CUET PG 2024 Chemistry Question Paper with Solutions

Time Allowed :1 hour 45 minutes	**Maximum Marks :**300	**Total questions :**75

General Instructions

Read the following instructions very carefully and strictly follow them:

(i) This question paper comprises 75 questions. All questions are compulsory.

(ii) Each question carries 04 (four) marks.

(iii) For each correct response, candidate will get 04 (four) marks.

(iv) For each incorrect response, 01 (one) mark will be deducted from the total score.

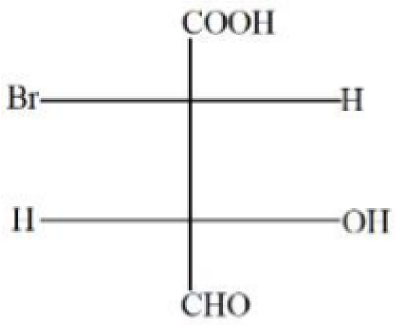
(v) Un-answered/un-attempted response will be given no marks.

(vi) To answer a question, the candidate needs to choose one option as correct option.

(vii) However, after the process of Challenges of the Answer Key, in case there are multiple correct options or change in key, only those candidates who have attempted it correctly as per the revised Final Answer Key will be awarded marks.

(viii) In case a Question is dropped due to some technical error, full marks shall be given to all the candidates irrespective of the fact who have attempted it or not

1. Assign the R and S configuration to the following molecule:



(A) $2S, 3R$

(B) $2R, 3S$

(C) $2S, 3S$

(D) $2R, 3R$

Correct Answer: (1) $2S, 3R$

Solution: Step 1: Identify chiral centers The given molecule has two chiral centers at Carbon-2 and Carbon-3.

Step 2: Assign priorities using Cahn-Ingold-Prelog rules

- Assign priority based on atomic number.
- Orient the lowest priority group away.
- Determine R/S configuration at each chiral center.

Step 3: Analyze the configurations

- Carbon-2 follows the counterclockwise direction, making it S.
- Carbon-3 follows the clockwise direction, making it R.

Thus, the correct configuration is $2S, 3R$.

Quick Tip

When assigning R and S configurations, always ensure the lowest priority group is placed at the back before determining the direction of the remaining groups.

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2. The correct order of the stability of different conformations of cyclohexane is:

(A) Chair

(B) Boat

(C) Twist Boat

(D) Half Chair

(1) (A)¿(B)¿(C)¿(D)

(2) (A)¿(C)¿(B)¿(D)

(3) (A)¿(D)¿(C)¿(B)

(4) (D)¿(C)¿(B)¿(A)

Correct Answer: (2) (A)¿(C)¿(B)¿(D)

Solution: Step 1: Understanding conformational stability The stability of cyclohexane conformations follows the order: Chair ¿ Twist Boat ¿ Boat ¿ Half Chair

Step 2: Energy consideration

- Chair is the most stable due to minimal steric strain.
- Twist boat is slightly more stable than boat due to reduced steric hindrance.
- Half chair is the least stable due to highest energy.

Thus, the correct order is A¿C¿B¿D.

Quick Tip

Cyclohexane prefers the chair conformation as it minimizes angle strain and steric repulsion.

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3. Which one is not an electrophile?

(1) NO^+

(2) BF_3

(3) CO_2

(4) NH_4^+

Correct Answer: (4) NH_4^+

Solution: Step 1: Understanding electrophiles Electrophiles are species that accept electron pairs.

Step 2: Analyzing given species

- NO^+ is an electrophile as it lacks electrons.

- BF_3 is electron-deficient and acts as an electrophile.

-CO_2 can act as an electrophile due to partial positive charge on carbon.

- NH_4^+ is not an electrophile as it has no vacant orbitals for accepting electrons.

Thus, the correct answer is NH_4^+.

Quick Tip

Electrophiles are electron-deficient species that can accept a pair of electrons.

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4. Iodoform reaction is given by:

(A) All methyl ketones with CH_3CO group

(B) Acetaldehyde

(C) All secondary alcohols with $CH_3CH(OH)$ group

(D) All primary alcohols

(1) $(A), (B), (D)$ only

(2) $(A), (B), (C)$ only

(3) $(A), (B), (C), (D)$

(4) $(B), (C), (D)$ only

Correct Answer: (2) $(A), (B), (C)$ only

Solution: Step 1: Understanding the Iodoform test

The Iodoform test is positive for:

- Methyl ketones (CH_3CO group)

- Acetaldehyde (CH_3CHO)

- Secondary alcohols with the structure $CH_3CH(OH)R$

Step 2: Checking applicability

- A (Methyl ketones) give a positive test.

- B (Acetaldehyde) gives a positive test.

- C (Certain secondary alcohols) give a positive test.

- D (Primary alcohols) do NOT give a positive test.

Thus, the correct answer is (A), (B), (C) only.

Quick Tip

The Iodoform test is used to detect compounds with a CH_3CO group or specific secondary alcohols.

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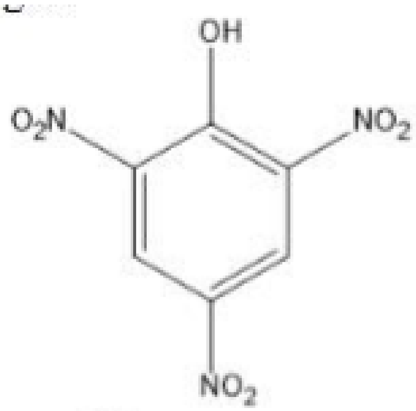
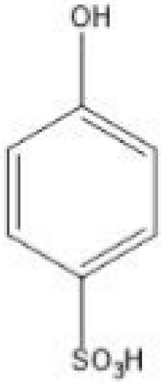
5. Arrange the following compounds A, B, C, and D in decreasing order of acidic strength:

(A).



(B).

(C).



(D).

(1) B¿D¿C¿A

(2) A¿C¿D¿B

(3) B¿A¿D¿C

(4) $B¿C¿A¿D$

Correct Answer: (2) $A¿C¿D¿B$

Solution: Step 1: Understanding acidity in phenols Acidic strength of phenols is influenced by electron-withdrawing and electron-donating substituents.
Step 2: Analyzing the given compounds - Compound A: Contains three strong electron-withdrawing nitro (NO_2) groups, which stabilize the negative charge on phenoxide ion, making it highly acidic.
- Compound C: Contains a sulfonic acid (SO_3H) group, which is a strong electron-withdrawing group, enhancing acidity.
- Compound D: Has a methyl (CH_3) group, which is electron-donating, reducing acidity.
- Compound B: Contains a methoxy (OCH_3) group, which is electron-donating and destabilizes the phenoxide ion, making it the least acidic.
Step 3: Establishing the correct order Since the nitro groups in A provide the strongest electron-withdrawing effect, A is the most acidic. C follows due to the strong SO_3H group, D is next, and B is the least acidic. Thus, the correct order is $A¿C¿D¿B$.

Quick Tip

Electron-withdrawing groups (-NO_2, -SO_3H) increase acidity by stabilizing the phenoxide ion, while electron-donating groups (-OCH_3, -CH_3) decrease acidity.

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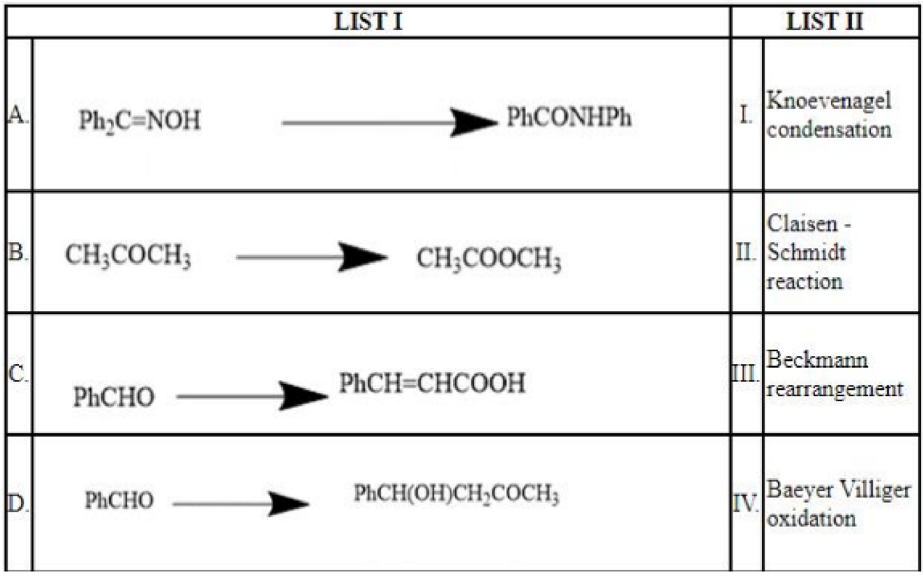
6. Match List I with List II:



LIST I		LIST II	
A.	$Ph_2C=NOH \longrightarrow PhCONHPh$	I.	Knoevenagel condensation
B.	$CH_3COCH_3 \longrightarrow CH_3COOCH_3$	II.	Claisen - Schmidt reaction
C.	$PhCHO \longrightarrow PhCH=CHCOOH$	III.	Beckmann rearrangement
D.	$PhCHO \longrightarrow PhCH(OH)CH_2COCH_3$	IV.	Baeyer Villiger oxidation

(1) $(A)-(III),(B)-(IV),(C)-(I),(D)-(II)$

(2) $(A)-(III),(B)-(III),(C)-(I),(D)-(IV)$

(3) $(A)-(I),(B)-(III),(C)-(IV),(D)-(III)$

(4) $(A)-(III),(B)-(I),(C)-(II),(D)-(IV)$

Correct Answer: (1) $(A)-(III),(B)-(IV),(C)-(I),(D)-(II)$

Solution:

Step 1: Understanding the given reactions

- Reaction (A) – Beckmann rearrangement:

The conversion of an oxime to an amide is known as Beckmann rearrangement.

- Reaction (B) – Baeyer-Villiger oxidation:

This reaction involves the oxidation of ketones to esters using peracids.

- Reaction (C) – Knoevenagel condensation:

It involves the condensation of aldehydes with active methylene compounds in the presence of a base.

- Reaction (D) – Claisen-Schmidt reaction:

This reaction is a type of aldol condensation between an aldehyde and a ketone to form α-β-unsaturated carbonyl compounds.

Step 2: Matching the correct reaction types

$$(A)-(III), \quad (B)-(IV), \quad (C)-(I), \quad (D)-(II)$$

Quick Tip

Match the functional group changes with their characteristic reactions. For example, oxime to amide conversion is Beckmann rearrangement, while aldehyde to ,-unsaturated compound follows Knoevenagel condensation.

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7. Arrange the following carbonyl compounds in the decreasing order of their reactivity towards nucleophilic addition reaction:

(A) CH_3CHO

(B) $HCHO$

(C) Cl_3CCHO

(D) $CH_3COCH_2CH_3$

(1) $A¿B¿C¿D$

(2) $B¿A¿D¿C$

(3) $B¿C¿A¿D$

(4) $C¿B¿A¿D$

Correct Answer: (3) $B¿C¿A¿D$

Solution:

Step 1: Understanding nucleophilic addition reactions The reactivity of carbonyl compounds towards nucleophilic addition depends on: - The partial positive charge on the carbonyl carbon (electrophilicity). - The steric hindrance around the carbonyl carbon.

Step 2: Analyzing the given compounds - Formaldehyde (HCHO): Most reactive due to the absence of alkyl groups, leading to less steric hindrance and a highly electrophilic carbonyl carbon. - Trichloroacetaldehyde (Cl_3CCHO): More reactive than simple aldehydes due to the strong -I effect of chlorine atoms, increasing the electrophilicity of the carbonyl carbon. - Acetaldehyde (Cl_3CCHO): Less reactive than HCHO and $ClCCHO$ but more reactive than ketones due to reduced steric hindrance. - Ketone ($CH_3COCH_2CH_3$): Least reactive due to steric hindrance from alkyl groups, which reduce the electrophilicity of the carbonyl carbon.

Step 3: Establishing the correct order

$$\textbf{B (HCHO)} > \textbf{C (}ClCCHO\textbf{)} > \textbf{A ((}Cl_3CCHO\textbf{))} > \textbf{D (CHCOCHCH)}$$

Quick Tip

Aldehydes are more reactive than ketones in nucleophilic addition due to lower steric hindrance and higher electrophilicity. Electron-withdrawing groups (-Cl, -NO_2) further increase the reactivity by stabilizing the negative charge on the intermediate.

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8. The number of distinct NMR signals observed in the case of acetone and ethyl methyl ketone are:

(1) 1 and 3

(2) 2 and 3

(3) 2 and 5

(4) 1 and 2

Correct Answer: (1) 1 and 3

Solution:

Step 1: Understanding NMR spectroscopy In ^1H-NMR spectroscopy, distinct signals correspond to chemically non-equivalent proton environments.

