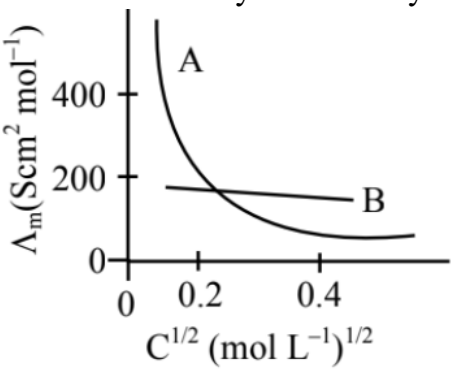
1 Chemistry

Question 1.
The molar conductivity for electrolytes A and B are plotted against $C^{1/2}$ as shown below.



Electrolytes A and B respectively are:

	A	B
(1)	Weak electrolyte	Weak electrolyte
(2)	Strong electrolyte	Strong electrolyte
(3)	Weak electrolyte	Strong electrolyte
(4)	Strong electrolyte	Weak electrolyte

Correct Answer: (3)
Solution:

Explanation: - The graph shows the variation of molar conductivity (Λ_m) with $C^{1/2}$, the square root of concentration: 1. Electrolyte A: The molar conductivity of A increases steeply as $C^{1/2}$ approaches 0, indicating A is a **weak electrolyte**. For weak electrolytes, the molar conductivity increases significantly with dilution due to ionization. 2. Electrolyte B: The molar conductivity of B remains relatively constant with $C^{1/2}$, indicating B is a **strong electrolyte**. For strong electrolytes, the variation of molar conductivity with concentration is minimal.
Therefore:

$$\text{Electrolyte A} \rightarrow \text{Weak electrolyte}, \quad \text{Electrolyte B} \rightarrow \text{Strong electrolyte}.$$

Final Answer: (3).

> Quick Tip
>
> 1. Weak electrolytes: Show significant variation of molar conductivity with concentration due to partial ionization. 2. Strong electrolytes: Exhibit almost constant molar conductivity, as they are completely ionized at all concentrations. 3. Analyze the behavior of molar conductivity (Λ_m) at low concentration ($C^{1/2} \rightarrow 0$) to distinguish the type of electrolyte.

Question 2.
Methods used for purification of organic compounds are based on:

1. neither on nature of compound nor on the impurity present.
2. nature of compound only.
3. nature of compound and presence of impurity.
4. presence of impurity only.

Correct Answer: (3)
Solution:

Organic compounds are purified based on:

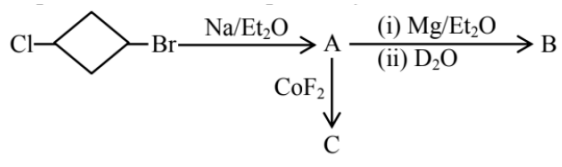
- The **nature of the compound** (e.g., solubility, boiling/melting point, volatility, etc.).
- The **nature of the impurity** present (e.g., soluble or insoluble, volatile or non-volatile, etc.).

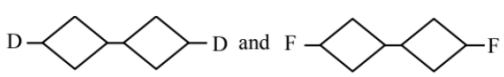
Thus, purification methods such as crystallization, distillation, chromatography, and sublimation are chosen based on the combination of the compound's properties and the impurities involved.
Final Answer: (3).

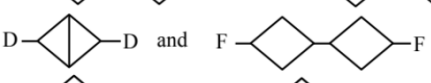
Quick Tip

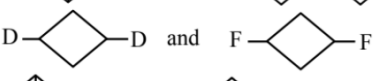
1. Understand the **properties of the organic compound** (e.g., polarity, solubility) for selecting the purification method. 2. Analyze the **nature of impurities** to determine the appropriate technique (e.g., filtration for insoluble impurities, distillation for volatile ones). 3. Common purification methods: - Crystallization: Based on solubility differences. - Distillation: Based on boiling points. - Chromatography: Based on adsorption and partition. - Sublimation: For sublimable compounds.

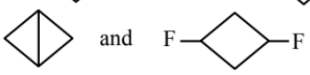
Question 3.
In the following sequence of reaction, the major products B and C respectively are:



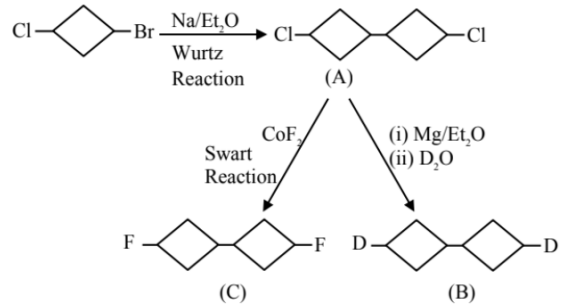
(1) 

(2) 

(3) 

(4) 

Correct Answer: (1)
Solution:



Final Answer: (1).

> Quick Tip
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> 1. Wurtz Reaction: Sodium in dry ether is used to couple alkyl halides, leading to symmetrical alkanes. 2. Grignard Reagent: Formed by reacting alkyl halides with magnesium in ether. Reaction with D_2O replaces the halide with deuterium. 3. Fluorination: CoF_2 catalyzes the introduction of fluorine atoms in place of hydrogen atoms. 4. Follow the sequence of reactions systematically to predict intermediates and products.

Question 4.

The correct order of basic strength of Pyrrole  Pyridine  , and Piperidine  is:

1. Piperidine > Pyridine > Pyrrole
2. Pyrrole > Pyridine > Piperidine
3. Pyridine > Piperidine > Pyrrole
4. Pyrrole > Piperidine > Pyridine

Correct Answer: (1)
Solution:

Explanation: The basicity of a compound depends on the availability of the lone pair of electrons on nitrogen for protonation. The order of basic strength is:

$\mathrm{N}(\mathrm{sp}^3, \text{localized lone pair}) > \mathrm{N}(\mathrm{sp}^2, \text{localized lone pair}) > \mathrm{N}(\mathrm{sp}^2, \text{delocalized lone pair, aromatic})$.

