MHT-CET Chemistry Sample Paper-17

Duration: 45 Minutes **Maximum Marks: 50**

Instructions

- This paper contains a total of **50** Multiple Choice Questions.
- Each correct answer carries **+1 marks**.
- No negative marking for incorrect questions.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.
- No marks will be deducted for questions that are left unattempted.

Q1. Which of the following carbocations is the most stable due to the combined effect of resonance and inductive effects?

(A) $(CH_3)_3C^+$

(B) $(C_6H_5)_2CH^+$

(C) $CH_2 = CH - CH_2^+$

(D) $(C_6H_5)_3C^+$

Q2. Arrange the following compounds in decreasing order of their acidic strength: (i) p-nitrophenol, (ii) p-cresol, (iii) phenol, (iv) p-methoxyphenol.

(A) (i) > (iii) > (ii) > (iv)

(B) (i) > (ii) > (iii) > (iv)

(C) (iv) > (ii) > (iii) > (i)

(D) (iii) > (i) > (ii) > (iv)

Q3. The number of stereoisomers possible for 2,3-dichlorobutane, including the meso form, is:

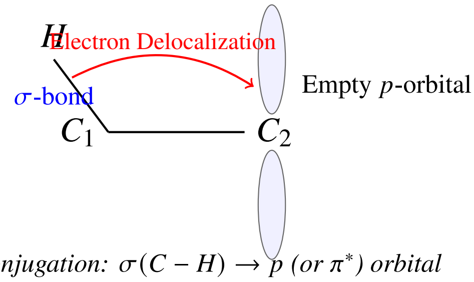
(A) 2

(B) 3

(C) 4

(D) 1

Q4. Hyperconjugation involves the delocalization of electrons from which of the following bonds?



Hyperconjugation: $\sigma(C-H) \rightarrow p$ *(or* π^**) orbital*

(A) σ-electrons of C-H bond of an alkyl group directly attached to an unsaturated system

(B) π-electrons of C-C double bond

(C) Lone pair electrons of a heteroatom

(D) σ-electrons of C-C bond in an alkane

Q5. Which of the following substituted biphenyls is expected to be optically active due to restricted rotation?

(A) 2,2’-dichlorobiphenyl

(B) 2,2’-dinitrobiphenyl-6,6’-dicarboxylic acid

(C) 4,4’-dichlorobiphenyl

(D) Biphenyl

Q6. Ozonolysis of an alkene produces formaldehyde as one of the products. This result confirms the presence of which structural unit in the original alkene?

(A) Two ethylenic double bonds

(B) A vinyl group ($-CH = CH_2$)

(C) An isopropyl group

(D) A terminal alkyne group

Q7. In the Birch reduction of benzene using $Na/NH_3(l)$ in the presence of ethanol, the major product formed is:

(A) Cyclohexane

(B) 1,3-cyclohexadiene

(C) 1,4-cyclohexadiene

(D) Cyclohexene

Q8. Reaction of 3-methylbut-1-ene with HBr yields 2-bromo-2-methylbutane as the major product. This occurs primarily because of:

(A) Anti-Markovnikov addition

(B) Formation of a primary carbocation

(C) 1,2-hydride shift to form a more stable carbocation

(D) Steric hindrance during nucleophilic attack

Q9. Which of the following compounds will produce a white precipitate when treated with ammoniacal silver nitrate solution?

(A) But-2-yne

(B) Ethyne

(C) Propyne

(D) Both (B) and (C)

Q10. The rate of an S_N2 reaction for a given alkyl halide is typically highest in which of the following solvents?