Step 2: Analyzing the given compounds

- Acetone (CH_3COCH_3):

- Contains two identical methyl (CH_3) groups attached to the same carbonyl.

- Results in only one NMR signal (singlet).

- Ethyl methyl ketone ($CH_3COCH_2CH_3$):

- Contains three distinct proton environments:

1. Methyl group (CH_3CO) next to the carbonyl.

2. Methylene group (CH_2) between the ketone and ethyl group.

3. Terminal ethyl group (CH_3CH_2).

- Results in three distinct NMR signals.

Quick Tip

Symmetry in molecules reduces the number of distinct NMR signals. Acetone has identical methyl groups, leading to a single peak, while ethyl methyl ketone has three distinct proton environments.

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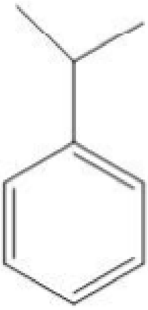
9. The structure of the compound having molecular formula C_9H_{12} showing NMR peaks at δ 7.1, 2.2, 1.5, and 0.9 ppm is:

1.



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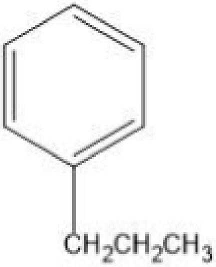

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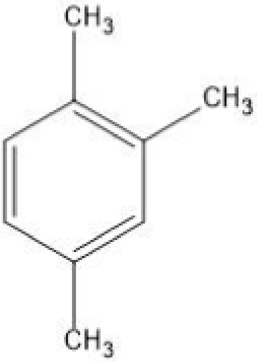

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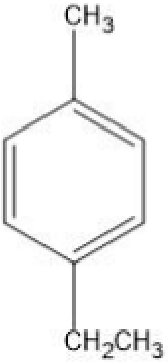

Correct Answer: (2) Ethyl benzene

Solution:

Step 1: Understanding NMR chemical shifts

- δ 7.1 ppm: Indicates aromatic proton signals from a benzene ring.

- δ 2.2 ppm: Typical of benzylic $-CH_2-$ groups attached to a benzene ring.

- δ 1.5 ppm and 0.9 ppm: Suggests the presence of an ethyl ($-CH_2CH_3$) group.

Step 2: Identifying the correct structure - The presence of δ 2.2 ppm (benzylic CH_2) and δ 0.9 ppm (methyl CH_3) strongly indicates an ethyl group attached to the benzene ring.
- Among the given structures, structure (2) corresponds to ethylbenzene, which perfectly matches the observed NMR peaks.

Quick Tip

In ^1H-NMR spectroscopy, benzylic protons appear around 2.2 ppm, while alkyl methyl (CH_3) protons appear around 0.9 ppm. These chemical shifts help in identifying alkyl-substituted benzene compounds.

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10. Which of the following vibrational modes shows no IR absorption bands?

(1) Symmetric CO_2 stretch
(2) Antisymmetric CO_2 stretch
(3) Symmetric $O = C = S$ stretch
(4) $CH_3C \equiv CH$ stretch

Correct Answer: (1) Symmetric CO_2 stretch

Solution:
Step 1: Understanding IR Absorption in Vibrational Modes
Infrared (IR) spectroscopy measures molecular vibrations. A vibration is IR-active only if it results in a change in dipole moment.
Step 2: Analyzing the Given Vibrational Modes
- Symmetric CO_2 stretch (Option 1):
- CO_2 is a linear molecule with a symmetric stretch where both oxygen atoms move in the same direction.
- Since this motion does not create a change in dipole moment, it is IR inactive.
- Antisymmetric CO_2 stretch (Option 2):
- Involves oxygen atoms moving in opposite directions, leading to a fluctuating dipole moment, making it IR active.
- Symmetric $O = C = S$ stretch (Option 3):

- Since $O = C = S$ is not a completely symmetric linear molecule, this stretch induces a dipole change and is IR active.
- $CH_3C \equiv CH$ stretch (Option 4):
- Terminal alkyne C-H stretching appears in IR spectroscopy as a strong band, meaning it is IR active.

Step 3: Conclusion

Since the symmetric stretch of CO_2 does not induce a dipole change, it shows no IR absorption bands.

Quick Tip

A molecular vibration is IR active only if it changes the dipole moment of the molecule. Symmetric stretches of linear molecules like CO_2 often do not exhibit IR absorption.

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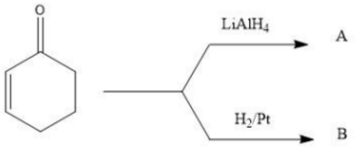
11. In the following reaction, identify the product A and B:



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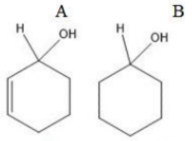

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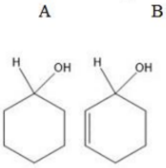

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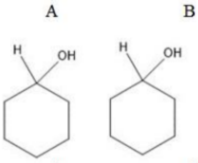

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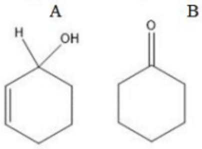

Correct Answer: (1)

Solution:

Step 1: Understanding the reaction sequence

- $LiAlH_4$ reduction (Step 1):

- Lithium aluminium hydride ($LiAlH_4$) is a strong reducing agent that reduces aldehydes and ketones to their corresponding alcohols.

- Here, the cyclohexanone (a ketone) is reduced to cyclohexanol (a secondary alcohol).

- H_2/Pt catalytic hydrogenation (Step 2):

- Hydrogenation with H_2/Pt reduces carbon-carbon double bonds, saturating the ring.

- In this case, any remaining unsaturation is removed, yielding a fully saturated cyclohexanol as product B.

Step 2: Identifying the correct product

- Product A: Cyclohexanol (from ketone reduction).

- Product B: Fully saturated cyclohexanol (from hydrogenation).

Thus, the correct option is (1).

Quick Tip

$LiAlH_4$ is a strong reducing agent that reduces ketones to alcohols, while catalytic hydrogenation (H_2/Pt) removes unsaturation from organic compounds.

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12. Consider the following statements with reference to Citral:

(A) Citral is a liquid which has a smell of lemon.

(B) Oxidation of citral with alkaline permanganate followed by chromic acid gives acetone, oxalic, and laevulic acid.

(C) It also forms oxime.

(D) It shows two geometrical isomers: trans isomer known as neral and cis isomer known as geranial.

Choose the correct answer from the options given below:

(1) (A), (B), (C), and (D)

(2) (A), (B), and (C) only

(3) (A), (B), and (D) only

(4) (B), (C), and (D) only

Correct Answer: (2) (A), (B), and (C) only

Solution:

Step 1: Understanding Citral Properties

- Citral is a volatile liquid with a strong lemon-like odor, making statement (A) correct.
- Oxidation of citral produces acetone, oxalic acid, and laevulic acid, making statement (B) correct.
- Citral can form oximes, supporting statement (C).

Step 2: Evaluating Geometrical Isomerism

- Citral has two geometrical isomers: neral (cis) and geranial (trans). - However, the given statement reverses their naming, making statement (D) incorrect.

Thus, the correct answer is (A), (B), and (C) only.

Quick Tip

Citral is an aldehyde found in citrus fruits and is commonly used in perfumery due to its lemon-like aroma. It forms oximes and undergoes oxidation to produce various acids.

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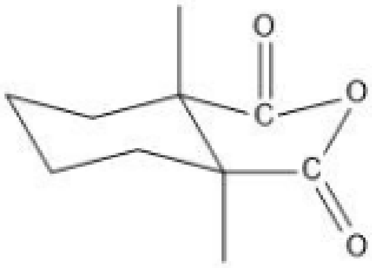
13. Which of the following isomer of 1,2-cyclohexanedicarboxylic acid forms anhydride on heating?

1.



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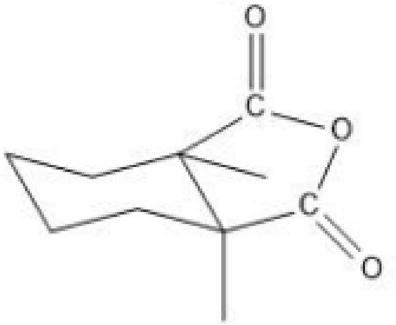

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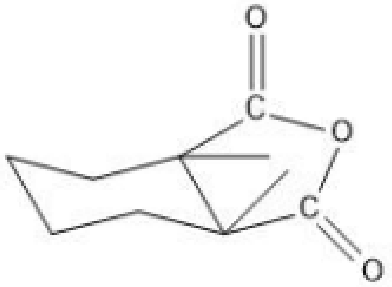

(4) Reaction not possible

Correct Answer: (2) Second isomer

Solution:

Step 1: Understanding Anhydride Formation

- Anhydrides form when two carboxyl (-COOH) groups are close enough to undergo intramolecular dehydration upon heating.

Step 2: Analyzing the Given Isomers

- The cis-isomer allows the carboxyl groups to be in close proximity, enabling anhydride formation.
- The trans-isomer prevents this due to steric hindrance.

Thus, the correct isomer is the cis-form (Second isomer).

Quick Tip

Cis-isomers of dicarboxylic acids tend to form anhydrides more readily than trans-isomers due to favorable spatial arrangement.

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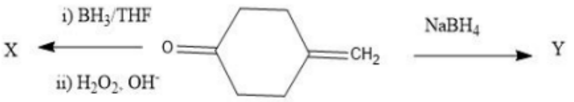
14. Give the structure of X and Y in the given reaction:



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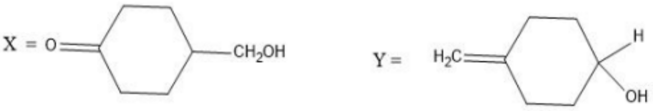

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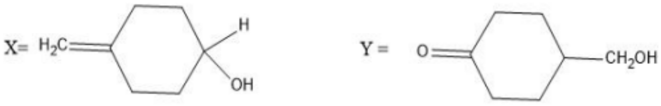

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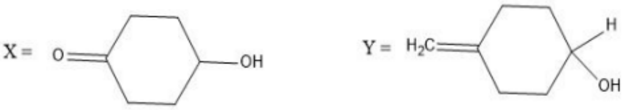

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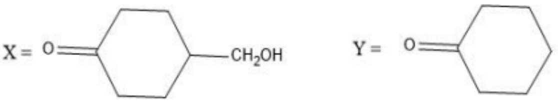


Correct Answer: (1)

Solution:

Step 1: Understanding Hydroboration-Oxidation

- BH$_3$/THF, H$_2$O$_2$, OH$^-$ converts alkenes to anti-Markovnikov alcohols. - The product X from this step contains a hydroxyl (-OH) group.

Step 2: Understanding NaBH$_4$ Reduction

- Sodium borohydride (NaBH$_4$) selectively reduces carbonyl (C=O) groups to alcohols without affecting alkenes or esters. - The final product Y has two hydroxyl (-OH) groups.

Step 3: Identifying the Correct Structures

- The correct X and Y structures match Option (1).

Quick Tip

Hydroboration-oxidation follows anti-Markovnikov addition, forming primary alcohols, while $NaBH_4$ selectively reduces ketones and aldehydes to alcohols.

15. Identify the structure of the alkaloid having the following characteristics:

(A) It is a coca alkaloid having molecular formula $C_8H_{15}NO$.

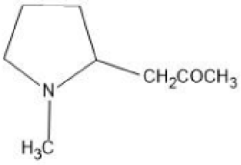
(B) As the free base, it rapidly racemizes.

(C) Its reactions show the presence of a keto group and a tertiary nitrogen atom.

(D) Synthesized by condensing γ-methylaminobutyraldehyde with ethylacetoacetate in buffered solution at pH 7.

Choose the correct answer from the options given below:

1.



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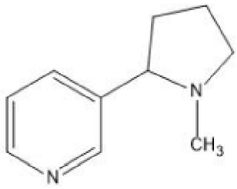

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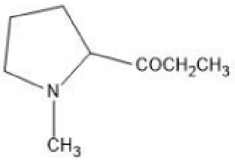

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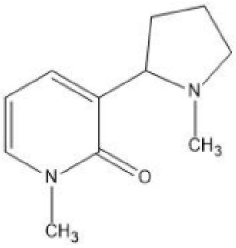

Correct Answer: (1)

Solution:

Step 1: Understanding Alkaloid Characteristics

- The molecular formula $C_8H_{15}NO$ corresponds to a well-known coca alkaloid.

- Racemization in free-base form suggests a structure with a chiral center adjacent to a nitrogen atom.