1. Piperidine: Contains an sp^3-hybridized nitrogen atom with a localized lone pair, making it the strongest base.
2. Pyridine: Contains an sp^2-hybridized nitrogen atom with a localized lone pair, making it moderately basic.

3. Pyrrole: Contains an sp^2-hybridized nitrogen atom with a delocalized lone pair due to its involvement in the aromatic ring, making it the least basic.
Thus, the order of basic strength is:

$$\text{Piperidine} > \text{Pyridine} > \text{Pyrrole}.$$

Final Answer: (1).

Quick Tip

1. Basicity and Hybridization: - Nitrogen with sp^3 hybridization has the highest basicity due to a localized lone pair. - sp^2-hybridized nitrogen has lower basicity due to reduced electron availability. - Delocalization of lone pairs (as in aromatic systems) further reduces basicity. 2. Aromaticity in Pyrrole: The lone pair on nitrogen contributes to the aromaticity, making it less available for protonation. 3. Memorize the order: Piperidine $>$ Pyridine $>$ Pyrrole.

Question 5.
In which one of the following pairs do the central atoms exhibit sp^2 hybridization?

1. BF_3 and NO_2^-
2. NH_2^- and H_2O
3. H_2O and NO_2
4. NH_2^- and BF_3

Correct Answer: (1)
Solution:

Explanation: 1. BF_3: The central atom, boron, forms three sigma bonds with fluorine and has no lone pairs. It undergoes sp^2 hybridization.
2. NO_2^-: The nitrogen atom has three regions of electron density (two sigma bonds and one lone pair). This corresponds to sp^2 hybridization.
3. H_2O: The central atom, oxygen, has two sigma bonds and two lone pairs, corresponding to sp^3 hybridization.
4. NH_2^-: The nitrogen atom forms two sigma bonds and has two lone pairs, corresponding to sp^3 hybridization.
Thus, only BF_3 and NO_2^- exhibit sp^2 hybridization.
Final Answer: (1).

Quick Tip

1. Hybridization Rule: Count the number of sigma bonds and lone pairs around the central atom: - sp: 2 regions of electron density.
- sp^2: 3 regions of electron density.
- sp^3: 4 regions of electron density.
2. Examples:
- $\mathrm{BF_3}$: 3 sigma bonds, no lone pairs $\rightarrow \mathrm{sp}^2$.
- $\mathrm{NO_2^-}$: 2 sigma bonds, 1 lone pair $\rightarrow \mathrm{sp}^2$.
- $\mathrm{H_2O}$: 2 sigma bonds, 2 lone pairs $\rightarrow \mathrm{sp}^3$.
- $\mathrm{NH_2^-}$: 2 sigma bonds, 2 lone pairs $\rightarrow \mathrm{sp}^3$.
3. Shortcut: For planar molecules or ions, suspect sp^2 hybridization.

Question 6.
The $\mathrm{F^-}$ ions make the enamel on teeth much harder by converting hydroxyapatite (the enamel on the surface of teeth) into much harder fluoroapatite having the formula:

1. $[3(\mathrm{Ca_3(PO_4)_2 \cdot CaF_2})]$
2. $[3(\mathrm{Ca_2(PO_4)_2 \cdot Ca(OH)_2})]$
3. $[3(\mathrm{Ca_3(PO_4)_3 \cdot CaF_2})]$
4. $[3(\mathrm{Ca_3(PO_4)_2 \cdot Ca(OH)_2})]$

Correct Answer: (1)
Solution:

Explanation: - Hydroxyapatite, $[\mathrm{Ca_5(PO_4)_3(OH)}]$, is present in tooth enamel. - When fluoride ions ($\mathrm{F^-}$) are introduced, they replace the hydroxide ions ($\mathrm{OH^-}$), forming fluoroapatite:

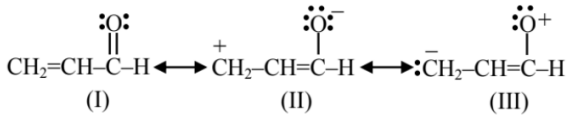
$$\mathrm{Ca_5(PO_4)_3(OH) + F^- \rightarrow Ca_5(PO_4)_3F}.$$

- Fluoroapatite has the molecular formula $[3(\mathrm{Ca_3(PO_4)_2 \cdot CaF_2})]$, which is harder and more resistant to decay.
Final Answer: $(\mathbf{1})$.

Quick Tip

1. Tooth Chemistry: - Hydroxyapatite: $[\mathrm{Ca_5(PO_4)_3(OH)}]$ is the primary component of tooth enamel. - Fluoroapatite: $[\mathrm{Ca_5(PO_4)_3F}]$ is formed when fluoride replaces $\mathrm{OH^-}$. 2. Hardness Increase: - Fluoroapatite is more stable and less soluble in acidic environments compared to hydroxyapatite, providing resistance to cavities. 3. Shortcut: - Remember the role of fluoride ($\mathrm{F^-}$) in strengthening teeth by forming fluoroapatite.

Question 7.
The relative stability of the contributing structures is:



1. (I) > (III) > (II)
2. (I) > (II) > (III)
3. (II) > (I) > (III)
4. (III) > (II) > (I)

Correct Answer: (2)
Solution:

Explanation: 1. Neutral structures are more stable than charged ones. Therefore, structure (I) is the most stable as it is neutral.
2. Among the charged structures, a positive charge (+) on a less electronegative atom (like carbon) is more stable than a positive charge on a more electronegative atom (like oxygen).
- Hence, structure (II), where C^+ is present, is more stable than (III), where O^+ is present.

$$\text{Order: } I > II > III.$$

Final Answer: (2).

Quick Tip

1. Neutrality Rule: Neutral resonance structures are always more stable than charged ones. 2. Electronegativity Consideration: Positive charges are more stable on less electronegative atoms. 3. Resonance Priority: Analyze the charge distribution and electronegativity to rank resonance structures effectively.