(A) Water

(B) Ethanol

(C) Dimethyl sulfoxide (DMSO)

(D) Methanol

Q11. The reaction of (R)-2-bromooctane with aqueous NaOH leads to the formation of (S)-octan-2-ol. This stereochemical outcome is described as:

(A) 100% inversion of configuration

(B) 100% retention of configuration

(C) Partial racemization

(D) Formation of a meso compound

Q12. Identify the product 'X' in the following Wurtz-Fittig reaction: $C_6H_5Br + CH_3Br + 2Na \xrightarrow{dry\ ether} X + 2NaBr$

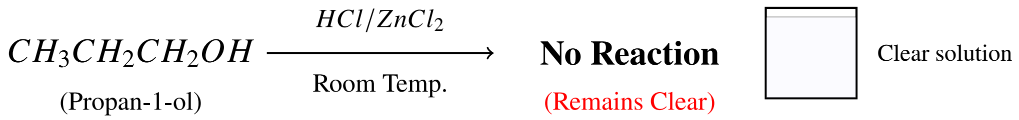
(A) Benzene

(B) Toluene

(C) Ethylbenzene

(D) Biphenyl

Q13. When Propan-1-ol is treated with Lucas reagent ($conc.HCl + ZnCl_2$) at room temperature, the observed result is:



$$\underset{\text{(Propan-1-ol)}}{CH_3CH_2CH_2OH} \xrightarrow[\text{Room Temp.}]{HCl/ZnCl_2} \underset{\text{(Remains Clear)}}{\textbf{No Reaction}}$$

Primary alcohols do not form alkyl chlorides at room temperature.

(A) Turbidity appears immediately

(B) Turbidity appears after 5 minutes

(C) No turbidity appears at room temperature

(D) Solution turns blue instantly

Q14. The most efficient reagent for the selective oxidation of a primary alcohol to an aldehyde without further oxidation to a carboxylic acid is:

(A) Alkaline $KMnO_4$

(B) Acidified $K_2Cr_2O_7$

(C) Pyridinium chlorochromate (PCC)

(D) CrO_3 in aqueous sulfuric acid

Q15. In the Reimer-Tiemann reaction where phenol reacts with chloroform and aqueous NaOH to form salicylaldehyde, the reactive intermediate is:

(A) Dichlorocarbene ($: CCl_2$)

(B) Trichloromethide ion ($: CCl_3^-$)

(C) Benzyl carbonium ion

(D) Phenoxide radical

Q16. The cleavage of anisole ($C_6H_5OCH_3$) with concentrated HI at high temperature yields:

(A) $C_6H_5I + CH_3OH$

(B) $C_6H_5OH + CH_3I$

(C) $C_6H_5I + CH_3I$

(D) $C_6H_6 + CH_3OI$

Q17. The cross-aldol condensation between benzaldehyde and acetophenone in the presence of dilute NaOH followed by heating produces:

(A) 1,3-diphenylprop-2-en-1-one

(B) 1,3-diphenylpropan-1-one

(C) 1,1-diphenylprop-2-en-1-one

(D) Benzyl alcohol and Sodium benzoate

Q18. The conversion of benzaldehyde to a mixture of benzyl alcohol and sodium benzoate by treatment with concentrated NaOH is known as:

(A) Rosenmund reduction

(B) Cannizzaro reaction

(C) Clemmensen reduction

(D) Kolbe's reaction

Q19. Propanone is reduced to propane on treatment with $Zn - Hg$ and concentrated HCl. This reaction is categorized as:

(A) Wolf-Kishner reduction

(B) Clemmensen reduction

(C) Stephen's reduction

(D) Rosenmund reduction

Q20. The nucleophilic addition of HCN to a carbonyl compound followed by complete acidic hydrolysis of the resulting cyanohydrin produces:

(A) α-hydroxy acid

(B) α-amino acid

(C) β-hydroxy acid

(D) α-keto acid

Q21. Which of the following reactions is used to prepare α-halo carboxylic acids by treating them with Cl_2/Br_2 in the presence of red phosphorus?

(A) Hell-Volhard-Zelinsky reaction

(B) Hunsdiecker reaction

(C) Stephen reaction

(D) Etard reaction

Q22. What is the correct order of basic strength of the following amines in aqueous solution?

(A) $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$

(B) $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$

(C) $(CH_3)_2NH > (CH_3)_3N > CH_3NH_2 > NH_3$

(D) $NH_3 > CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$

Q23. When propanamide is treated with bromine and aqueous potassium hydroxide, the primary amine formed is:

(A) Ethylamine

(B) Propylamine

(C) Methylamine

(D) Isopropylamine

Q24. The Gabriel phthalimide synthesis is a versatile method for the preparation of which class of compounds?