Step 2: Identifying Functional Groups

- Presence of a keto group (C=O) and a tertiary nitrogen (N) matches structure (1).
- The synthesis method (using γ-methylaminobutyraldehyde and ethylacetoacetate) is consistent with alkaloid biosynthesis.

Step 3: Conclusion

Among the given structures, option (1) correctly represents the alkaloid, satisfying all the given properties.

> Quick Tip
>
> Coca alkaloids often contain both a keto group and a tertiary nitrogen, making them important in medicinal chemistry and pharmacology.

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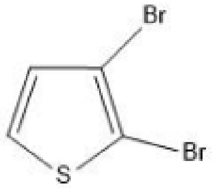
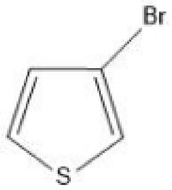
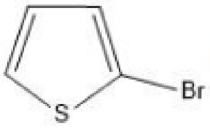
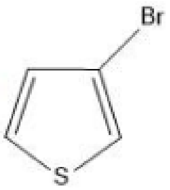
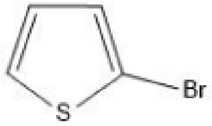
16. Identify the product in the following chemical reaction:

1. 

2. 

3. 

and


4. 

Correct Answer: (4) Monobromothiophene at the most reactive position

Solution:

Step 1: Understanding NBS Bromination

- N-Bromosuccinimide (NBS) is commonly used for selective bromination at the most reactive position in heterocyclic compounds.

Step 2: Analyzing the Reactivity of Thiophene

- Thiophene undergoes electrophilic substitution preferentially at the 2-position (alpha position) due to its higher electron density.
- Bromination with NBS selectively introduces a single bromine atom at the 2-position.

Step 3: Identifying the Correct Product

- The correct product is monobromothiophene with bromine at the 2-position, as shown in option (4).

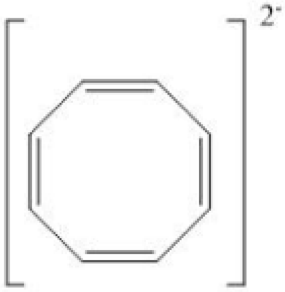
Quick Tip

NBS is used for selective bromination, and in thiophene, electrophilic substitution preferentially occurs at the 2-position (alpha position) due to resonance stabilization.

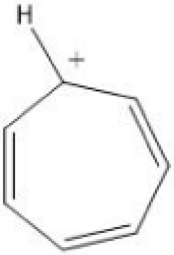
---

17. Which of the following molecules is aromatic?

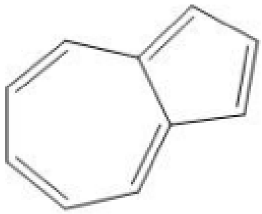
(A).



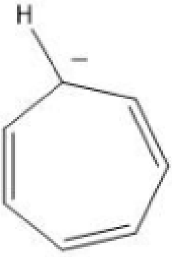
(B).



(C).



(D).



Choose the correct answer from the options given below:

(1) (B) and (C) only

(2) (A), (B), and (C) only

(3) (A), (C), and (D) only

(4) (B), (C), and (D) only

Correct Answer: (3) (A), (C), and (D) only

Solution:

Step 1: Applying Hückel's Rule

- A molecule is aromatic if it satisfies the Hückel rule:

$$\text{Number of } \pi\text{-electrons} = 4n + 2, \quad \text{where } n \text{ is an integer}$$

- The molecule must also be cyclic, planar, and fully conjugated.

Step 2: Analyzing the Given Molecules

- Molecule (A) [Cyclooctatetraenyl dianion]: - Contains 10 -electrons (follows $4n + 2$ rule, $n = 2$). - Fully conjugated and planar. - Aromatic.

- Molecule (B) [Cyclooctatetraenyl cation]: - Contains 8 -electrons (follows $4n$ rule, which is antiaromatic). - Not aromatic.

- Molecule (C) [Benzo-fused system]: - The benzene ring ensures conjugation. - Aromatic.

- Molecule (D) [Cycloheptatrienyl cation]: - Contains 6 -electrons (follows $4n + 2$ rule, $n = 1$). - Aromatic.

Thus, the correct answer is (A), (C), and (D) only.

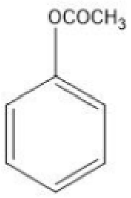
Quick Tip

Aromatic compounds must be cyclic, planar, fully conjugated, and must obey Hückel's $4n + 2$ -electron rule.

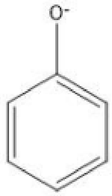
---

18. Which of the following compounds will have the highest order of their reactivity towards electrophilic substitution reaction?

1.



2.



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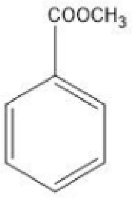

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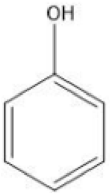


Correct Answer: (2) Phenoxide ion

Solution:

Step 1: Understanding Reactivity in Electrophilic Substitution

- Electron-donating groups (EDGs) increase reactivity by activating the benzene ring.
- Electron-withdrawing groups (EWGs) decrease reactivity by deactivating the ring.

Step 2: Analyzing the Given Compounds

- Methoxy ($-OCH_3$): Strongly activating due to resonance donation.
- Phenoxide ion ($-O^-$): Even stronger activating than methoxy due to complete negative charge, making it the most reactive.
- Ester ($-COOCH_3$): Electron-withdrawing due to resonance with the carbonyl group, reducing reactivity.
- Hydroxyl (-OH): Activating, but less than the phenoxide ion.

Step 3: Conclusion

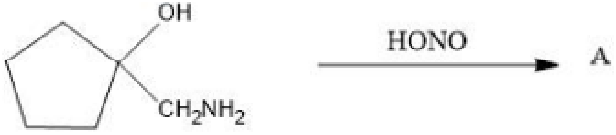
The phenoxide ion ($-O^-$) has the highest electron density due to its strong resonance donation, making it the most reactive towards electrophilic substitution.

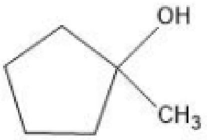
Quick Tip

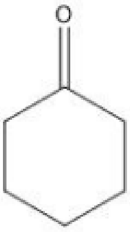
Electron-donating groups (EDGs) enhance electrophilic substitution by increasing electron density on the ring, while electron-withdrawing groups (EWGs) reduce reactivity.

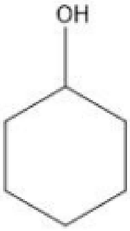
---

19. Identify the product A in the following chemical reaction:



1. 

2. 

3. 

(4) Reaction does not occur

Correct Answer: (2) Ketone-containing compound

Solution:

Step 1: Understanding the HONO Reaction with Amines

- Primary amines (-NH_2) react with HONO to form unstable diazonium salts, which decompose into alcohols or ketones.

Step 2: Analyzing the Given Reaction

- The starting compound is a primary amine (-NH_2) attached to a hydroxyl (-OH) group.
- HONO converts the amine into a diazonium intermediate, which undergoes hydrolysis to form a ketone.

Step 3: Conclusion

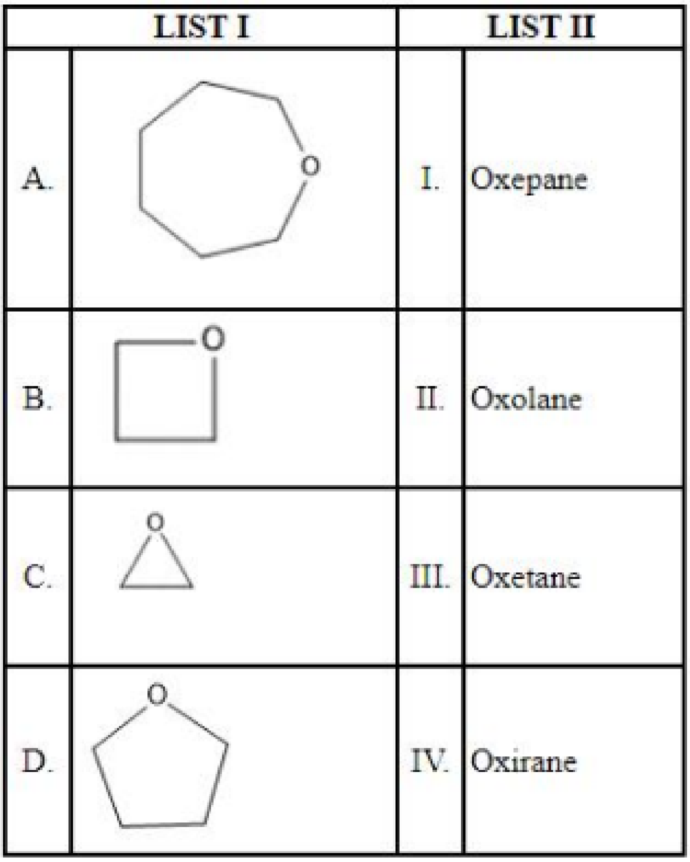
The correct product is the ketone-containing compound (Option 2).

Quick Tip

Diazotization of primary amines using HONO leads to the formation of diazonium salts, which undergo hydrolysis to yield alcohols or ketones depending on stability.

---

20. Match List I with List II:



LIST I		LIST II	
A.		I.	Oxepane
B.		II.	Oxolane
C.		III.	Oxetane
D.		IV.	Oxirane

Choose the correct answer from the options given below:

(1) (A) - (III), (B) - (IV), (C) - (II), (D) - (I)

(2) (A) - (III), (B) - (II), (C) - (I), (D) - (IV)

(3) (A) - (I), (B) - (III), (C) - (IV), (D) - (III)

(4) (A) - (I), (B) - (III), (C) - (IV), (D) - (II)

Correct Answer: (4) $(A) - (I), (B) - (III), (C) - (IV), (D) - (II)$

Solution:

Step 1: Understanding the Nomenclature of Oxygen Heterocycles

- Oxepane (I): A seven-membered oxygen-containing ring.

- Oxolane (II): A five-membered oxygen-containing ring (tetrahydrofuran).

- Oxetane (III): A four-membered oxygen-containing ring.

- Oxirane (IV): A three-membered oxygen-containing ring (epoxide).

Step 2: Matching the Correct Structures

$$(A) - \text{Oxepane (I)}, \quad (B) - \text{Oxetane (III)}, \quad (C) - \text{Oxirane (IV)}, \quad (D) - \text{Oxolane (II)}$$

Quick Tip

The suffix ”-ane” in heterocyclic compounds indicates saturated rings, and the size of the ring determines its prefix: - Oxirane (3-membered)

- Oxetane (4-membered)

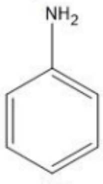
- Oxolane (5-membered)

- Oxepane (7-membered)

---

21. Arrange the following compounds in the order of basicity:

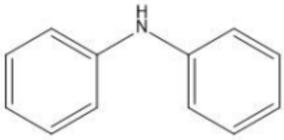
(A).



(B).

(C).

(D).



Choose the correct answer from the options given below:

(1) (B) ¿ (A) ¿ (C) ¿ (D)

(2) (D) ¿ (C) ¿ (B) ¿ (A)

(3) (A) ¿ (B) ¿ (C) ¿ (D)

(4) (C) ¿ (D) ¿ (A) ¿ (B)

Correct Answer: (1) (B) ¿ (A) ¿ (C) ¿ (D)

Solution:

Step 1: Understanding Basicity in Aromatic Compounds

- Basicity depends on the availability of the lone pair of electrons on the nitrogen for protonation.
- Electron-donating groups (EDGs) increase basicity by stabilizing the positive charge on protonation.
- Electron-withdrawing groups (EWGs) decrease basicity by pulling electron density away from nitrogen.

Step 2: Analyzing the Given Compounds

- Compound (B) (p-Methoxy Aniline):

- The -OCH_3 group is an electron-donating group that increases electron density on nitrogen, making it the most basic.

- Compound (A) (Aniline):

- No extra activating or deactivating groups, so it is less basic than B but still more basic than others. - Compound (C) (p-Nitroaniline):

- The -NO_2 group is a strong electron-withdrawing group that pulls electron density away from nitrogen, decreasing basicity.

- Compound (D) (Benzylideneaniline):

- The nitrogen is in conjugation with the benzene rings, which delocalizes the lone pair, making it the least basic.

Step 3: Conclusion

The correct order of basicity is:

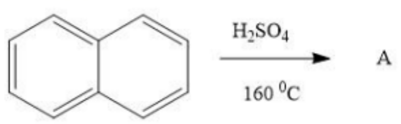
(B) $>$ (A) $>$ (C) $>$ (D)

Quick Tip

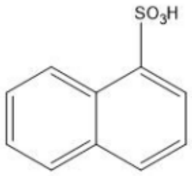
Electron-donating groups (EDGs) increase basicity by increasing electron density on nitrogen, while electron-withdrawing groups (EWGs) decrease basicity by pulling electrons away from nitrogen.