Question 8.
Given below are two statements:

Statement (I): The oxidation state of an element in a particular compound is the charge acquired by its atom on the basis of electron gain enthalpy consideration from other atoms in the molecule.
Statement (II): $p\pi - p\pi$ bond formation is more prevalent in second period elements over other periods.

In the light of the above statements, choose the **most appropriate** answer from the options given below:

1. Both **Statement I** and **Statement II** are incorrect.

2. **Statement I** is correct but **Statement II** is incorrect.
3. Both **Statement I** and **Statement II** are correct.
4. **Statement I** is incorrect but **Statement II** is correct.

Correct Answer: (4)
Solution:

Explanation: 1. Statement (I): Incorrect. - The oxidation state of an element is not determined based on electron gain enthalpy. Instead, it is based on the number of electrons lost, gained, or shared during bond formation.
2. Statement (II): Correct. - $p\pi - p\pi$ bond formation is more common in second-period elements (e.g., C, N, O) due to their small size and effective overlap of p-orbitals, which diminishes in larger elements from lower periods.
Final Answer: (4).

Quick Tip

1. Oxidation state is based on electron transfer/sharing in bonds, not electron gain enthalpy. 2. $p\pi - p\pi$ bonding is significant in smaller atoms like second-period elements due to their ability to form effective orbital overlaps. 3. For conceptual questions, analyze definitions and atomic properties carefully.

Question 9.
Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**:

Assertion (A): S_N2 reaction of $C_6H_5CH_2Br$ occurs more readily than the S_N2 reaction of CH_3CH_2Br.
Reason (R): The partially bonded unhybridized p-orbital that develops in the trigonal bipyramidal transition state is stabilized by conjugation with the phenyl ring.

In the light of the above statements, choose the **most appropriate** answer from the options given below:

1. (A) is not correct but (R) is correct.
2. Both (A) and (R) are correct but (R) is not the correct explanation of (A).
3. Both (A) and (R) are correct and (R) is the correct explanation of (A).
4. (A) is correct but (R) is not correct.

Correct Answer: (3)
Solution:

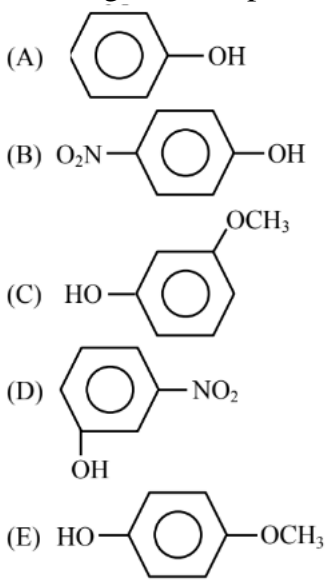
Explanation: 1. Assertion (A): Correct. - In $C_6H_5CH_2Br$, the CH_2-Br bond is connected to a benzyl group. The phenyl ring allows for stabilization of the transition state via

resonance, facilitating the S_N2 reaction. This makes the reaction proceed more readily compared to CH_3CH_2Br, where no such stabilization exists.
2. Reason (R): Correct. - The unhybridized p-orbital formed during the trigonal bipyramidal transition state interacts with the conjugated system of the phenyl ring, providing extra stabilization.
3. Conclusion: Both (A) and (R) are correct, and (R) is the correct explanation for (A).
Final Answer: (3).

Quick Tip

1. In S_N2 reactions, consider the factors stabilizing the transition state (e.g., resonance, inductive effects). 2. Resonance stabilization, such as in benzyl halides, enhances reaction rates. 3. For assertion-reason questions, ensure that the reason directly explains the assertion logically and scientifically.

Question 10.
For the given compounds, the correct order of increasing pK_a value is:



1. (E) < (D) < (C) < (B) < (A)
2. (D) < (E) < (C) < (B) < (A)
3. (E) < (D) < (B) < (A) < (C)
4. (B) < (D) < (A) < (C) < (E)

Correct Answer: BONUS (Originally: 4)

Solution:

Explanation:
1. Definition of pK_a: Lower pK_a corresponds to a stronger acid.

2. Factors affecting pK_a:
- Electron-withdrawing groups (EWG) increase acidity by stabilizing the conjugate base.
- Electron-donating groups (EDG) decrease acidity by destabilizing the conjugate base.
3. Order Analysis:
- (D) Dinitrophenol: Strongest acid due to two nitro (EWG) groups stabilizing the phenoxide ion.
- (B) Nitrophenol: Less acidic than (D), but still acidic due to one nitro group. - (A) Phenol: Less acidic than (B) due to the absence of strong EWGs.
- (C) Methoxyphenol: The methoxy group (EDG) destabilizes the phenoxide ion, making it less acidic than phenol.
- (E) Methoxy-dinitrophenol: The methoxy group reduces the effect of the nitro groups, making it less acidic than dinitrophenol but more acidic than phenol.

4. Final Order:

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

Final Answer: BONUS.

Quick Tip

1. Compare the number and position of electron-withdrawing and electron-donating groups to determine acidity. 2. Strong acids have lower pK_a values. 3. Nitro groups significantly enhance acidity, while methoxy groups reduce it.

Question 11.
Assertion (A): Both rhombic and monoclinic sulphur exist as S_8, while oxygen exists as O_2.
Reason (R): Oxygen forms $p\pi$-$p\pi$ multiple bonds with itself and other elements having small size and high electronegativity like C, N, which is not possible for sulphur.

In the light of the above statements, choose the **most appropriate answer** from the options given below:

1. Both (A) and (R) are correct and (R) is the correct explanation of (A).
2. Both (A) and (R) are correct but (R) is not the correct explanation of (A).
3. (A) is correct but (R) is not correct.
4. (A) is not correct but (R) is correct.

Correct Answer: (3)
Solution:

- Assertion (A) is correct because sulphur exists as S_8 due to its ability to form crown-shaped structures. Oxygen exists as O_2 due to its smaller size and ability to form $p\pi$-$p\pi$ bonds.

- Reason (R) is incorrect because sulphur's inability to form $p\pi$-$p\pi$ bonds is due to its larger size, which prevents effective overlap of orbitals.
- Thus, (A) is correct, but (R) is not the correct reason for (A).

