the pH of the solution. Therefore, the pH will be approximately 7.

Step 4: Conclusion.

The correct answer is (1) 7.

Quick Tip

When a salt is formed from a weak acid and a weak base, the pH of the solution can be determined by considering the relative strengths of the acid and base. In this case, the equal strength leads to a neutral pH of around 7.

10. We are given with 3 NaCl samples and their van't Hoff factors

| Sample | van't Hoff factor |
|-------------------|-------------------|
| Sample-1 (0.1M) | i_1 |
| Sample-2 (0.01M) | i_2 |
| Sample-3 (0.001M) | i_3 |

- (1) $i_1 = i_2 = i_3$
- (2) $i_1 > i_2 > i_3$
- (3) $i_3 > i_2 > i_1$
- (4) $i_1 > i_3 > i_2$

Correct Answer: (1) $i_1 = i_2 = i_3$

Solution:

Step 1: Understanding the concept of van't Hoff factor.

The van't Hoff factor i represents the number of particles a solute dissociates into

when dissolved in a solvent. For NaCl, which is a strong electrolyte, it dissociates completely in water. The degree of dissociation (α) for NaCl will remain constant for each concentration. Since NaCl dissociates completely in all samples, the van't Hoff factor will be the same for each concentration. Thus, $i_1 = i_2 = i_3$.

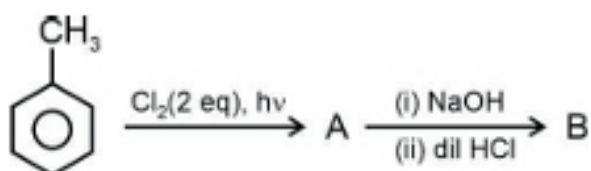
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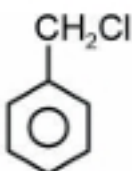
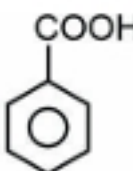
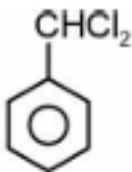
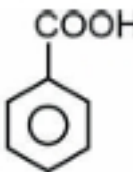
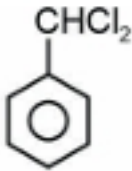
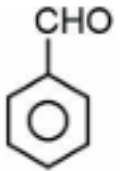
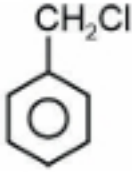
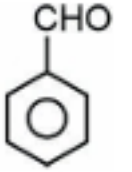
The correct answer is (1) $i_1 = i_2 = i_3$.

Quick Tip

For a strong electrolyte like NaCl, the van't Hoff factor remains the same across different concentrations, as it dissociates completely into ions.

11. A and B in the following reaction are:



- | | | | |
|---------|---|-----|---|
| (1) (A) |  | (B) |  |
| (2) (A) |  | (B) |  |
| (3) (A) |  | (B) |  |
| (4) (A) |  | (B) |  |

Correct Answer: (3) (A) CH_2Cl , (B) CHO

Solution:

Step 1: Identifying the reactions.

The given reaction involves the chlorination of methyl chloride (CH_3Cl) with chlorine in the presence of light, leading to the formation of a product A. The second step involves treatment with NaOH , which would lead to the formation of a carboxylate ion (forming B after hydrolysis). The second reaction is most likely a reduction to an aldehyde.

Step 2: Conclusion.

Thus, the correct answer is (3) (A) CH_3Cl , (B) CHO .

Quick Tip

When halogenating alkyl compounds and following with NaOH treatment, oxidation and reduction processes can occur, leading to aldehydes or carboxylic acids.

12. We have a mixture of gases having 2 moles of monoatomic gas

$$C_{v,m} = \frac{3R}{2}$$

and 6 moles of diatomic gas

$$C_{v,m} = \frac{5R}{2}$$

Find molar heat capacity $C_{v,m}$ of the mixture.

- (1) $\frac{9R}{4}$
- (2) $\frac{9R}{2}$
- (3) $3R$
- (4) $4R$

Correct Answer: (1) $\frac{9R}{4}$

Solution:

Step 1: Formula for molar heat capacity.

The molar heat capacity of a mixture of gases is the weighted average of the heat capacities of the individual gases:

$$C_{v,m} = \frac{2 \times \left(\frac{3R}{2}\right) + 6 \times \left(\frac{5R}{2}\right)}{2 + 6}$$

Step 2: Calculation.

Substituting the values:

$$C_{v,m} = \frac{3R + 15R}{8} = \frac{18R}{8} = \frac{9R}{4}$$

Step 3: Conclusion.