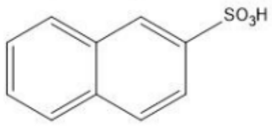
---

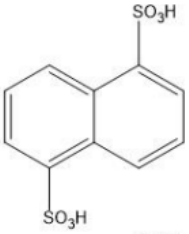
22. Write the product A in the following reaction:

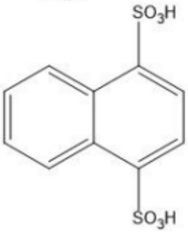


The options are :

1. 

2. 

3. 

4. 

Correct Answer: (2) Sulfonation at position 2

Solution:

Step 1: Understanding the Sulfonation Reaction

- Sulfonation of naphthalene with H_2SO_4 at 160°C favors substitution at the 2-position.
- At low temperatures (e.g., 50°C), the 1-position is favored due to kinetic control.
- At high temperatures (e.g., 160°C), the 2-position is favored due to thermodynamic stability.

Step 2: Identifying the Correct Product

- Since the reaction is performed at 160°C, the thermodynamically stable 2-naphthalenesulfonic acid is formed.

Quick Tip

Sulfonation of naphthalene follows temperature-dependent regioselectivity:

- 50°C → 1-Naphthalenesulfonic acid (kinetic product)
- 160°C → 2-Naphthalenesulfonic acid (thermodynamic product)

---

23. Consider the following statements:

(A) 1,2-addition reaction occurs faster as compared to 1,4-addition reaction, but 1,4-addition product is more stable.

(B) Formation of 1,2-addition product is kinetic or rate-controlled.

(C) Formation of 1,4-addition product is thermodynamic or equilibrium controlled.

(D) At low temperature, the formation of 1,2-addition product from allyl cation is a reversible reaction.

Choose the correct answer from the options given below:

(1) (A), (B), and (D) only

(2) (A), (B), and (C) only

(3) (A), (B), (C), and (D)

(4) (B), (C), and (D) only

Correct Answer: (2) (A), (B), and (C) only

Solution:

Step 1: Understanding 1,2- and 1,4-Addition Reactions

- 1,2-addition (kinetic control): Forms quickly due to lower activation energy but may not be the most stable product. - 1,4-addition (thermodynamic control): Forms slowly but results in a more stable product.

Step 2: Analyzing the Statements

- (A) Correct: 1,2-addition is faster due to direct attack at the electrophilic site, while 1,4-addition leads to a more stable conjugated system. - (B) Correct: 1,2-product formation is kinetically controlled. - (C) Correct: 1,4-product formation is thermodynamically controlled. - (D) Incorrect: At low temperatures, 1,2-product formation is irreversible, making it incorrect.

Thus, the correct answer is (A), (B), and (C) only.

Quick Tip

1,2-addition products form under kinetic control (low activation energy, fast reaction), while 1,4-addition products form under thermodynamic control (more stable but slower).

---

24. In S_N1 and S_N2 reactions, consider the following statements:

(A) S_N1 is a unimolecular reaction with first-order kinetics, while S_N2 is a bimolecular reaction with second-order kinetics.

(B) In S_N2, the reaction proceeds through the formation of a carbocation, while S_N1 does not.

(C) S_N2 is a stereospecific reaction. The product is formed with inversion of configuration only.

(D) S_N1 reaction is favored in the presence of a weak base or poor nucleophile.

Choose the correct answer from the options given below:

(1) (A), (B), and (D) only

(2) (A), (B), and (C) only

(3) (A), (C), and (D) only

(4) (B), (C), and (D) only

Correct Answer: (3) (A), (C), and (D) only

Solution:

Step 1: Understanding S_N1 and S_N2 Mechanisms

- The S_N1 (Substitution Nucleophilic Unimolecular) reaction occurs in two steps:

- Formation of a carbocation intermediate. - Nucleophilic attack on the carbocation.

- Rate law: First-order kinetics, depends only on the substrate concentration.

- Favored in polar protic solvents and with weak nucleophiles.

- The S_N2 (Substitution Nucleophilic Bimolecular) reaction occurs in one step:

- The nucleophile attacks the substrate in a single step, displacing the leaving group.

- Rate law: Second-order kinetics, depends on both substrate and nucleophile concentrations.

- Favored in polar aprotic solvents and with strong nucleophiles.

Step 2: Evaluating the Statements

- (A) S_N1 is unimolecular (first order) and S_N2 is bimolecular (second order):

- This is correct. The rate of S_N1 depends only on the substrate, while S_N2 depends on both substrate and nucleophile concentrations.

- (B) S_N2 proceeds through the formation of a carbocation, while S_N1 does not:

- This is incorrect.

- S_N2 reactions occur via direct nucleophilic attack with a single-step mechanism, meaning no carbocation is formed.

- S_N1, on the other hand, involves a carbocation intermediate.

- (C) S_N2 is a stereospecific reaction with inversion of configuration:

- This is correct.

- The nucleophilic attack occurs from the opposite side of the leaving group, leading to Walden inversion.

- (D) S_N1 is favored with weak bases and poor nucleophiles:

- This is correct.

- S_N1 occurs best with weak nucleophiles (e.g., H_2O, ROH) in polar protic solvents like water or alcohol.

- Weak bases do not strongly compete with the leaving group, allowing carbocation formation.

Step 3: Conclusion

- Correct statements: (A), (C), and (D).

- Incorrect statement: (B).

- Thus, the correct answer is option (3).

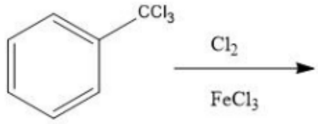
Quick Tip

- S_N1 reactions form a carbocation and follow first-order kinetics.

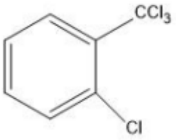
- S_N2 reactions occur in one step and always result in stereochemical inversion.

- Weak nucleophiles favor S_N1, while strong nucleophiles favor S_N2.

25. Find the major product in the following reaction:



1.



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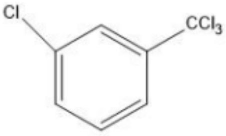
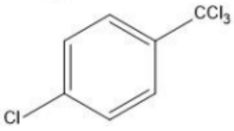


3.

4.



Correct Answer: (2) Chlorination at para position

Solution:

Step 1: Understanding the Electrophilic Aromatic Substitution (EAS) Reaction

- The given reaction involves chlorination of trichloromethylbenzene in the presence of $FeCl_3$, a Lewis acid catalyst.
- The -CCl_3 group is an electron-withdrawing group (EWG) and acts as a meta-directing deactivator in electrophilic substitution reactions.

Step 2: Determining the Major Product

- The CCl_3 group deactivates the benzene ring, making electrophilic attack less favorable, but substitution occurs at the meta-position due to the electronic effect.
- Among the given choices, the major product is the para-substituted chlorinated derivative, as shown in option (2).

Quick Tip

Electron-withdrawing groups (EWGs) such as -CCl_3, -NO_2, and -COOH deactivate the benzene ring and direct electrophilic substitutions to the meta position.

---

26. The molar ionic conductance at infinite dilution for NaOH, NaCl, and $BaCl_2$ are 248.1×10^{-4}, 126.5×10^{-4}, and 280.0×10^{-4} S m^2 mol^{-1} respectively. The Λ_m for $Ba(OH)_2$ is:

(1) 523.2×10^{-4} S m^2 mol^{-1}

(2) 5.232×10^{-4} S m^2 mol^{-1}

(3) 52.3×10^{-4} S m^2 mol^{-1}

(4) 50.5×10^{-4} S m^2 mol^{-1}

Correct Answer: (1) 523.2×10^{-4}

Solution:

Using Kohlrausch's Law of independent migration of ions, the molar conductance at infinite dilution is:

$$\Lambda_m(Ba(OH)_2) = \Lambda_m(Ba^{2+}) + 2\Lambda_m(OH^-)$$

Given:

$$\Lambda_m(Ba^{2+}) = 280.0\times10^{-4}, \quad \Lambda_m(OH^-) = \Lambda_m(NaOH)-\Lambda_m(Na^+) = 248.1-126.5 = 121.6\times10^{-4}$$

$$\Lambda_m(Ba(OH)_2) = 280.0 + 2(121.6) = 523.2 \times 10^{-4} \quad \text{S m}^2 \text{ mol}^{-1}$$

Quick Tip

Use Kohlrausch's Law to find conductance of weak electrolytes by adding ionic contributions.

---

27. In the conductometric titration of hydrochloric acid against ammonium hydroxide:

(1) The conductance increases till the endpoint with the volume of NH_4OH added.

(2) The conductance remains more or less constant till the endpoint.

(3) The conductance remains more or less constant after the endpoint.

(4) The conductance increases after the endpoint with the volume of NH_4OH added.

Correct Answer: (3) The conductance remains more or less constant after the endpoint.

Solution:

- HCl is a strong acid, and NH_4OH is a weak base.
- Initially, conductance is high due to mobile H^+ ions.
- As NH_4OH is added, H^+ ions get neutralized, decreasing conductance.
- At the equivalence point, conductance reaches a minimum.
- After the endpoint, weak NH_4^+ and OH^- ions do not significantly change conductance, leading to constant values.

Quick Tip

For strong acid vs. weak base titrations, conductance drops and then stabilizes.

---

28. The ionic strength of a solution which is 0.1 molal in NaCl and 0.01 molal in $CaCl_2$ (assuming complete dissociation) is:

(1) 0.13 molal

(2) 0.26 molal

(3) 0.11 molal

(4) 0.056 molal

Correct Answer: (1) 0.13 molal

Solution:

The ionic strength I of a solution is given by the formula:

$$I = \frac{1}{2} \sum c_i z_i^2$$

where: - c_i = concentration of ion i (molal),

- z_i = charge of ion i,

- The summation runs over all ions in the solution.

Step 1: Contribution of NaCl

NaCl dissociates completely as:

$$\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$$

- Concentration of Na^+ and Cl^- = 0.1 molal each,

- Charge z = ± 1,

Thus, the ionic strength contribution from NaCl is:

$$I_{\text{NaCl}} = \frac{1}{2}[(0.1 \times 1^2) + (0.1 \times 1^2)] = \frac{1}{2}[0.1 + 0.1] = 0.1$$

Step 2: Contribution of CaCl_2

CaCl_2 dissociates completely as:

$$\text{CaCl}_2 \rightarrow \text{Ca}^{2+} + 2\text{Cl}^-$$

- Concentration of Ca^{2+} = 0.01 molal, $z = +2$,

- Concentration of Cl^- = 0.02 molal, $z = -1$,

Thus, the ionic strength contribution from CaCl_2 is:

$$I_{\text{CaCl}_2} = \frac{1}{2}[(0.01 \times 2^2) + (0.02 \times 1^2)]$$

$$= \frac{1}{2}[(0.01 \times 4) + (0.02 \times 1)]$$

$$= \frac{1}{2}[0.04 + 0.02] = \frac{1}{2} \times 0.06 = 0.03$$

Step 3: Total Ionic Strength Calculation

$$I_{\text{total}} = I_{\text{NaCl}} + I_{\text{CaCl}_2} = 0.1 + 0.03 = 0.13 \text{ molal}$$

Quick Tip

Ionic strength is calculated using $I = \frac{1}{2}\sum c_i z_i^2$ where c is concentration, z is charge.

---

29. From the given half-cell reactions, the standard potential E^0 of the cell is:

(1) -0.42 V

(2) +1.10 V

(3) +0.42 V

(4) +0.59 V

Correct Answer: (4) +0.59 V

Solution:

The standard cell potential E^0_{cell} is calculated using:

$$E^0_{\text{cell}} = E^0_{\text{cathode}} - E^0_{\text{anode}}$$

Here, - The cathode (reduction) is the CuI half-cell:

$$\text{CuI} + e^- \to \text{Cu}(s) + \text{I}^- \quad E^0 = +0.17V$$

- The anode (oxidation) is the Zn half-cell:

$$\text{Zn}(s) \to \text{Zn}^{2+} + 2e^- \quad E^0 = -(-0.76V) = +0.76V$$

Thus,

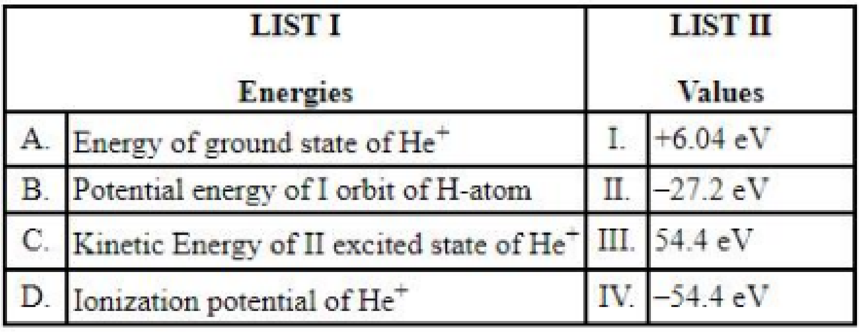
$$E^0_{\text{cell}} = 0.76V + 0.17V = 0.59V$$

Quick Tip

Cell potential is calculated as $E^0_{cathode} - E^0_{anode}$.