Quick Tip

1. Recognize that S_8 is a stable allotrope of sulphur, while oxygen prefers O_2 due to its double bond. 2. Larger atomic size limits the ability of sulphur to form $p\pi$-$p\pi$ bonds. 3. Understand that high electronegativity and small size are key factors in forming $p\pi$-$p\pi$ bonds.

Question 12.
Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**.
Assertion (A): The total number of geometrical isomers shown by $[Co(en)_2Cl_2]^+$ complex ion is three.
Reason (R): $[Co(en)_2Cl_2]^+$ complex ion has an octahedral geometry.

In the light of the above statements, choose the most appropriate answer from the options given below:

1. Both (A) and (R) are correct and (R) is the correct explanation of (A).
2. (A) is correct but (R) is not correct.
3. (A) is not correct but (R) is correct.
4. Both (A) and (R) are correct but (R) is not the correct explanation of (A).

Answer: (3)

Solution:
The complex ion $[Co(en)_2Cl_2]^+$ has an octahedral geometry. However, it shows only two geometrical isomers:

- **Cis-isomer:** Both chloride ligands are adjacent to each other.
- **Trans-isomer:** Chloride ligands are opposite to each other.

This refutes the assertion that it shows three geometrical isomers. Thus, **(A)** is incorrect. However, the reason **(R)** stating that the complex has an octahedral geometry is true.

Final Answer: (3) (A) is not correct but (R) is correct.

Quick Tip

For octahedral complexes, the number of geometrical isomers depends on the arrangement of ligands. Check symmetry and coordination numbers carefully.

Question 13.
The electronic configuration of Cu(II) is $3d^9$, whereas that of Cu(I) is $3d^{10}$. Which of the following is correct?

1. Cu(II) is less stable.
2. Stability of Cu(I) and Cu(II) depends on the nature of copper salts.
3. Cu(II) is more stable.
4. Cu(I) and Cu(II) are equally stable.

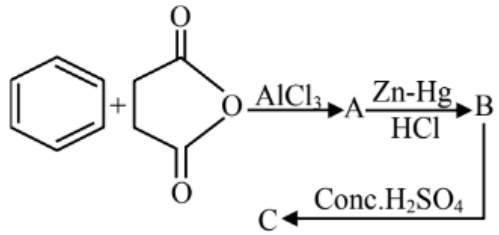
Correct Answer: (3)
Solution:

- The stability of Cu(II) arises because it has a partially filled d-subshell ($3d^9$), which allows it to participate in ligand bonding and form complexes more effectively.
- Cu(I) with $3d^{10}$ is more stable in certain cases due to the completely filled d-subshell, but Cu(II) is generally more stable in aqueous solutions.
- The higher stability of Cu(II) over Cu(I) in aqueous medium is attributed to the higher hydration enthalpy of Cu(II) ions.

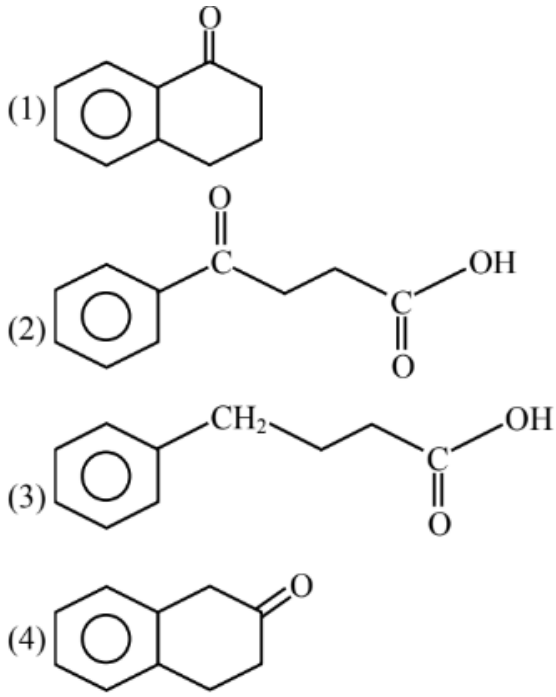
Quick Tip

1. Stability of oxidation states depends on electronic configuration, hydration enthalpy, and ligand interactions. 2. Cu(II) is favored in aqueous media due to its higher hydration energy compared to Cu(I). 3. Partially filled d-orbitals in Cu(II) contribute to stronger ligand bonding in complexes.

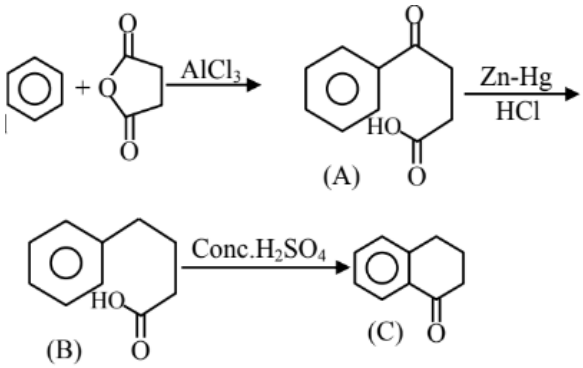
Question 14.



What is the structure of C?



Correct Answer: 1
Solution:



Quick Tip

1. Recognize the key reactions: - Friedel-Crafts acylation for aromatic ketones or anhydrides. - Clemmensen reduction to reduce carbonyl groups to methylene. - Sulfonation as an electrophilic substitution reaction. 2. Analyze stepwise changes in the functional groups of the compound. 3. Sulfonation occurs preferentially at the para position when steric hindrance is absent.