The correct answer is (1) $\frac{9R}{4}$.

Quick Tip

When calculating the heat capacity of a mixture, consider the mole fractions and the individual heat capacities of each component.

13. Assertion (A): KCN reacts with R-X to give cyanide and AgCN reacts with R-X to give isocyanide mainly.

Reason (R): KCN and AgCN both are ionic compounds.

- (1) Both Assertion and Reason are true and Reason explains Assertion.
- (2) Both Assertion and Reason are true but Reason does not explain Assertion.
- (3) Assertion is true and Reason is false.
- (4) Assertion is false but reason is true.

Correct Answer: (3) Assertion is true and Reason is false.

Solution:

Step 1: Understanding the assertion.

The assertion is correct because KCN reacts with R-X to give cyanide (R-CN), while AgCN reacts with R-X to give isocyanide (R-NC). The reaction pathways differ due to the nucleophilic nature of cyanide ions and the electrophilic nature of AgCN.

Step 2: Analyzing the reason.

The reason is incorrect because KCN and AgCN are not both ionic compounds. KCN is ionic, but AgCN is covalent and behaves differently during reactions. AgCN primarily starts its reaction with nitrogen rather than carbon.

Step 3: Conclusion.

The correct answer is (3) because the assertion is true, but the reason is false.

Quick Tip

Always analyze the nature of reagents in chemical reactions. Ionic compounds and covalent compounds can behave very differently despite similar names.

14. Consider the following two statements.

Statement I: $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is green in color.

Statement II: $[\text{Ni}(\text{CN})_4]^{2-}$ is colorless.

- (1) Statement I is true, Statement II is false
- (2) Statement I is true, Statement II is true
- (3) Statement I is false, Statement II is true
- (4) Statement I is false, Statement II is false

Correct Answer: (2) Statement I is true, Statement II is true

Solution:

Step 1: Understanding the statement about $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$.

The complex $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is octahedral and absorbs red light, emitting green light, which gives it a green color.

Step 2: Understanding the statement about $[\text{Ni}(\text{CN})_4]^{2-}$.

The complex $[\text{Ni}(\text{CN})_4]^{2-}$ is square planar and has a strong field ligand (CN^-) that pairs the electrons of Ni^{2+} , making it colorless as it does not absorb light in the visible region.

Step 3: Conclusion.

Both statements are correct: $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is green and $[\text{Ni}(\text{CN})_4]^{2-}$ is colorless. Thus, the correct answer is (2).

Quick Tip

The color of coordination compounds depends on their ligand field, geometry, and electronic transitions. Strong field ligands like CN^- result in colorless complexes due to electron pairing.

15. Statement-I: Potassium hydrogen phthalate is the primary standard for NaOH solution.

Statement-II: Phenolphthalein is used to detect completion of titration.

- (1) Both Statement-I and Statement-II are correct
- (2) Statement-I is correct and Statement-II is incorrect
- (3) Statement-I is incorrect and Statement-II is correct
- (4) Both Statement-I and Statement-II are incorrect

Correct Answer: (1) Both Statement-I and Statement-II are correct

Solution:

Step 1: Understanding Statement-I.

Potassium hydrogen phthalate (KHP) is a primary standard used to standardize NaOH solutions because it is stable, non-hygroscopic, and has a known molecular weight.

Step 2: Understanding Statement-II.

Phenolphthalein is commonly used as an indicator in acid-base titrations. It changes color (from colorless to pink) at the endpoint of the titration, indicating the completion of the reaction.

Step 3: Conclusion.

Both statements are correct, so the correct answer is (1).

Quick Tip

Potassium hydrogen phthalate is an ideal primary standard because it is stable and easily weighed. Phenolphthalein is a common indicator in titrations, particularly for acid-base reactions.

16. Statement-I: In aniline, $-\text{NH}_2$ group is a strong deactivating group for all ESR.

Statement-II: Aniline does not show Friedel-Craft alkylation reaction.

- (1) Both statement-I and statement-II are correct
- (2) Both statement-I and statement-II are incorrect
- (3) Statement-I is correct and statement-II is incorrect
- (4) Statement-I is incorrect and statement-II is correct

Correct Answer: (4) Statement-I is incorrect and statement-II is correct

Solution:

Step 1: Analyzing Statement-I.

The $-\text{NH}_2$ group in aniline is an electron-donating group, which increases the electron density on the benzene ring, making it more reactive towards electrophilic aromatic substitution (EAS) reactions. Therefore, the statement that it is a strong deactivating group for all EAS is incorrect.