(A) Primary aliphatic amines

(B) Primary aromatic amines

(C) Secondary amines

(D) Tertiary amines

Q25. Lactose is a disaccharide composed of glucose and galactose. Which specific linkage connects these two units?

(A) α-1,4-glycosidic linkage

(B) β-1,4-glycosidic linkage

(C) α-1,2-glycosidic linkage

(D) α-1,6-glycosidic linkage

Q26. Which of the following is classified as an addition polymer?

(A) Nylon-6,6

(B) Terylene

(C) Polyvinyl chloride (PVC)

(D) Bakelite

Q27. The secondary structure of proteins, such as the α-helix, is primarily stabilized by:

(A) Peptide bonds

(B) Hydrogen bonds

(C) Disulfide bridges

(D) Van der Waals forces

Q28. According to VSEPR theory, the geometry and shape of the XeF_2 molecule are respectively:

(A) Trigonal bipyramidal and Linear

(B) Trigonal bipyramidal and Bent

(C) Linear and Linear

(D) Square planar and Linear

Q29. Which of the following molecules possesses the highest dipole moment?

(A) CH_3Cl **(D)** CCl_4

In CH_3Cl, all bond dipoles reinforce the molecular dipole.

(A) CH_3Cl

(B) CH_2Cl_2

(C) $CHCl_3$

(D) CCl_4

Q30. The correct order of bond orders for O_2, O_2^+, and O_2^- is:

(A) $O_2^+ > O_2 > O_2^-$

(B) $O_2 > O_2^+ > O_2^-$

(C) $O_2^- > O_2 > O_2^+$

(D) $O_2^+ > O_2^- > O_2$

Q31. Among the following ionic solids, which is expected to have the highest lattice enthalpy?

(A) LiF

(B) NaCl

(C) KBr

(D) RbI

Q32. In which of the following electronic transitions does the bond order increase while the magnetic behavior changes from paramagnetic to diamagnetic?

(A) $O_2 \rightarrow O_2^+$

(B) $N_2 \rightarrow N_2^+$

(C) $NO \rightarrow NO^+$

(D) $O_2 \rightarrow O_2^{2-}$

Q33. The correct IUPAC name for the coordination compound $K_3[Fe(CN)_6]$ is:

(A) Potassium hexacyanoferrate(II)

(B) Potassium hexacyanoferrate(III)

(C) Tripotassium hexacyanoiron(III)

(D) Potassium ferricyanide

Q34. Which of the following square planar complexes can exhibit geometrical (cis-trans) isomerism?

(A) $[Pt(NH_3)_3Cl]^+$

(B) $[Pt(NH_3)Cl_3]^-$

(C) $[Pt(NH_3)_2Cl_2]$

(D) $[Pt(NH_3)_4]^{2+}$

Q35. The crystal field stabilization energy (CFSE) for a d^4 high-spin octahedral complex in terms of Δ_o is:

(A) $-0.6\Delta_o$

(B) $-1.8\Delta_o$

(C) $-1.6\Delta_o$

(D) $-1.2\Delta_o$

Q36. Which of the following complex ions is diamagnetic?

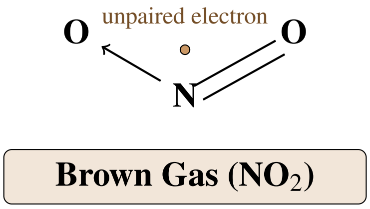
(A) $[Fe(CN)_6]^{3-}$

(B) $[Co(NH_3)_6]^{3+}$

(C) $[NiCl_4]^{2-}$

(D) $[Mn(H_2O)_6]^{2+}$

Q37. Which of the following oxides of nitrogen is a brown-colored paramagnetic gas?



The presence of an unpaired electron makes it paramagnetic.