Question 15.
Compare the energies of the following sets of quantum numbers for a multielectron system:

- (A) $n = 4, l = 1$
- (B) $n = 4, l = 2$

- (C) $n = 3, l = 1$
- (D) $n = 3, l = 2$
- (E) $n = 4, l = 0$

Choose the correct order of energies:

1. (B) > (A) > (C) > (E) > (D)
2. (E) > (C) < (D) < (A) < (B)
3. (E) > (C) > (A) > (D) > (B)
4. (C) < (E) < (D) < (A) < (B)

Correct Answer: (4)

Solution:
In multielectron systems, the energy of an electron in an orbital depends on both the principal quantum number (n) and the azimuthal quantum number (l). The energy increases as the value of $n + l$ increases. For orbitals with the same $n + l$, the one with the lower n has lower energy.

(A) $n + l = 4 + 1 = 5$
(B) $n + l = 4 + 2 = 6$
(C) $n + l = 3 + 1 = 4$
(D) $n + l = 3 + 2 = 5$
(E) $n + l = 4 + 0 = 4$

Order by $n + l$:

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

For orbitals with the same $n + l$, compare n:

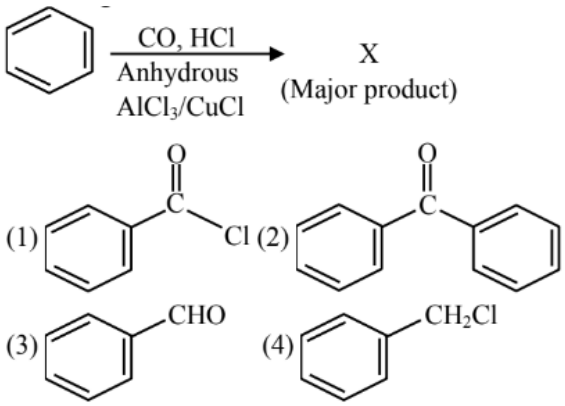
$$(C) < (E), \text{ as } n = 3 \text{ for (C) and } n = 4 \text{ for (E).}$$

Final Order: $(C) < (E) < (D) < (A) < (B)$.
Final Answer: (4)

Quick Tip

1. For multielectron systems, energy depends on $n + l$ (higher $n + l$, higher energy). 2. For equal $n + l$, lower n corresponds to lower energy. 3. Always calculate $n + l$ values for comparison. 4. Pay close attention to the principal quantum number (n) when $n + l$ is the same.

Question 16.
Identify the major product "X" formed in the following reaction:



Correct Answer: (3)
Solution:

The reaction is the **Gattermann–Koch reaction**, which involves the formylation of benzene to produce benzaldehyde (C_6H_5CHO). In the presence of carbon monoxide (CO), hydrogen chloride (HCl), and anhydrous $AlCl_3/CuCl$, the formyl group (CHO) is introduced into the benzene ring.

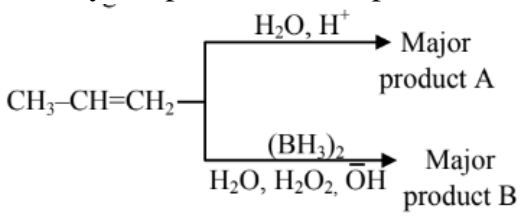
$$C_6H_6 + CO + HCl \xrightarrow{AlCl_3/CuCl} C_6H_5CHO$$

Thus, the major product X is benzaldehyde (3).
Final Answer: (3)

Quick Tip

1. The Gattermann–Koch reaction is used to introduce a formyl group (CHO) into an aromatic ring. 2. Requires CO, HCl, and $AlCl_3/CuCl$ as catalysts. 3. Useful for synthesizing benzaldehyde derivatives. 4. Ensure to differentiate between CHO, COOH, and C=O functionalities based on the reaction conditions.

Question 17.
Identify the product A and product B in the following set of reactions:



(1) A-$CH_3CH_2CH_2$–OH, B-$CH_3CH_2CH_2$–OH
(2) A-$CH_3CH_2CH_2$–OH, B-$CH_3\underset{\underset{OH}{|}}{CH}–CH_3$
(3) A- $CH_3–\underset{\underset{OH}{|}}{CH}–CH_3$, B-$CH_3CH_2CH_2$–OH
(4) A-$CH_3CH_2CH_3$, B-$CH_3CH_2CH_3$

Correct Answer: (3)
Solution:

(1) Hydration Reaction :

$$CH_3-CH=CH_2+H^+ \longrightarrow \underset{\text{(More stable)}}{CH_3-\overset{+}{C}H-CH_3}$$

$$CH_3-\overset{+}{C}H-CH_3 + H_2O \longrightarrow \underset{\underset{OH}{|}}{(CH_3-CH-CH_3)} + H^+$$
(A)

(2) Hydroboration Oxidation Reaction :

$$3CH_3-CH=CH_2 + B_2H_6 \xrightarrow{THF}$$
$$2(CH_3CH_2CH_2)_3B$$
$$(CH_3CH_2CH_2)_3B + 3H_2O_2 \xrightarrow{OH^-}$$
$$\underset{(B)}{3CH_3CH_2CH_2OH} + H_3BO_3$$

Final Answer: (3)

> Quick Tip
>
> 1. Markovnikov's Rule: In acid-catalyzed hydration, the hydroxyl group attaches to the more substituted carbon atom. 2. Anti-Markovnikov's Rule: In hydroboration-oxidation, the hydroxyl group attaches to the less substituted carbon atom. 3. Understand regioselectivity for reactions involving alkenes to predict products accurately. 4. Hydroboration-oxidation is a syn-addition process, but in this context, we are only concerned about regioselectivity.

Question 18.
On reaction of Lead Sulphide with dilute nitric acid which of the following is **not** formed?

1. Lead nitrate
2. Sulphur
3. Nitric oxide
4. Nitrous oxide

Correct Answer: (4)
Solution:

The reaction between Lead Sulphide (PbS) and dilute nitric acid (HNO_3) proceeds as follows:

$$PbS + 2HNO_3 \rightarrow Pb(NO_3)_2 + NO + S + H_2O.$$

Key Points:
1. The products of this reaction are:
- Lead nitrate ($Pb(NO_3)_2$) – a soluble salt.
- Nitric oxide (NO) – a gaseous product.
- Sulphur (S) – a precipitate.
- Water (H_2O).
2. Nitrous oxide (N_2O) is **not** formed during this reaction.