Step 2: Analyzing Statement-II.

Aniline does not show Friedel-Craft alkylation reaction because the $-\text{NH}_2$ group is too basic and forms a complex with the catalyst (AlCl_3), deactivating the ring for this reaction. Therefore, Statement-II is correct.

Step 3: Conclusion.

Since Statement-I is incorrect and Statement-II is correct, the correct answer is (4) Statement-I is incorrect and statement-II is correct.

Quick Tip

For electrophilic aromatic substitution reactions, the presence of electron-donating groups like $-\text{NH}_2$ makes the ring more reactive. However, in Friedel-Craft reactions, such groups can interfere by coordinating with the catalyst, preventing the reaction.

17. Which of the following is homoleptic complex?

- (1) $[\text{Ni}(\text{CN})_4]^{2-}$
- (2) $[\text{Cu}(\text{H}_2\text{O})_3\text{Cl}_3]$
- (3) $[\text{PtCl}_2\text{Br}_2]^{2-}$
- (4) $[\text{Cu}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

Correct Answer: (1) $[\text{Ni}(\text{CN})_4]^{2-}$

Solution:

Step 1: Understanding Homoleptic Complexes.

Homoleptic complexes are those where the central metal ion is bound to only one type of ligand. In this case, the correct answer is $[\text{Ni}(\text{CN})_4]^{2-}$ as it contains only

cyanide (CN) ligands.

Step 2: Analyzing the options.

(1) $[Ni(CN)_4]^{2-}$: This is a homoleptic complex because it is bound only to cyanide ligands.

(2) $[Cu(H_2O)_3Cl_3]$: This complex is not homoleptic as it is bound to both water and chloride ions.

(3) $[PtCl_2Br_2]^{2-}$: This is not a homoleptic complex because it contains both chloride and bromide ligands.

(4) $[Cu(NH_3)_5Cl]Cl_2$: This complex is also not homoleptic because it contains both ammonia and chloride ligands.

Step 3: Conclusion.

The correct answer is (1) $[Ni(CN)_4]^{2-}$.

Quick Tip

Homoleptic complexes are formed when a metal ion is bonded to a single type of ligand.

18. For ionic reaction in organic compounds, which type of bond cleavage occurs?

- (1) Heterolytic cleavage
- (2) Homolytic cleavage
- (3) Free radical
- (4) No cleavage of bond

Correct Answer: (1) Heterolytic cleavage

Solution:

Step 1: Understanding Bond Cleavage.

In ionic reactions, heterolytic bond cleavage occurs where ions are formed. This is characteristic of reactions in which one atom retains both electrons of the bond, resulting in the formation of cations and anions.

Step 2: Analyzing the options.

(1) Heterolytic cleavage: Correct. In heterolytic cleavage, ions are formed, making it the correct process for ionic reactions in organic compounds.

(2) Homolytic cleavage: This involves the splitting of a bond where each atom retains one electron, forming free radicals. It is not relevant in ionic reactions.

(3) Free radical: This is not a type of bond cleavage but refers to a species with unpaired electrons, typically formed during homolytic cleavage.

(4) No cleavage of bond: This option is incorrect because cleavage is required in ionic reactions.

Step 3: Conclusion.

The correct answer is (1) Heterolytic cleavage, as this is the bond cleavage type in ionic reactions.

Quick Tip

In ionic reactions, look for heterolytic cleavage where ions are formed, not homolytic cleavage or no cleavage.

19. K_a values of three acids A, B, and C are 10^{-3} , 5×10^{-9} , and 9×10^{-11} respectively. The acidic strength order of these acids is

(1) A \gt B \gt C

(2) B \gt A \gt C

(3) C \gt B \gt A

(4) C \gt A \gt B

Correct Answer: (1) A \gt B \gt C

Solution:

Step 1: Understanding K_a values.

The K_a value represents the acid dissociation constant, which indicates the strength of an acid. A higher K_a value means a stronger acid.

Step 2: Analyzing the options.

The given K_a values for the acids are:

- Acid A: 10^{-3} (strongest)

- Acid B: 5×10^{-9}

- Acid C: 9×10^{-11} (weakest)

Therefore, the order of acidic strength is A \gt B \gt C based on the higher K_a values.

Step 3: Conclusion.

The correct answer is (1) A \gt B \gt C, as acid A has the highest K_a value, indicating

the strongest acid.