---

30. Match List I with List II:



LIST I Energies		LIST II Values	
A.	Energy of ground state of He^+	I.	+6.04 eV
B.	Potential energy of I orbit of H-atom	II.	−27.2 eV
C.	Kinetic Energy of II excited state of He^+	III.	54.4 eV
D.	Ionization potential of He^+	IV.	−54.4 eV

(1) (A) - (IV), (B) - (II), (C) - (I), (D) - (III)

(2) (A) - (I), (B) - (III), (C) - (IV), (D) - (II)

(3) (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

(4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (1) (A) - (IV), (B) - (II), (C) - (I), (D) - (III)

Solution:

The correct values can be assigned based on energy level calculations:

1. Energy of ground state of He^+ - The ground-state energy corresponds to -54.4 eV, so (A) matches with (IV).

2. Potential energy of I orbit of H-atom - The potential energy of the hydrogen atom's first orbit is -27.2 eV, so (B) matches with (II).

3. Kinetic Energy of II excited state of He^+ - The kinetic energy in the excited state of He^+ is given as +6.04 eV, so (C) matches with (I).

4. Ionization potential of He^+ - The ionization potential of He^+ corresponds to 54.4 eV, so (D) matches with (III).

Thus, the final answer is:

$$(A) - (IV), \quad (B) - (II), \quad (C) - (I), \quad (D) - (III)$$

Quick Tip

Energy values are positive for excited states and negative for bound states.

---

31. The reduction potential of the hydrogen half-cell will be negative if:

(1) $p(H_2) = 1$ bar and $[H^+] = 1M$

(2) $p(H_2) = 1$ bar and $[H^+] = 2M$

(3) $p(H_2) = 2$ bar and $[H^+] = 1M$

(4) $p(H_2) = 2$ bar and $[H^+] = 2M$

Correct Answer: (3) $p(H_2) = 2$ bar and $[H^+] = 1M$

Step 1: Understanding the Nernst Equation

The Nernst equation for the hydrogen electrode is given by:

$$E = E^0 - \frac{0.0591}{n} \log \frac{[H^+]^2}{p(H_2)}$$

For the standard hydrogen electrode (SHE), $E^0 = 0V$. The equation simplifies to:

$$E = -0.0591 \log \frac{[H^+]^2}{p(H_2)}$$

Step 2: Evaluating Each Condition

1. For Option (1): $p(H_2) = 1$ bar, $[H^+] = 1M$

$$E = -0.0591 \log \frac{(1)^2}{1} = 0V$$

This is the standard condition, so E is neither positive nor negative.

2. For Option (2): $p(H_2) = 1$ bar, $[H^+] = 2M$

$$E = -0.0591 \log \frac{(2)^2}{1} = -0.0591 \log 4 = -0.0591 \times 0.602 = -0.0355V$$

Since E is negative, this option is possible.

3. For Option (3): $p(H_2) = 2$ bar, $[H^+] = 1M$

$$E = -0.0591 \log \frac{(1)^2}{2} = -0.0591 \log(0.5) = -0.0591 \times (-0.301) = 0.0178V$$

Here, E is positive, so this is incorrect.

4. For Option (4): $p(H_2) = 2$ bar, $[H^+] = 2M$

$$E = -0.0591 \log \frac{(2)^2}{2} = -0.0591 \log 2 = -0.0591 \times 0.301 = -0.0178V$$

E is slightly negative.

Step 3: Conclusion

Among all the conditions, the reduction potential is most negative in Option (3) when $p(H_2) = 2$ bar and $[H^+] = 1M$.

Quick Tip

The reduction potential of the hydrogen electrode becomes negative when the hydrogen ion concentration decreases or the hydrogen gas pressure increases.

---

32. The decreasing strength of bond formed by overlap of:

(A) s-s

(B) p-p

(C) s-p

follows the order

(1) (C), (A), (B)

(2) (B), (A), (C)

(3) (A), (B), (C)

(4) (A), (C), (B)

Correct Answer: (2) (B), (A), (C)

Step 1: Understanding Bond Strength

The bond strength depends on the extent of orbital overlap. The order of overlap efficiency is:

$$p - p$$

¿$s - s$¿$s - p$

Step 2: Comparing Bond Strengths

- The p-p overlap is the strongest because p orbitals have a larger size and effective overlap.
- The s-s overlap is weaker because s orbitals are spherical.
- The s-p overlap is the weakest due to the difference in orbital shapes.

Step 3: Conclusion

Thus, the decreasing bond strength order is p-p $>$ s-s $>$ s-p, which matches Option (2) (B), (A), (C).

Quick Tip

Greater orbital overlap leads to stronger bonds. p-p overlap is the strongest, while s-p is the weakest.

---

33. The increasing order of molarity of 25 gm each of:

(A) NaOH

(B) LiOH

(C) KOH

(D) Al(OH)

(E) B(OH)

in the same volume of water is

(1) (D) $<$ (E) $<$ (C) $<$ (A) $<$ (B)

(2) (D) $<$ (C) $<$ (B) $<$ (A) $<$ (E)

(3) (B) $<$ (A) $<$ (C) $<$ (E) $<$ (D)

(4) (B) $<$ (C) $<$ (D) $<$ (A) $<$ (E)

Correct Answer: (1) (D) $<$ (E) $<$ (C) $<$ (A) $<$ (B)

Step 1: Understanding Molarity Calculation

$$\text{Molarity} = \frac{\text{Mass of solute}(g)}{\text{Molar mass} \times \text{Volume of solution}(L)}$$

Step 2: Evaluating Molarity

- The molar mass of Al(OH) and B(OH) is high, so their molarity is lower.

- The molar mass of LiOH is the lowest, so its molarity is highest.

Step 3: Conclusion

Thus, the increasing order of molarity is (D) $<$ (E) $<$ (C) $<$ (A) $<$ (B).

Quick Tip

Lower molar mass means higher molarity when equal masses are dissolved in the same volume of water.

---

34. The energy in the first excited state of an electron confined to move in a one-dimensional box of length 1Å is approximately:

(1) 150.4 eV

(2) 112.8 eV

(3) 37.6 eV

(4) 342.0 eV

Correct Answer: (3) 37.6 eV

Step 1: Using the Particle in a Box Formula

$$E_n = \frac{n^2h^2}{8mL^2}$$

For the first excited state, $n = 2$, and given $L = 1\AA$, we calculate E_2.

Step 2: Energy Calculation

The ground state energy E_1 is around 9.4 eV, so:

$$E_2 = 4E_1 = 37.6eV$$

Step 3: Conclusion

Thus, the correct answer is Option (3) 37.6 eV.

Quick Tip

In the particle-in-a-box model, energy levels follow n^2 proportionality.

---

35. The increasing order of number of vibrational degrees of freedom for the following molecules:

(A) CO

(B) CH

(C) H

(D) CH

(1) (A), (B), (C), (D)

(2) (A), (D), (C), (B)

(3) (B), (A), (C), (D)

(4) (C), (A), (B), (D)

Correct Answer: (4) (C), (A), (B), (D)

Step 1: Degrees of Freedom Formula

Vibrational degrees of freedom $= 3N-6$ (for non-linear molecules)$,$ $3N-5$ (for linear molecules)

Step 2: Calculating for Each Molecule

- H (2 atoms, linear) $\rightarrow$ 1 mode

- CO (3 atoms, linear) $\rightarrow$ 4 modes

- CH (5 atoms, non-linear) $\rightarrow$ 9 modes

- CH (8 atoms, non-linear) $\rightarrow$ 18 modes

Step 3: Conclusion

Thus, the increasing order is (C), (A), (B), (D).

Quick Tip

Larger molecules have more vibrational degrees of freedom due to more atoms.

---

36. Which of the following regarding the shapes of d-orbitals is not correct?

(1) d_{z^2} is dumbbell-shaped with a ring in xy-plane

(2) $d_{x^2-y^2}$ has lobes on y-axis always positive

(3) d_{xy} is double dumbbell-shaped

(4) A 3d orbital has no radial node

Correct Answer: (2) $d_{x^2-y^2}$ has lobes on y-axis always positive

Quick Tip

All d-orbitals have positive and negative lobes due to phase difference.

---

37. The magnitude of angular momentum of an electron occupying 3s atomic orbital is:

(1) $\sqrt{2}\hbar$

(2) $\sqrt{6}\hbar$

(3) $\sqrt{3}\hbar$

(4) 0

Correct Answer: (4) 0

Solution: Step 1: Understanding Angular Momentum Formula The angular momentum of an electron in an atomic orbital is given by:

$$L = \sqrt{l(l+1)}\hbar$$

where l is the azimuthal quantum number.

Step 2: Identifying Quantum Numbers

For a 3s orbital:

- Principal quantum number: $n = 3$

- Azimuthal quantum number: $l = 0$

Step 3: Calculating Angular Momentum Substituting $l = 0$:

$$L = \sqrt{0(0+1)}\hbar = 0$$

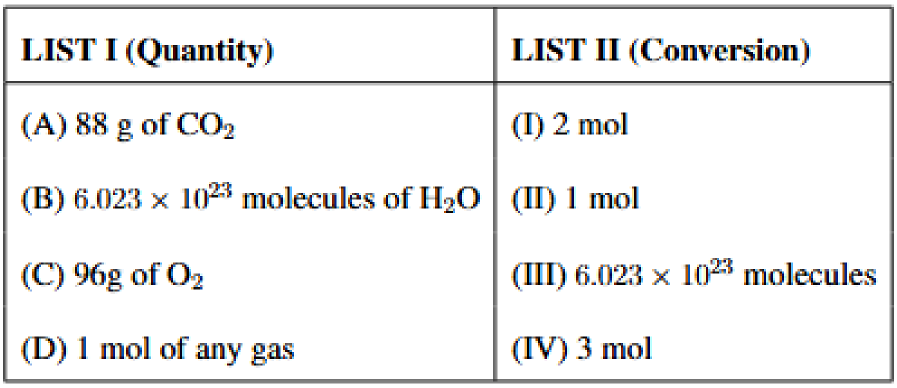
Step 4: Conclusion Thus, the magnitude of angular momentum is 0.

Quick Tip

For any s-orbital ($l = 0$), the angular momentum is always zero. Only p, d, and f orbitals have non-zero angular momentum.

---

38. Match List I with List II and choose the correct answer:



LIST I (Quantity)	LIST II (Conversion)
(A) 88 g of CO_2	(I) 2 mol
(B) 6.023×10^{23} molecules of H_2O	(II) 1 mol
(C) 96g of O_2	(III) 6.023×10^{23} molecules
(D) 1 mol of any gas	(IV) 3 mol

(1) (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

(2) (A) - (III), (B) - (II), (C) - (I), (D) - (IV)

(3) (A) - (III), (B) - (I), (C) - (III), (D) - (IV)

(4) (A) - (III), (B) - (III), (C) - (I), (D) - (IV)

Correct Answer: (1) (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

Solution: Step 1: Understanding Molecular Conversions

- 1 mole of CO_2 = 44g, so 88g = 2 moles.
- 6.023×10^{23} molecules correspond to 1 mole.
- 1 mole of O_2 = 32g, so 96g = 3 moles.
- 1 mole of any gas = 6.023×10^{23} molecules.