(A) N_2O

(B) NO

(C) NO_2

(D) N_2O_5

Q38. The hybridization of the phosphorus atom in PCl_5 in the gaseous state is:

(A) sp^3

(B) sp^3d

(C) sp^3d^2

(D) dsp^2

Q39. Among the following phosphorus oxyacids, which one acts as the strongest reducing agent?

(A) H_3PO_4

(B) H_3PO_3

(C) H_3PO_2

(D) $H_4P_2O_7$

Q40. The boiling point of noble gases increases consistently from Helium to Radon primarily due to:

(A) Increase in ionization enthalpy

(B) Increase in polarizability and London dispersion forces

(C) Decrease in atomic radius

(D) Increase in electron gain enthalpy

Q41. Potassium dichromate ($K_2Cr_2O_7$) reacts with H_2O_2 in an acidic medium to form a deep blue compound CrO_5. The oxidation state of Chromium in CrO_5 is:

(A) +3

(B) +6

(C) +5

(D) +10

Q42. What is the correct electronic configuration of Gadolinium ($Z = 64$)?

(A) $[Xe]4f^7 5d^1 6s^2$

(B) $[Xe]4f^8 5d^0 6s^2$

(C) $[Xe]4f^7 5d^0 6s^2$

(D) $[Xe]4f^9 6s^1$

Q43. Transition metals exhibit variable oxidation states mainly because:

(A) The energy difference between (n-1)d and ns orbitals is very small

(B) They have high effective nuclear charge

(C) They are all metallic in nature

(D) They form stable complexes with ligands

Q44. Which of the following elements in the second period of the periodic table has the highest electronegativity value?

(A) Nitrogen

(B) Oxygen

(C) Fluorine

(D) Carbon

Q45. What is the correct increasing order of ionic radii for the isoelectronic species O^{2-}, F^{-}, Na^{+}, and Mg^{2+}?

(A) $Mg^{2+} < Na^{+} < F^{-} < O^{2-}$

(B) $O^{2-} < F^{-} < Na^{+} < Mg^{2+}$

(C) $Na^{+} < Mg^{2+} < O^{2-} < F^{-}$

(D) $F^{-} < O^{2-} < Mg^{2+} < Na^{+}$

Q46. A solution is prepared by dissolving 10 g of a non-volatile solute in 100 g of water. If the boiling point of the solution is $100.52°C$ and K_b for water is $0.52\ K\ kg\ mol^{-1}$, the molar mass of the solute is:

(A) $100\ g\ mol^{-1}$

(B) $200\ g\ mol^{-1}$

(C) $50\ g\ mol^{-1}$

(D) $150\ g\ mol^{-1}$

Q47. The radius of the second Bohr orbit for the He^{+} ion is approximately (where $a_o = 0.529$ Å):

(A) 0.529 Å

(B) 1.058 Å

(C) 2.116 Å

(D) 0.2645 Å

Q48. For a chemical reaction to be spontaneous at high temperatures but non-spontaneous at low temperatures, the signs of enthalpy change (ΔH) and entropy change (ΔS) must be:

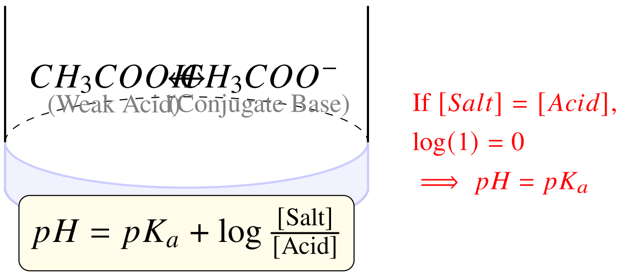
(A) $\Delta H = +ve, \Delta S = +ve$

(B) $\Delta H = -ve, \Delta S = -ve$

(C) $\Delta H = +ve, \Delta S = -ve$

(D) $\Delta H = -ve, \Delta S = +ve$

Q49. The pH of an acidic buffer solution containing 0.1 M CH_3COOH and 0.1 M CH_3COONa (pK_a of $CH_3COOH = 4.74$) is:



Acidic buffer maintains pH near the pK_a of the weak acid.