Final Answer: (4)

Quick Tip

1. Reactions of sulphides with acids often produce free sulphur and other gaseous products. 2. Dilute nitric acid typically produces NO, not N_2O, in redox reactions. 3. Be familiar with products of reactions involving sulphides and acids to answer such questions.

Question 19.
Identify the **incorrect** statements regarding the primary standard of titrimetric analysis:
(A) It should be purely available in dry form.
(B) It should not undergo chemical change in air.
(C) It should be hygroscopic and should react with another chemical instantaneously and stoichiometrically.
(D) It should be readily soluble in water.
(E) $KMnO_4$ and NaOH can be used as primary standards.

Choose the correct answer from the options given below:

1. (C) and (D) only
2. (B) and (E) only
3. (A) and (B) only
4. (C) and (E) only

Correct Answer: (4)
Solution:

A primary standard substance used in titrimetric analysis must satisfy the following criteria: 1. It should be available in **pure** and **dry form**. 2. It must not be hygroscopic (i.e., it should not absorb moisture) or undergo any chemical change in air. 3. It should be **readily soluble** in water. 4. $KMnO_4$ and NaOH are **not** suitable as primary standards

due to their hygroscopic nature and tendency to absorb CO_2 from air, making them impure.
Incorrect Statements:

- **(C):** The substance **should not be hygroscopic**. Hence, this statement is incorrect.
- **(E):** Both $KMnO_4$ and NaOH are unsuitable as primary standards. This statement is also incorrect.

Final Answer: (4)

Quick Tip

1. A primary standard must be chemically pure, stable, and non-hygroscopic.
2. It should not absorb moisture or CO_2 from the air. 3. Substances like NaOH and $KMnO_4$ are **secondary standards** due to their instability.

Question 20.
0.05M $CuSO_4$ when treated with 0.01M $K_2Cr_2O_7$ gives a green-colored solution of $Cu_2Cr_2O_7$.
[SPM: Semi-Permeable Membrane]

$K_2Cr_2O_7$	$CuSO_4$

Side X SPM Side Y

Due to osmosis:

1. Green color formation observed on side Y.
2. Green color formation observed on side X.
3. Molarity of $K_2Cr_2O_7$ solution is lowered.
4. Molarity of $CuSO_4$ solution is lowered.

Correct Answer: (4)
Solution:

Due to osmosis, the solvent molecules from side Y ($CuSO_4$) diffuse across the semi-permeable membrane (SPM) into side X ($K_2Cr_2O_7$). This dilution effect causes the molarity of the $CuSO_4$ solution (side Y) to decrease over time.
- $CuSO_4$ reacts with $K_2Cr_2O_7$, forming $Cu_2Cr_2O_7$, which is responsible for the green color. - The green color is observed due to the formation of $Cu_2Cr_2O_7$, but the key change is in the molarity of the $CuSO_4$ solution on side Y, which decreases as the solvent diffuses.
Final Answer: (4)

Quick Tip

1. Osmosis causes solvent movement from lower to higher solute concentration through an SPM. 2. Chemical reactions involving diffusion across SPM change molarity on either side. 3. For $CuSO_4$, molarity decreases on side Y as solvent moves to side X. 4. Always analyze solvent flow and its impact on molarity for osmosis-related reactions.

Question 21.
The heat of solution of anhydrous $CuSO_4$ and $CuSO_4 \cdot 5H_2O$ are $-70\,\text{kJ mol}^{-1}$ and $+12\,\text{kJ mol}^{-1}$, respectively.
The heat of hydration of $CuSO_4$ to $CuSO_4 \cdot 5H_2O$ is $-x\,\text{kJ}$. The value of x is .....

Correct Answer: (82)
Solution:

The heat of hydration of $CuSO_4$ to $CuSO_4 \cdot 5H_2O$ is given by the difference between the heat of solution of anhydrous $CuSO_4$ and $CuSO_4 \cdot 5H_2O$.

Heat of hydration = Heat of solution of anhydrous $CuSO_4$−Heat of solution of $CuSO_4 \cdot 5H_2O$.

Substitute the values:

$$x = \left|-70\,\text{kJ mol}^{-1} - (+12\,\text{kJ mol}^{-1})\right|.$$

$$x = |-70 - 12| = |-82| = 82.$$

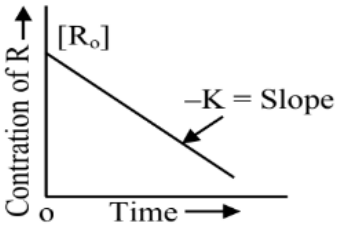
Final Answer: $82\,\text{kJ}$.

Quick Tip

1. The heat of hydration is calculated by subtracting the heat of solution of the hydrated salt from the anhydrous salt. 2. Always account for the signs of the heat values when performing the calculation. 3. Ensure the correct absolute value is taken for the final result. 4. Review the definitions of heat of solution and hydration for clarity in solving similar problems.

Question 22.
Statement I:
The rate law for the reaction $A + B \rightarrow C$ is rate $(r) = k[A]^2[B]$. When the concentration of both A and B is doubled, the reaction rate is increased "x" times.

Statement II:



The figure shows the variation in concentration against time (t) for a "y" order reaction. The value of $x + y$ is .....

Correct Answer: (8)
Solution:

Step 1: Analyze Statement I The rate law is:

$$r = k[A]^2[B].$$

When the concentrations of A and B are doubled:

$$r' = k[2A]^2[2B] = k(2^2)[A]^2(2)[B].$$

$$r' = 8\,k[A]^2[B].$$

Thus, $r' = 8r$, so $x = 8$.
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Step 2: Analyze Statement II From the figure, the concentration decreases linearly with time. A linear decrease in concentration indicates a zero-order reaction ($y = 0$).
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Final Step: Calculate $x + y$

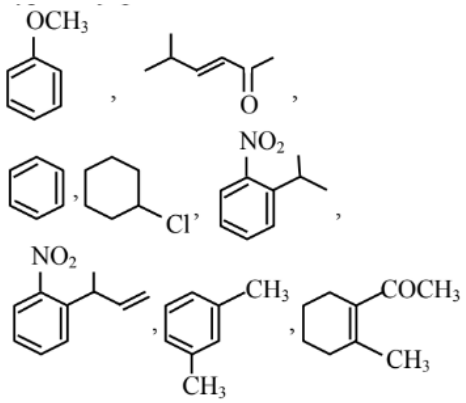
$$x + y = 8 + 0 = 8.$$

Final Answer: 8.