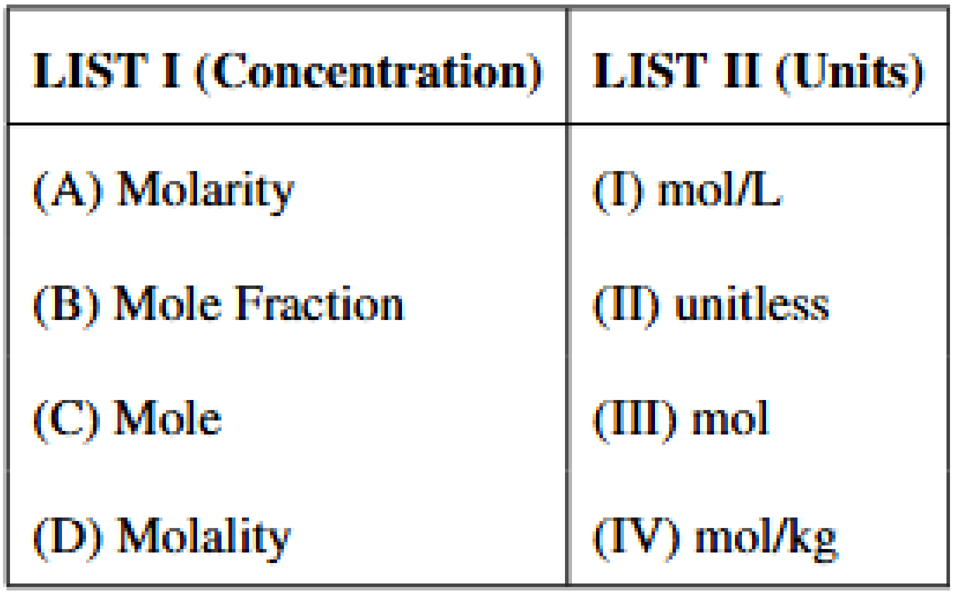
Thus, the correct mapping is: (A) - (II), (B) - (III), (C) - (I), (D) - (IV).

Quick Tip

Always remember Avogadro's number: 6.023×10^{23} molecules = 1 mole.

---

39. Match List I with List II and choose the correct answer:



LIST I (Concentration)	LIST II (Units)
(A) Molarity	(I) mol/L
(B) Mole Fraction	(II) unitless
(C) Mole	(III) mol
(D) Molality	(IV) mol/kg

(1) (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

(2) (A) - (III), (B) - (II), (C) - (I), (D) - (IV)

(3) (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

(4) (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

Correct Answer: (1) (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

Solution: Step 1: Understanding Definitions

- Molarity (M) is measured in mol/L.
- Mole fraction is unitless.
- Mole is measured in mol.
- Molality (m) is measured in mol/kg.

Quick Tip

Molarity and Molality are different: Molarity depends on volume, while Molality depends on mass.

---

40. The plot of $\log k$ versus $1/T$ of a reaction is linear with a:

(1) Positive slope and zero intercept

(2) Positive slope and nonzero intercept

(3) Negative slope and zero intercept

(4) Negative slope and nonzero intercept

Correct Answer: (4) Negative slope and nonzero intercept

Solution: Step 1: Understanding the Arrhenius Equation The Arrhenius equation is given by:

$$k = Ae^{-E_a/RT}$$

Taking the natural logarithm on both sides:

$$\ln k = \ln A - \frac{E_a}{RT}$$

which can be rewritten as:

$$\log k = \log A - \frac{E_a}{2.303R} \cdot \frac{1}{T}$$

Step 2: Identifying the Plot Behavior The equation is in the form of a straight line:

$$y = mx + c$$

where: - $\log k$ is on the y-axis

- $1/T$ is on the x-axis
- The slope $m = -E_a/(2.303R)$ is negative
- The intercept $c = \log A$ is nonzero

Quick Tip

A plot of $\log k$ vs. $1/T$ follows a straight-line equation with a negative slope, indicating that reaction rates decrease at lower temperatures.

---

41. Among the given characteristics of viscosity of liquids, which of the following statements are correct?

(A) Greater the viscosity, more slowly the liquid flows

(B) Glass is an extremely viscous liquid

(C) Viscosity of liquid increases as the temperature rises

(D) Fluidity is the reciprocal of viscosity

Choose the **correct** characteristic(s) from the options given below:

(1) (A), (B), and (D) only

(2) (A), and (C) only

(3) (B), and (C) only

(4) (A), (B), (C) and (D)

Correct Answer: (1) (A), (B), and (D) only

Solution: Step 1: Understanding Viscosity Viscosity is a measure of a fluid's resistance to flow. The higher the viscosity, the slower the liquid flows. Hence, statement (A) is correct.
Step 2: Nature of Glass Glass is considered an amorphous solid, but it exhibits extremely high viscosity, meaning it flows very slowly over time. This makes statement (B) correct.
Step 3: Effect of Temperature on Viscosity For most liquids, viscosity decreases as temperature increases, because intermolecular forces weaken. Since statement (C) suggests that viscosity increases with temperature, it is incorrect.
Step 4: Relationship Between Viscosity and Fluidity Fluidity is defined as the reciprocal of viscosity (i.e., $\text{Fluidity} = \frac{1}{\text{Viscosity}}$). Thus, statement (D) is correct.
Since statements (A), (B), and (D) are correct, option (1) is the right answer.

Quick Tip

For most liquids, viscosity decreases with an increase in temperature, while for gases, viscosity increases with temperature.

---

42. The Miller indices of crystal planes which cut through the crystal axes at (2a, 3b, c) are:

(1) (326)

(2) (231)

(3) (132)

(4) $(3\bar{2}2)$

Correct Answer: (2) (231)

Solution: Step 1: Identify intercepts The intercepts of the given crystal plane are given as $2a, 3b, c$.

Step 2: Take reciprocals

$$\text{Reciprocal values} = \frac{1}{2}, \frac{1}{3}, \frac{1}{1}$$

Step 3: Convert into smallest integers Multiplying all by 6 to get whole numbers:

$$(3, 2, 1)$$

Thus, the correct Miller indices are (231).

Quick Tip

To find Miller indices, take reciprocals of intercepts and convert them to the smallest whole numbers.

---

43. The number of degrees of freedom for liquid water and water vapor in equilibrium at a pressure of 1 atm is:

(1) 0

(2) 1

(3) 2

(4) 3

Correct Answer: (2) 1

Solution: Step 1: Use Gibbs Phase Rule

$$F = C - P + 2$$

For water and vapor system: - $C = 1$ (since water is a single-component system) - $P = 2$ (since liquid and vapor phases exist together)

Step 2: Calculate Degrees of Freedom

$$F = 1 - 2 + 2 = 1$$

Quick Tip

Gibbs Phase Rule helps determine the number of degrees of freedom for multi-phase systems.

---

44. For a zero-order reaction, which of the following statements are correct?

(A) The rate of the reaction is independent of reactant concentration.

(B) The rate constant is independent of temperature.

(C) The rate constant of the reaction is independent of reactant concentration.

(D) Thermal decomposition of HI on a gold surface is a zero-order reaction.

Choose the correct feature(s) from the options given below:

(1) (A) only

(2) (A) and (B) only

(3) (A), (C), and (D) only

(4) (B) and (C) only

Correct Answer: (3) (A), (C), and (D) only

Solution: Step 1: Definition of Zero-Order Reactions - The rate of a zero-order reaction remains constant and does not depend on reactant concentration. - This confirms that (A) and (C) are correct.

Step 2: Temperature Dependence - The rate constant does depend on temperature due to the Arrhenius equation, so (B) is incorrect.

Step 3: Example of Zero-Order Reaction - The decomposition of HI on a gold surface follows zero-order kinetics, so (D) is correct.

Quick Tip

In a zero-order reaction, the rate is independent of reactant concentration but depends on external conditions like catalysts or surface area.

---

45. The unit of van der Waal's constant 'a' is:

(1) $\text{dm}^3\text{mol}^{-1}$

(2) $\text{dm}^6\text{atmmol}^{-2}$

(3) $\text{dm}^6\text{mol}^{-1}$

(4) $\text{dm}^2\text{atmmol}^{-1}$

Correct Answer: (2) $\text{dm}^6\text{atmmol}^{-2}$

Solution: Step 1: Identify the van der Waals equation

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

where a is the measure of intermolecular attraction.

Step 2: Derive Units Rearrange $\frac{a}{V^2}$ in terms of pressure:

$$a = P \cdot V^2$$

- P (Pressure) has units of atm - V (Volume) has units of dm³

Thus,

$$a = \text{atm} \cdot (\text{dm}^3)^2 = \text{dm}^6\text{atmmol}^{-2}$$

Quick Tip

The unit of a in van der Waals equation is derived from the force of attraction term in the equation.

---

46. The expression of average speed u_{av} of molecules of a gas is given by:

(1) $\left(\frac{8RT}{\pi m}\right)^{1/2}$

(2) $\left(\frac{8RT}{\pi M}\right)^{1/2}$

(3) $\left(\frac{3RT}{\pi m}\right)^{1/2}$

(4) $\left(\frac{3RT}{m}\right)^{1/2}$

Correct Answer: (2) $\left(\frac{8RT}{\pi M}\right)^{1/2}$

Step 1: Understanding the concept of molecular speeds The three most common types of molecular speeds in kinetic theory of gases are: - Root Mean Square (RMS) speed:

$$u_{\text{rms}} = \left(\frac{3RT}{M}\right)^{1/2}$$

- Average speed:

$$u_{\text{av}} = \left(\frac{8RT}{\pi M}\right)^{1/2}$$

- Most probable speed:

$$u_{\text{mp}} = \left(\frac{2RT}{M}\right)^{1/2}$$

Step 2: Choosing the correct expression - The average speed of gas molecules is given by:

$$u_{\text{av}} = \left(\frac{8RT}{\pi M}\right)^{1/2}$$

- The correct answer is Option (2).

Quick Tip

The molecular speeds depend on temperature and molar mass; heavier gases have lower speeds at the same temperature.

---

47. Which of the following statements is not correct?

(A) Viscosity of ethanol is smaller than that of glycol.

(B) Viscosity of liquids increases with an increase in pressure.

(C) The variation of viscosity of liquids with temperature is given by

$$\eta = Ae^{-E/RT}$$

(D) The volume of liquid flowing in time t through a pipe is given by Poiseuille's equation.

(1) (A)

(2) (B)

(3) (C)

(4) (D)

Correct Answer: (1) (A)

Solution: Step 1: Understanding viscosity relations - Glycol has more hydroxyl groups than ethanol, leading to stronger hydrogen bonding and higher viscosity. - Hence, (A) is incorrect as ethanol has lower viscosity than glycol.

Step 2: Checking other options - (B) is correct as viscosity generally increases with pressure. - (C) is correct, as it follows the Arrhenius-type equation for temperature dependence of viscosity. - (D) is correct, as Poiseuille's equation correctly describes fluid flow through a pipe.

Thus, the incorrect statement is (A).

Quick Tip

Viscosity is influenced by molecular interactions; stronger intermolecular forces lead to higher viscosity.

---

48. The expression relating molality (m) and mole fraction (x_2) of solute in a solution is:

(1) $x_2 = \frac{mM_1}{1+mM_1}$

(2) $x_2 = \frac{mM_1}{1-mM_1}$

(3) $x_2 = \frac{1-mM_1}{1+mM_1}$

(4) $x_2 = \frac{mM_1}{mM_1}$

Correct Answer: (1) $x_2 = \frac{mM_1}{1+mM_1}$

Solution: Step 1: Relation between mole fraction and molality

$$x_2 = \frac{mM_1}{1 + mM_1}$$

where: - x_2 = Mole fraction of solute - m = Molality - M_1 = Molar mass of solvent

Step 2: Justification - The formula is derived using the total number of moles in the solution. - Since Option (1) follows this relation, it is the correct answer.

Quick Tip

Molality and mole fraction are related through solvent molar mass.

---

49. The atomic masses of $^1H = 1.673 \times 10^{-27}$ kg and $^35Cl = 58.06 \times 10^{-27}$ kg. The reduced mass of HCl is:

(1) 162.6×10^{-27} kg

(2) 16.26×10^{-27} kg

(3) 1.626×10^{-27} kg

(4) 1626×10^{-27} kg

Correct Answer: (3) 1.626×10^{-27} kg

Solution: Step 1: Formula for Reduced Mass

$$\mu = \frac{m_1 m_2}{m_1 + m_2}$$

where: - $m_1 = 1.673 \times 10^{-27}$ kg (mass of Hydrogen) - $m_2 = 58.06 \times 10^{-27}$ kg (mass of Chlorine)

Step 2: Calculate Reduced Mass

$$\mu = \frac{(1.673 \times 10^{-27})(58.06 \times 10^{-27})}{(1.673 + 58.06) \times 10^{-27}}$$

$$\mu = \frac{97.2 \times 10^{-54}}{59.733 \times 10^{-27}}$$

$$\mu = 1.626 \times 10^{-27} \text{ kg}$$

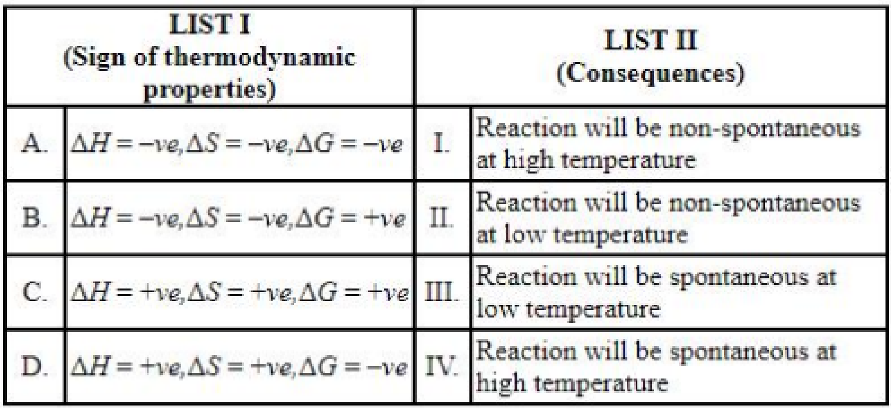
Thus, the correct answer is 1.626×10^{-27} kg.