Quick Tip

Remember: A higher K_a value means a stronger acid. Compare the K_a values to determine the strength of the acids.

20. Which of the following is a disproportionation reaction?

- (A) $Cu^+ \rightarrow Cu^{2+} + Cu$
- (B) $MnO_4^{2-} \rightarrow MnO_4^+ + MnO_2$
- (C) $H_2O_2 \rightarrow O_2 + H_2O$
- (D) $Cr_2O_7^{2-} \rightarrow Cr^{3+} + H_2O$

- (1) All A, B, C and D
- (2) A and B only
- (3) A and C only
- (4) A, B and C only

Correct Answer: (4) A, B and C only

Solution:

Step 1: Understanding Disproportionation Reactions.

A disproportionation reaction is a reaction in which a substance (element) is simultaneously oxidised and reduced.

Step 2: Analyzing the options.

(A) $Cu^+ \rightarrow Cu^{2+} + Cu$: This is a disproportionation reaction because Cu^+ is both oxidized to Cu^{2+} and reduced to Cu .

(B) $MnO_4^{2-} \rightarrow MnO_4^+ + MnO_2$: This is also a disproportionation reaction. The MnO_4^{2-} ion is oxidized to MnO_4^+ and reduced to MnO_2 .

(C) $H_2O_2 \rightarrow O_2 + H_2O$: This is a disproportionation reaction as H_2O_2 is both oxidized to O_2 and reduced to H_2O .

(D) $Cr_2O_7^{2-} \rightarrow Cr^{3+} + H_2O$: This is not a disproportionation reaction because the chromium is only reduced, not oxidized.

Step 3: Conclusion.

The correct answer is (4) A, B and C only because reactions A, B, and C all involve a substance being both oxidized and reduced.

Quick Tip

Disproportionation reactions involve the simultaneous oxidation and reduction of the same element. Always look for reactions where the same element undergoes both processes.

SECTION B

21. Find out total possible optical isomers of 2-chlorobutane.

Correct Answer: 2

Solution:

Step 1: Understanding the structure of 2-chlorobutane.

The structure of 2-chlorobutane has one chiral center at carbon 2, where chlorine (*Cl*) is attached. This makes the compound unsymmetrical.

Step 2: Applying the formula for optical isomers.

The formula for calculating optical isomers is 2^n , where n is the number of stereogenic centers. Since there is one chiral center in 2-chlorobutane, we have:

$$n = 1, \quad \text{so} \quad 2^1 = 2.$$

Step 3: Conclusion.

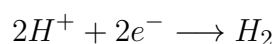
Therefore, the total number of optical isomers is 2, which are shown below:

(R)-2-chlorobutane and (S)-2-chlorobutane.

Quick Tip

To calculate the number of optical isomers, use the formula 2^n , where n is the number of stereogenic centers in the molecule.

22. We are given with following cell reaction:



If $P_{H_2} = 2 \text{ atm}$, $[H^+] = 1 \text{ M}$, and E_{cell} for reaction is given by $-x \times 10^{-3} \text{ V}$, find out x .

Correct Answer: (9)

Solution:

We will use the Nernst equation for the calculation of E_{cell} .

$$E_{\text{cell}} = 0 - \frac{0.06}{2} \log 2$$

Step 1: Calculation.

$$\begin{aligned} E_{\text{cell}} &= -\frac{0.06}{2} \log 2 \\ &= -0.03(0.3) \\ &= -0.009 \\ E_{\text{cell}} &= -9 \times 10^{-3} \text{ V} \end{aligned}$$

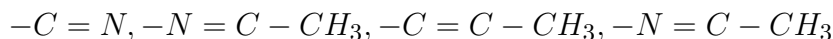
Step 2: Conclusion.

Thus, $x = 9$.

Quick Tip

Use the Nernst equation to calculate the cell potential for non-standard conditions, and remember to adjust for the number of electrons transferred.

23. Total number of deactivating groups among the following



Correct Answer: (2)

Solution:

Step 1: Identifying deactivating groups.

$-C = N$ and $-N = C - CH_3$ are deactivating groups because they withdraw electron density through induction.

Step 2: Identifying activating groups.

$-N = C - CH_3$ and $-N = C - CH_3$ are activating due to the lone pair of electrons on nitrogen which donates electron density.

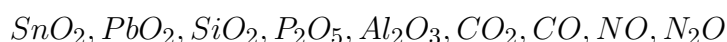
Step 3: Conclusion.

Thus, the total number of deactivating groups is 2.