Quick Tip

1. For rate law questions, substitute doubled concentrations into the rate expression to calculate the change in rate. 2. A linear concentration-time graph corresponds to a zero-order reaction. 3. Understand how the order of a reaction affects its graphical representation. 4. Sum contributions from individual statements to get the final result.

Question 23.
How many compounds among the following compounds show inductive, mesomeric, as well as hyperconjugation effects?



Correct Answer: (4)
Solution:

Step 1: Analyze each compound - Compound 1 ($-OCH_3$ group attached): The $-OCH_3$ group exhibits both inductive ($-I$) and mesomeric ($+M$) effects. However, hyperconjugation is not applicable here. Not included.
- Compound 2 (Alkene with $-CH_3$): The $-CH_3$ group shows inductive ($+I$) and hyperconjugation effects due to the presence of alpha hydrogens. Mesomeric effect is not present. Not included.
- Compound 3 ($-NO_2$ group): The $-NO_2$ group exhibits both $-I$ (inductive) and $-M$ (mesomeric) effects but does not participate in hyperconjugation. Not included.
- Compound 4 ($-Cl'$ group): The $-Cl'$ group shows $-I$ (inductive) and $+M$ (mesomeric) effects, but no hyperconjugation. Not included.
- Compound 5 ($-NO_2$ group): Similar to Compound 3, exhibits inductive and mesomeric effects but not hyperconjugation. Not included.
- Compound 6 ($-CH_3$ groups attached to a benzene ring): The $-CH_3$ groups exhibit inductive ($+I$) effects and hyperconjugation due to alpha hydrogens. Mesomeric effect is also observed with the aromatic ring. Included.
- Compound 7 ($-COCH_3$ group): The $-COCH_3$ group exhibits inductive ($-I$) and mesomeric ($-M$) effects. However, no hyperconjugation is observed. Not included.

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Step 2: Final Count From the analysis, only 4 compounds exhibit all three effects: inductive, mesomeric, and hyperconjugation.
Final Answer: 4.

Quick Tip

1. Identify inductive effects ($+I$ or $-I$) based on the electron-withdrawing or donating nature of the group. 2. Mesomeric effects ($+M$ or $-M$) occur due to resonance involving lone pairs or conjugated systems. 3. Hyperconjugation requires the presence of alpha hydrogens adjacent to a double bond or aromatic ring. 4. Analyze each compound individually for all three effects before counting.

Question 24.
The standard reduction potentials at 298 K for the following half-cells are given below:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O,\ E^\circ = 1.33\,V$$

$$Fe^{3+}(aq) + 3e^- \rightarrow Fe,\ E^\circ = -0.04\,V$$

$$Ni^{2+}(aq) + 2e^- \rightarrow Ni,\ E^\circ = -0.25\,V$$

$$Ag^+(aq) + e^- \rightarrow Ag,\ E^\circ = 0.80\,V$$

$$Au^{3+}(aq) + 3e^- \rightarrow Au,\ E^\circ = 1.40\,V$$

Consider the given electrochemical reactions. The number of metal(s) which will be oxidized by $Cr_2O_7^{2-}$ in aqueous solution is

Correct Answer: (3)
Solution:

Metals with lower standard reduction potentials (E°) compared to $Cr_2O_7^{2-}$ ($E^\circ = 1.33\,V$) will be oxidized. These are:

- Fe ($E^\circ = -0.04\,V$),
- Ni ($E^\circ = -0.25\,V$),
- Ag ($E^\circ = 0.80\,V$).

Thus, the number of metals oxidized is **3**.
Final Answer: (3)

Quick Tip

1. Compare the standard reduction potential (E°) of species to determine their relative oxidation or reduction. 2. Species with lower E° are oxidized by those with higher E°. 3. Pay attention to the order of half-cell potentials in the problem.

Question 25.
When equal volume of 1M HCl and 1M H SO are separately neutralized by excess volume of 1M NaOH, X and Y kJ of heat is liberated respectively. The value of $\frac{Y}{X}$ is

Correct Answer: (2)
Solution:

Neutralization reactions:

$$H^+ + OH^- \rightarrow H_2O \quad \text{(from HCl: } X\text{)},$$

$$2H^+ + 2OH^- \rightarrow 2H_2O \quad \text{(from } H_2SO_4 : Y\text{)}.$$

From the reactions:

$$Y = 2X \implies \frac{Y}{X} = 2.$$

Final Answer: 2

Quick Tip

1. The heat of neutralization depends on the number of moles of H^+ and OH^-. 2. For strong acids like HCl and H_2SO_4, consider the dissociation of H_2SO_4 into two H^+ ions. 3. Use the stoichiometry of reactions to find the ratio of heat liberated.