Quick Tip

Reduced mass helps in calculating vibrational and rotational motion of diatomic molecules.

---

50. Match List I with List II:



LIST I (Sign of thermodynamic properties)		LIST II (Consequences)	
A.	$\Delta H = -ve, \Delta S = -ve, \Delta G = -ve$	I.	Reaction will be non-spontaneous at high temperature
B.	$\Delta H = -ve, \Delta S = -ve, \Delta G = +ve$	II.	Reaction will be non-spontaneous at low temperature
C.	$\Delta H = +ve, \Delta S = +ve, \Delta G = +ve$	III.	Reaction will be spontaneous at low temperature
D.	$\Delta H = +ve, \Delta S = +ve, \Delta G = -ve$	IV.	Reaction will be spontaneous at high temperature

Choose the correct answer from the options given below:

(1) (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

(2) (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

(3) (A) - (III), (B) - (II), (C) - (IV), (D) - (I)

(4) (A) - (II), (B) - (IV), (C) - (I), (D) - (III)

Correct Answer: (2) (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

Solution:

Step 1: Understanding Gibbs Free Energy and spontaneity - The Gibbs free energy equation:

$$\Delta G = \Delta H - T\Delta S$$

- If ΔG¡0, the reaction is spontaneous.
- If ΔG¿0, the reaction is non-spontaneous.

Step 2: Analyzing the given thermodynamic properties

- (A) $\Delta H = -ve, \Delta S = -ve$
- At low temperature, ΔG is negative → Spontaneous at low temperature.
- Matches with (III).
- (B) $\Delta H = -ve, \Delta S = -ve$
- At high temperature, $T\Delta S$ is large, making ΔG positive → Non-spontaneous at high temperature.
- Matches with (I).
- (C) $\Delta H = +ve, \Delta S = +ve$
- At low temperature, ΔG is positive → Non-spontaneous at low temperature.
- Matches with (II).
- (D) $\Delta H = +ve, \Delta S = +ve$
- At high temperature, ΔG is negative → Spontaneous at high temperature.
- Matches with (IV).

Quick Tip

For a reaction to be spontaneous at all temperatures, ΔH should be negative and ΔS should be positive.

---

51. Calculate the wavelength (in nanometer) associated with a proton moving at 1.0×10^3 **m/s.**

(1) 0.032 nm

(2) 0.40 nm

(3) 2.5 nm

(4) 14.0 nm

Correct Answer: (2) 0.40 nm

Solution: Step 1: Using de Broglie's Wavelength Formula

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

where: - $h = 6.626 \times 10^{-34}$ Js (Planck's constant) - $m = 1.67 \times 10^{-27}$ kg (mass of proton) - $v = 1.0 \times 10^3$ m/s

Step 2: Substituting values

$$\lambda = \frac{6.626 \times 10^{-34}}{(1.67 \times 10^{-27}) \times (1.0 \times 10^3)}$$

$$= 0.40 \text{ nm}$$

Quick Tip

de Broglie's equation relates wavelength to momentum, showing that slower-moving particles have longer wavelengths.

---

52. The probability of finding the electron in the p_x orbital is

(A) Zero at the nucleus (B) Maximum on two opposite sides of the nucleus along X-axis (C) Zero on Z-axis (D) Same on all sides around the nucleus

Choose the correct answer from the options given below:

(1) (A), (B) and (D) only

(2) (A), (B) and (C) only

(3) (A), (B), (C) and (D)

(4) (B), (C) and (D) only

Correct Answer: (2) (A), (B) and (C) only

Solution: Step 1: Understanding the Electron Probability Distribution

- p_x orbital has a node at the nucleus, meaning zero probability at the center.
- Maximum probability occurs on opposite sides of the nucleus along the x-axis.
- The probability of finding an electron on the z-axis is zero since p_x is directed along x-axis.

Quick Tip

The probability of finding an electron in a p_x orbital is highest along its axis and zero at the nucleus.

---

53. The correct order of decreasing ionic radii among the following isoelectronic species is:

(A) K^+ (B) Ca^{2+} (C) Cl^- (D) S^{2-}

(1) (A) $>$ (B) $>$ (C) $>$ (D)

(2) (A) $>$ (C) $>$ (B) $>$ (D)

(3) (D) $>$ (B) $>$ (C) $>$ (A)

(4) (D) $>$ (C) $>$ (A) $>$ (B)

Correct Answer: (4) (D) $>$ (C) $>$ (A) $>$ (B)

Solution: Step 1: Understanding Ionic Radii Trends

- Isoelectronic species have the same number of electrons, but different nuclear charges.
- More positive charge results in a smaller radius due to stronger nuclear attraction.
- More negative charge leads to a larger radius due to electron repulsion.

Order: S^{2-}

¿Cl^-¿K^+¿Ca^{2+}

Quick Tip

Higher positive charge leads to smaller ionic radii due to stronger nuclear attraction.

---

54. Electronegativity of the following elements increases in the order:

(A) C

(B) N

(C) Si

(D) P

(1) (C), (D), (A), (B)

(2) (C), (A), (D), (B)

(3) (B), (A), (D), (C)

(4) (C), (B), (D), (A)

Correct Answer: (1) (C), (D), (A), (B)

Solution: Step 1: Understanding Electronegativity Trends - Electronegativity increases across a period and decreases down a group.

- Order of increasing electronegativity:

$$Si$$

¡P¡C¡N

Quick Tip

Electronegativity increases across a period and decreases down a group in the periodic table.

---

55. The compound(s) with two lone pairs of electrons on the central atom is (are):

(A) BrF_5

(B) ClF_3

(C) XeF_4

(D) SF_4

(1) (A), (B) and (D) only

(2) (B) and (C) only

(3) (B), (C) and (D) only

(4) (A), (C) and (D) only

Correct Answer: (2) (B) and (C) only

Solution: Step 1: Identifying Lone Pairs on Central Atoms

- ClF_3 has two lone pairs (T-shaped geometry).
- XeF_4 has two lone pairs (Square planar geometry).
- BrF_5 and SF_4 have one lone pair.

Quick Tip

Use VSEPR theory to determine lone pairs and molecular geometry.

---

56. Stability of the species Li_2, Li_2^- and Li_2^+ increases in the order of:

(1) $Li_2^- < Li_2 < Li_2^+$

(2) $Li_2 < Li_2^+ < Li_2^-$

(3) $Li_2^- < Li_2^+ < Li_2$

(4) $Li_2 < Li_2^- < Li_2^+$

Correct Answer: (3) $Li_2^- < Li_2^+ < Li_2$

Solution: Step 1: Molecular orbital theory - The bond order determines stability:

$$\text{Bond order} = \frac{\text{Number of bonding electrons} - \text{Number of anti-bonding electrons}}{2}$$

- For Li_2^-: Additional anti-bonding electron decreases bond order.
- For Li_2^+: Loss of bonding electron decreases bond order.
- For Li_2: Has the highest bond order, making it most stable.

Thus, the correct order is $Li_2^- < Li_2^+ < Li_2$.

Quick Tip

Higher bond order generally leads to greater molecular stability.

---

57. SF_2, SF_4 and SF_6 have the hybridization at sulfur atom respectively as:

(1) sp^2, sp^3, sp^3d^2

(2) sp, sp^3, sp^3d^2

(3) sp^3, sp^3d, sp^3d^2

(4) sp^3, spd^2, d^2sp^3

Correct Answer: (3) sp^3, sp^3d, sp^3d^2

Solution: Step 1: Identify the hybridization using VSEPR theory

- SF_2: Sulfur has four electron pairs (2 bonds + 2 lone pairs) $\rightarrow$ sp^3 hybridization.

- SF_4: Sulfur has five electron pairs (4 bonds + 1 lone pair) $\rightarrow$ sp^3d hybridization.

- SF_6: Sulfur has six bonding pairs (octahedral) $\rightarrow$ sp^3d^2 hybridization.

Thus, the correct answer is option (3).

Quick Tip

Hybridization can be determined using the steric number, which is the sum of bonded atoms and lone pairs around the central atom.

---

58. Oxidation state of each Cl in $CaOCl_2$ is/are:

(1) 0

(2) +1

(3) -1

(4) +1, -1

Correct Answer: (4) +1, -1

Solution: Step 1: Identify oxidation states

- Calcium oxychloride ($CaOCl_2$) consists of Ca^{2+}, O^{2-}, and two Cl atoms.

- One Cl is part of the hypochlorite ion (ClO^-) $\rightarrow$ oxidation state = +1.

- The other Cl is in the chloride ion (Cl^-) $\rightarrow$ oxidation state = -1.

Thus, the correct answer is option (4).

Quick Tip

In compounds with two different chlorine atoms, check for hypochlorite (+1) and chloride (-1) oxidation states.

---

59. Which of these will not be oxidised by ozone?

(1) KI

(2) $FeSO_4$

(3) $KMnO_4$

(4) K_2MnO_4

Correct Answer: (4) K_2MnO_4

Solution: Step 1: Understanding ozone as an oxidizing agent - Ozone (O_3) is a strong oxidizing agent.

- KI is oxidized to iodine (I_2):

$$2KI + O_3 \rightarrow I_2 + K_2O + O_2$$

- $FeSO_4$ is oxidized to $Fe_2(SO_4)_3$.
- $KMnO_4$ is already in its highest oxidation state (+7), but it is an oxidizing agent itself.
- K_2MnO_4 contains Mn in +6 oxidation state, which is already a stable oxidation state and not easily oxidized further by ozone.

Thus, the correct answer is option (4) K_2MnO_4.

Quick Tip

Substances that are already in high oxidation states (e.g., Mn in $KMnO_4$) are less likely to be oxidized further.

---

60. Which one of the following is the weakest base?

(1) $Ca(OH)_2$

(2) KOH

(3) LiOH

(4) $Sr(OH)_2$

Correct Answer: (3) LiOH

Solution: Step 1: Understanding base strength in alkali and alkaline earth metals

- KOH is a strong alkali because potassium (K) is highly electropositive.

- $Ca(OH)_2$ and $Sr(OH)_2$ are alkaline earth metal hydroxides and have strong basic character due to high lattice energy and solubility in water.

- LiOH is the weakest base among them because:

- Li^+ has a high charge density, making it strongly hydrated in solution.

- This decreases the availability of OH^- ions, reducing basic strength.

Thus, the correct answer is option (3) LiOH.

Quick Tip

The basic strength of alkali metal hydroxides increases down the group, meaning LiOH is the weakest.

---

61. Which of the following oxides is not expected to react with sodium hydroxide?

(1) CaO

(2) SiO_2

(3) BeO

(4) B_2O_3

Correct Answer: (1) CaO

Solution:

Step 1: Understanding the nature of oxides

- CaO (Calcium Oxide) is a basic oxide and reacts with acids, but does not react with NaOH (a strong base).

- SiO_2 (Silicon Dioxide) is an acidic oxide and reacts with NaOH to form silicates.

- BeO (Beryllium Oxide) is amphoteric, meaning it reacts with both acids and bases.

- B_2O_3 (Boron Trioxide) is an acidic oxide and reacts with NaOH to form borates.

Since CaO does not react with NaOH, it is the correct answer.

Quick Tip

Basic oxides do not react with strong bases, while acidic and amphoteric oxides react with bases.

---

62. The basic structural unit of silicates is:

(1) SiO_3^{2-}

(2) SiO_4^{2-}

(3) SiO^{-}

(4) SiO_4^{4-}

Correct Answer: (4) SiO_4^{4-}

Solution:

Step 1: Understanding silicate structure

- Silicates are compounds containing silicon and oxygen, often found in minerals.

- The basic structural unit of silicates is the silicate tetrahedron SiO_4^{4-}, where a silicon atom is covalently bonded to four oxygen atoms.

- Different silicate structures arise from how these tetrahedral units link together.

Step 2: Examining the given options

- SiO_3^{2-} does not represent a fundamental unit but may exist in chain silicates.

- SiO_4^{2-} is incorrect as it does not carry the correct charge.

- SiO^{-} does not exist as a primary structural unit.