Quick Tip

Deactivating groups are electron-withdrawing groups, usually through induction, while activating groups donate electrons and increase the reactivity of the molecule.

24. How many oxides are amphoteric in nature?



Correct Answer: (3)

Solution:

Step 1: Understanding Amphoteric Oxides.

Amphoteric oxides are those that can react with both acids and bases.

Step 2: Analyzing the oxides.

- SnO_2 , PbO_2 , and Al_2O_3 are amphoteric oxides. They can react with both acids and bases.
- SiO_2 , P_2O_5 , and CO_2 are acidic oxides. They only react with bases.
- CO , NO , and N_2O are neutral oxides. They do not react significantly with acids or bases.

Step 3: Conclusion.

Therefore, the total number of amphoteric oxides is 3: SnO_2 , PbO_2 , and Al_2O_3 .

Quick Tip

Amphoteric oxides can react with both acids and bases. Keep in mind that acidic oxides react with bases, and neutral oxides have minimal reactivity with both.

25. For carbon dating of a wood sample

$$\left(\frac{C^{14}}{C^{12}}\right)_t = \left(\frac{C^{14}}{C^{12}}\right)_0 \left(\frac{1}{2}\right)^n$$

If Half-life of C^{14} is 1580 years, what is the life of wood sample (in yr)?

Correct Answer: (4740)

Solution:

Step 1: Understanding the equation.

The given formula for carbon dating is:

$$\left(\frac{C^{14}}{C^{12}}\right)_t = \left(\frac{C^{14}}{C^{12}}\right)_0 \left(\frac{1}{2}\right)^n$$

where n is the number of half-lives, t is the time, and the half-life of C^{14} is given as 1580 years.

Step 2: Calculating the time.

We are told that $n = 3$, so the time t is:

$$t = 3 \times 1580 = 4740 \text{ years}$$

Step 3: Conclusion.

Thus, the life of the wood sample is 4740 years.

Quick Tip

In carbon dating, the number of half-lives is used to estimate the age of the sample. The formula for half-life decay is $\left(\frac{1}{2}\right)^n$, where n is the number of half-lives.

26. What is the minimum energy (in eV) required for an electron to excite from ground state to 1st excited state for hydrogen atom?

Correct Answer: (10)

Solution:

Step 1: Understanding the formula for energy levels.

The energy of an electron in a hydrogen atom at a particular energy level is given by the formula:

$$\Delta E = 13.6 \text{ eV} \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

where $n_1 = 1$ (ground state) and $n_2 = 2$ (1st excited state).

Step 2: Calculating the energy.

$$\begin{aligned}\Delta E &= 13.6 \times \left(\frac{1}{1^2} - \frac{1}{2^2} \right) \\ \Delta E &= 13.6 \times (1 - 0.25) \\ \Delta E &= 13.6 \times 0.75 = 10.05 \text{ eV}\end{aligned}$$

Step 3: Conclusion.

Thus, the minimum energy required for the electron to excite from the ground state to the 1st excited state is 10.05 eV.

Quick Tip

The energy required for an electron to move between energy levels in a hydrogen atom can be calculated using the formula $\Delta E = 13.6 \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$ where n_1 and n_2 are the principal quantum numbers.

27. Find out moles of precipitate product formed when 72 moles of PbCl_2 reacts with 50 moles of $(\text{NH}_4)_2\text{SO}_4$.

Correct Answer: (50)

Solution:

The given reaction is:



Step 1: Use the mole ratio.

From the balanced equation, we see that 1 mole of PbCl_2 reacts with 1 mole of $(\text{NH}_4)_2\text{SO}_4$ to form 1 mole of PbSO_4 .

Step 2: Identify the limiting reactant.

We are given 72 moles of PbCl_2 and 50 moles of $(\text{NH}_4)_2\text{SO}_4$. According to the reaction, both reactants are in a 1:1 molar ratio. The limiting reactant here is $(\text{NH}_4)_2\text{SO}_4$, as there are fewer moles of it (50 moles).

Step 3: Calculate moles of precipitate.

Since 1 mole of $(\text{NH}_4)_2\text{SO}_4$ reacts with 1 mole of PbCl_2 to form 1 mole of PbSO_4 , 50 moles of $(\text{NH}_4)_2\text{SO}_4$ will form 50 moles of PbSO_4 .

Step 4: Conclusion.

Thus, 50 moles of PbSO_4 are formed as the precipitate.

Quick Tip

In reactions, the limiting reactant determines the amount of product formed. Use the mole ratio to identify the limiting reactant and calculate the moles of the product.