Question 26.
Molarity (M) of an aqueous solution containing x g of anhydrous $CuSO_4$ in 500 mL solution at 32°C is 2×10^{-1} M. Its molality will be ..... $\times 10^{-3}$ m (nearest integer). [Given: Density of the solution = 1.25 g/mL].
Correct Answer: (NTA : 81) BONUS
Solution:

Given:

- Molarity (M) = 0.2 mol/L
- Volume of solution (V_{sol}) = $500\,\text{mL} = 0.5\,\text{L}$
- Density of solution (d_{sol}) = 1.25 g/mL
- Molar mass of $CuSO_4$ = 159.5 g/mol

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Step 1: Calculate the mass of the solution

$$M_{\text{sol}} = V_{\text{sol}} \times d_{\text{sol}} = 500\,\text{mL} \times 1.25\,\text{g/mL} = 625\,\text{g}.$$

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Step 2: Calculate the mass of solute

$$\text{Mass of solute } (CuSO_4) = M \times V_{\text{sol}} \times \text{Molar mass}.$$
$$= 0.2 \times 0.5 \times 159.5 = 15.95\,\text{g}.$$

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Step 3: Calculate the mass of the solvent

$$\text{Mass of solvent} = \text{Mass of solution} - \text{Mass of solute}.$$
$$= 625 - 15.95 = 609.05\,\text{g} = 0.60905\,\text{kg}.$$

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Step 4: Calculate the molality

$$m = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}} = \frac{0.1}{0.60905}.$$
$$m = 0.164\,\text{mol/kg} = 164 \times 10^{-3}\,\text{mol/kg}.$$

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Final Answer

The molality of the solution is:

$$\boxed{0.164\,\text{mol/kg (or } 164 \times 10^{-3}\text{ mol/kg)}}.$$

Quick Tip

1. Use the relationship $M = \frac{\text{moles of solute}}{\text{volume of solution in litres}}$ to find the moles of solute. 2. Subtract the solute's mass from the total solution's mass to determine the solvent's mass. 3. Molality is defined as moles of solute per kilogram of solvent, so ensure proper unit conversion. 4. Approximate results to the nearest integer if specified in the question.

Question 27.
The total number of species from the following in which one unpaired electron is present, is .....

$$N_2,\ O_2,\ C_2^-,\ O_2^-,\ H_2^+,\ CN^-,\ He_2^+$$

Correct Answer: (4)
Solution:

Step 1: Analyze each species for unpaired electrons
1. N_2: All electrons are paired.
2. O_2: Two unpaired electrons are present in antibonding orbitals.
3. C_2^-: One unpaired electron is present.
4. O_2^-: One unpaired electron is present.
5. H_2^+: One unpaired electron is present.
6. CN^-: All electrons are paired.
7. He_2^+: One unpaired electron is present.

Step 2: Count the species with one unpaired electron
Species with one unpaired electron:

$$C_2^-,\ O_2^-,\ H_2^+,\ He_2^+$$

Total number = 4.
Final Answer: 4.

Quick Tip

1. Use molecular orbital theory (MOT) to determine the presence of unpaired electrons.
2. Remember common molecular orbital arrangements:
- O_2 has two unpaired electrons.
- H_2^+ and He_2^+ each have one unpaired electron.
3. For charged species (C_2^- or O_2^-), add or remove electrons accordingly before analyzing.

Question 28.
Number of ambidentate ligands among the following is.....

$$NO_2^-, SCN^-, C_2O_4^{2-}, NH_3, CN^-, SO_4^{2-}, H_2O.$$

Correct Answer: (3)
Solution:

Step 1: Define ambidentate ligands
Ambidentate ligands are ligands that can coordinate to a metal center through two different atoms.
Step 2: Analyze the ligands
1. NO_2^-: Ambidentate ligand; can bind through N or O.
2. SCN^-: Ambidentate ligand; can bind through S or N.
3. $C_2O_4^{2-}$: Not ambidentate; it is a bidentate ligand.
4. NH_3: Not ambidentate; monodentate ligand binding through N.
5. CN^-: Ambidentate ligand; can bind through C or N.
6. SO_4^{2-}: Not ambidentate; it is a bidentate ligand.
7. H_2O: Not ambidentate; monodentate ligand binding through O.

Step 3: Count ambidentate ligands
Ambidentate ligands are:

$$NO_2^-, SCN^-, CN^-.$$

Total number = 3.
Final Answer: 3.

Quick Tip

1. Ambidentate ligands have more than one potential donor atom for binding, such as NO_2^- (via N or O) or SCN^- (via S or N). 2. Differentiate between bidentate ligands ($C_2O_4^{2-}$) and ambidentate ligands (can bind through two different atoms). 3. Monodentate ligands like NH_3 or H_2O are not ambidentate.

Question 29.
Total number of essential amino acids among the given list of amino acids is .....

Arginine, Phenylalanine, Aspartic acid, Cysteine, Histidine, Valine, Proline.

Correct Answer: (4)
Solution:

Step 1: Identify essential amino acids
Essential amino acids are those that cannot be synthesized by the human body and must be obtained from the diet. From the given list:
1. Arginine - Essential.
2. Phenylalanine - Essential.
3. Histidine - Essential.
4. Valine - Essential.
5. Aspartic acid, Cysteine, and Proline are non-essential.

Step 2: Count essential amino acids
Essential amino acids in the list = 4.

Final Answer: 4.

Quick Tip

1. Essential amino acids must be consumed via diet; common examples include Valine, Histidine, and Phenylalanine.
2. Non-essential amino acids like Aspartic acid can be synthesized by the body.
3. Familiarize yourself with the complete list of essential amino acids for such questions.

Question 30.
Number of colourless lanthanoid ions among the following is .....

Eu^{3+}, Lu^{3+}, Nd^{3+}, La^{3+}, Sm^{3+}.

Correct Answer: (2)
Solution:

Step 1: Analyze electronic configurations
1. La^{3+}: $[Xe]4f^0$ (No unpaired electrons, colourless).
2. Lu^{3+}: $[Xe]4f^{14}$ (No unpaired electrons, colourless).
3. Nd^{3+}: $[Xe]4f^3$ (Unpaired electrons, coloured).
4. Sm^{3+}: $[Xe]4f^5$ (Unpaired electrons, coloured).

5. Eu^{3+}: $[Xe]4f^6$ (Unpaired electrons, coloured).

Step 2: Count colourless ions
Lanthanide ions that are colourless: La^{3+} and Lu^{3+}.

Final Answer: 2.

Quick Tip

1. Colour of lanthanoid ions depends on the presence of unpaired electrons in their 4f orbitals. 2. Ions with all paired electrons ($4f^0$ or $4f^{14}$) are colourless, while those with unpaired electrons are coloured. 3. For such questions, memorize the electronic configurations of common lanthanoid ions.