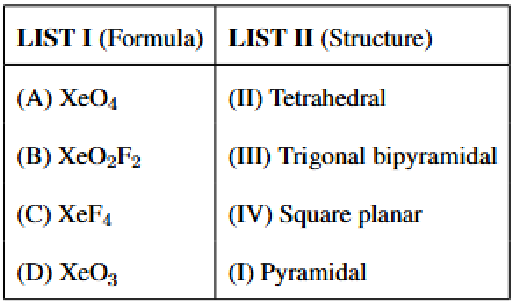
- SiO_4^{4-} is the correct answer, as it is the fundamental unit of silicate structures.

Quick Tip

Silicates are classified into various types (e.g., nesosilicates, inosilicates, phyllosilicates) based on how SiO_4^{4-} tetrahedral units are linked.

---

63. Match List I with List II and choose the correct answer from the options given below.



LIST I (Formula)	LIST II (Structure)
(A) XeO_4	(II) Tetrahedral
(B) XeO_2F_2	(III) Trigonal bipyramidal
(C) XeF_4	(IV) Square planar
(D) XeO_3	(I) Pyramidal

(1) (A) - (II), (B) - (III), (C) - (IV), (D) - (I)

(2) (A) - (III), (B) - (IV), (C) - (III), (D) - (I)

(3) (A) - (I), (B) - (III), (C) - (IV), (D) - (III)

(4) (A) - (I), (B) - (III), (C) - (IV), (D) - (II)

Correct Answer: (1) (A) - (II), (B) - (III), (C) - (IV), (D) - (I)

Solution:

Step 1: Understanding the molecular structures

- XeO_4 has a tetrahedral structure as xenon forms bonds with four oxygen atoms.
- XeO_2F_2 has a trigonal bipyramidal shape due to five bonding domains around xenon.
- XeF_4 has a square planar structure because xenon forms four bonds with fluorine and has two lone pairs.
- XeO_3 is pyramidal as it has three bonded oxygens and one lone pair.

Step 2: Matching with List II

- (A) - (II) (XeO_4 - Tetrahedral)
- (B) - (III) (XeO_2F_2 - Trigonal bipyramidal)
- (C) - (IV) (XeF_4 - Square planar)
- (D) - (I) (XeO_3 - Pyramidal)

Thus, the correct answer is option (1).

Quick Tip

Xenon compounds often exhibit expanded octets, leading to varied molecular geometries due to the presence of lone pairs.

---

64. Reaction of diborane with excess ammonia at low temperature gives initially:

(1) $B_2H_6 \cdot NH_3$

(2) Borazole

(3) $[BH_2(NH_3)_2]^+[BH_4]^-$

(4) $B_2N_4H_{10}$

Correct Answer: (3) $[BH_2(NH_3)_2]^+[BH_4]^-$

Solution:

Step 1: Understanding the reaction between diborane and ammonia

- Diborane (B_2H_6) reacts with excess ammonia at low temperatures to form an ammonia-borane complex. - The primary intermediate formed in this reaction is $[BH_2(NH_3)_2]^+[BH_4]^-$.

Step 2: Explanation of the options

- Option 1 ($B_2H_6 \cdot NH_3$): This is an adduct but not the main product at low temperatures. - Option 2 (Borazole): Formed at higher temperatures, not initially. - Option 3 ($[BH_2(NH_3)_2]^+[BH_4]^-$): Correct, as it is the first stable product. - Option 4 ($B_2N_4H_{10}$): Incorrect, as it does not form in this reaction.

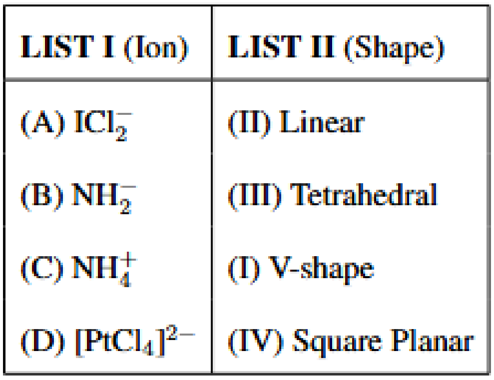
Thus, the correct answer is option (3).

Quick Tip

Diborane forms adducts with ammonia in a stepwise manner. The first major product at low temperatures is diborane diammoniate complex.

---

65. Match List I with List II and choose the correct answer from the options given below.



LIST I (Ion)	LIST II (Shape)
(A) ICl_2^-	(II) Linear
(B) NH_2^-	(III) Tetrahedral
(C) NH_4^+	(I) V-shape
(D) $[PtCl_4]^{2-}$	(IV) Square Planar

(1) (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

(2) (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

(3) (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

(4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (3) (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

Solution:

Step 1: Understanding molecular geometries

- ICl_2^- has a linear shape due to the presence of three lone pairs around iodine. - NH_2^- has a bent or V-shape due to the presence of lone pairs on nitrogen. - NH_4^+ is tetrahedral because nitrogen is bonded to four hydrogen atoms without lone pairs. - $[PtCl_4]^{2-}$ adopts a square planar shape, typical for d^8 metal complexes.

Step 2: Matching with List II

- (A) - (II) (ICl_2^- - Linear)
- (B) - (I) (NH_2^- - V-shape)
- (C) - (III) (NH_4^+ - Tetrahedral)
- (D) - (IV) ($[PtCl_4]^{2-}$ - Square Planar)

Thus, the correct answer is option (3).

Quick Tip

Lone pairs influence molecular geometry significantly. The Valence Shell Electron Pair Repulsion (VSEPR) theory helps predict the shape of molecules.

---

66. Which of the following species has the highest electron affinity?

(1) F^-

(2) Cl^-

(3) O^-

(4) Na^-

Correct Answer: (3) O^-

Solution: Electron affinity is the energy change when an atom gains an electron. Oxygen has the highest electron affinity among these species because of its smaller size and higher effective nuclear charge.

Quick Tip

Elements in group 16 generally have higher electron affinities than group 17 due to their electronic configuration.

---

67. Arrange the increasing order of charges (molar conductivity) of the compounds used in Werner coordination theory:

(A) $CoCl_3 \cdot 6NH_3$ (B) $CoCl_3 \cdot 5NH_3$ (C) $CoCl_3 \cdot 4NH_3$ (D) $CoCl_3 \cdot 3NH_3$

Choose the correct answer:

(1) (A), (B), (C), (D)

(2) (D), (C), (B), (A)

(3) (B), (A), (D), (C)

(4) (C), (B), (D), (A)

Correct Answer: (2) (D), (C), (B), (A)

Solution: The number of chloride ions available for dissociation determines molar conductivity. More dissociated chloride ions result in higher conductivity. As ligands replace chloride ions, molar conductivity decreases in the order given.

Quick Tip

In Werner's theory, primary valency corresponds to charge, while secondary valency is linked to coordination number.

---

68. What is the EAN (Effective Atomic Number) of $[Co(NH_3)_6]^{3+}$?

(1) 36

(2) 38

(3) 35

(4) 54

Correct Answer: (1) 36

Solution: EAN is calculated using the formula:

$$EAN = Z - O + 2C$$

where $Z = 27$ (atomic number of Co), $O = 3$ (oxidation state), and $C = 6$ (coordination number).

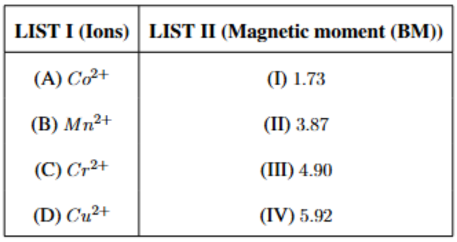
$$EAN = 27 - 3 + 2(6) = 36$$

Quick Tip

The EAN rule helps predict the stability of complexes, with values closer to noble gas configurations being more stable.

---

69. Match List I with List II:



LIST I (Ions)	LIST II (Magnetic moment (BM))
(A) Co^{2+}	(I) 1.73
(B) Mn^{2+}	(II) 3.87
(C) Cr^{2+}	(III) 4.90
(D) Cu^{2+}	(IV) 5.92

Choose the correct match:

(1) (A) - (II), (B) - (IV), (C) - (III), (D) - (I)

(2) (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

(3) (A) - (I), (B) - (II), (C) - (IV), (D) - (III)

(4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (1) (A) - (II), (B) - (IV), (C) - (III), (D) - (I)

Solution: Magnetic moment is calculated using:

$$\mu = \sqrt{n(n+2)}$$

where n is the number of unpaired electrons. Based on electronic configurations, the matches are correct.

Quick Tip

Higher unpaired electrons lead to stronger paramagnetism and greater magnetic moments.

---

70. Match List I with List II:

LIST I (Metal/Compounds)	LIST II (Catalytic Properties)
(A) $TiCl_3$	(I) Adams catalyst
(B) $FeSO_4$	(II) Repp synthesis
(C) $PtPrO$	(III) Used as Ziegler-Natta catalyst
(D) Ni	(IV) Used as Fenton's reagent

Choose the correct match:

(1) (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

(2) (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

(3) (A) - (I), (B) - (III), (C) - (IV), (D) - (II)

(4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Solution: Each metal/compound is correctly paired with its catalytic function. Ziegler-Natta catalysts are crucial in polymerization reactions, while Adams and Fenton's catalysts are used in different oxidation processes.

Quick Tip

Catalysts lower activation energy and speed up reactions without being consumed.

---

71. Europium(Eu) resembles Calcium(Ca) in the following ways:

(A). Both are diamagnetic

(B). Insolubility of their sulphates and carbonates in water

(C). Solubility of these metals in liquid NH_3

(D). Insolubility of their dichlorides in strong HCl

(1) (A). (B) and (D) only.

(2) (A). (B) and (C) only.

(3) (A). (B). (C) and (D).

(4) (B). (C) and (D) only.

Correct Answer: (1) (A). (B) and (D) only.

Solution: The correct answer is option (1) because Europium (Eu) and Calcium (Ca) both share similarities in terms of their diamagnetism, insolubility of their sulphates and carbonates in water, and the insolubility of their dichlorides in strong HCl. However, the solubility of these metals in liquid NH_3 is not a characteristic shared by both.

Quick Tip

When comparing the properties of elements, carefully examine the specific characteristics like solubility, magnetic properties, and behavior in different solvents to determine similarities.

---

72. The Lanthanide contraction from Ce to Lu is:

(1) 0.20 Å
(2) 0.10 Å
(3) 0.30 Å
(4) 0.25 Å

Correct Answer: (1) 0.20 Å

Solution: The lanthanide contraction refers to the gradual decrease in the ionic radii of the lanthanide series elements from cerium (Ce) to lutetium (Lu). The magnitude of this contraction is approximately 0.20 Å. This is due to the poor shielding effect of the f-electrons, which causes the effective nuclear charge to increase across the series, thereby reducing the size of the ions.

Quick Tip

The lanthanide contraction is an important concept in understanding the periodic trends in the lanthanide series, particularly the decrease in ionic radii as the atomic number increases.

---

73. Mg-ATP complex is a substrate for:

(1) Kinase
(2) Catalase
(3) Helicase
(4) Hydrolyses

Correct Answer: (1) Kinase

Solution: The Mg-ATP complex is a well-known substrate for kinases. Kinases are enzymes that catalyze the transfer of phosphate groups from ATP to other molecules, which is crucial for various cellular processes. The other options—catalase, helicase, and hydrolyses—are involved in different biochemical reactions and do not utilize the Mg-ATP complex as a substrate.

Quick Tip

Remember that kinases typically use ATP as a phosphate donor for phosphorylation reactions, whereas other enzymes like helicases and catalases serve different roles in the cell.

---

74. What is the oxidation state of Pd in [Pd(OAC)$_2$]?

(1) 0
(2) 1
(3) 2
(4) 3

Correct Answer: (3) 2

Solution: In the complex [Pd(OAC)$_2$], each acetate ion (OAC) has a charge of -1, and there are two such ions. Let the oxidation state of Pd be x. Since the overall charge of the complex is neutral, we have the following equation:

$$x + 2(-1) = 0 \quad \Rightarrow \quad x - 2 = 0 \quad \Rightarrow \quad x = 2.$$

Thus, the oxidation state of Pd is 2.

Quick Tip

To determine the oxidation state of a metal in a complex, use the charges of the ligands and balance the equation for the total charge of the complex.

---

75. Cytochrome C is a/an:

(1) Electron donor
(2) Electron acceptor
(3) Neutral
(4) Negatively charged

Correct Answer: (2) Electron acceptor

Solution: Cytochrome C is an electron acceptor in the electron transport chain. It functions by accepting electrons during cellular respiration and then transferring them to other components, such as oxygen in the final step of the electron transport chain. This process is crucial for energy production in cells.

Quick Tip

Cytochrome C plays a key role in the electron transport chain, where it functions as an electron carrier, helping to generate ATP by transferring electrons to oxygen.