(A) 4.74

(B) 3.74

(C) 5.74

(D) 7.00

Q50. The standard electrode potentials for Zn^{2+}/Zn and Fe^{2+}/Fe are $-0.76\ V$ and $-0.44\ V$ respectively. The standard EMF (E°) for the cell $Zn|Zn^{2+}(1M)||Fe^{2+}(1M)|Fe$ is:

(A) $1.20\ V$

(B) $-1.20\ V$

(C) $0.32\ V$

(D) $-0.32\ V$

Detailed Solutions

Q1.

Solution

Concept:
The stability of a carbocation depends on the degree of delocalization of the positive charge. This delocalization can occur via inductive effect ($+I$), hyperconjugation, and resonance (mesomeric effect, $+M$). Resonance is generally the most dominant stabilizing factor. For triphenylmethyl carbocation, the positive charge is delocalized over three benzene rings through resonance.

Solution:
1. In $(CH_3)_3C^+$, the tertiary carbocation is stabilized by nine hyperconjugative hydrogens and the $+I$ effect of three methyl groups. 2. In $(C_6H_5)_2CH^+$, the charge is delocalized over two phenyl rings. 3. In $CH_2 = CH - CH_2^+$, the charge is stabilized by resonance with one double bond. 4. In $(C_6H_5)_3C^+$, the vacant p-orbital on the central carbon atom is in conjugation with the π-systems of three benzene rings. This provides extensive resonance stabilization, making it significantly more stable than the others.

Final Answer: The most stable carbocation is $(C_6H_5)_3C^+$.

Answer: (D)

Q2.

Solution

Concept:
The acidic strength of substituted phenols is determined by the stability of the phenoxide ion formed after losing a proton. Electron-withdrawing groups (EWG) like $-NO_2$ increase acidity by stabilizing the negative charge through $-M$ and $-I$ effects. Electron-donating groups (EDG) like $-CH_3$ ($+I$ and hyperconjugation) and $-OCH_3$ ($+M$) decrease acidity by destabilizing the phenoxide ion.

Solution:
1. p-Nitrophenol: The $-NO_2$ group is a strong EWG, exerting both $-I$ and $-M$ effects, making it the most acidic. 2. Phenol: Has no substituting group, serving as the reference point. 3. p-Cresol: The $-CH_3$ group is an EDG ($+I$ and hyperconjugation), which reduces the acidity compared to phenol. 4. p-Methoxyphenol: The $-OCH_3$ group has a strong $+M$ effect (despite its $-I$ effect), which significantly destabilizes the phenoxide ion, making it the least acidic in this group. 5. Therefore, the order is: p-nitrophenol > phenol > p-cresol > p-methoxyphenol.

Final Answer: The order is (i) > (iii) > (ii) > (iv).

Answer: (A)

Q3.

Solution

Concept:
Stereoisomerism in molecules with multiple chiral centers depends on whether the molecule has a plane of symmetry. For a molecule with n chiral centers, the number of stereoisomers is 2^n if there is no symmetry. However, if the molecule is symmetrical (like 2,3-dichlorobutane), meso forms exist.

Solution:
1. 2,3-Dichlorobutane ($CH_3 - CHCl - CHCl - CH_3$) has two chiral centers at C2 and C3. 2. Because the substituents on both chiral centers are identical, the molecule is symmetrical. 3. The stereoisomers are: - A pair of enantiomers (d- and l- forms) which are non-superimposable mirror images. - One meso form, which has an internal plane of symmetry and is optically inactive. 4. Total stereoisomers = 2 (enantiomers) + 1 (meso) = 3.

Final Answer: The number of stereoisomers is 3.

Answer: (B)

Q4.

Solution

Concept:
Hyperconjugation (also known as the Baker-Nathan effect or no-bond resonance) is a permanent effect where the σ-electrons of a C-H bond of an alkyl group, which is at the α-position relative to an atom of an unsaturated system or an atom with an unshared p-orbital (like a carbocation), undergo delocalization.

Solution:
1. Hyperconjugation involves the overlap of the σ-orbital of the C-H bond with an adjacent empty p-orbital or a π-orbital. 2. This leads to the delocalization of σ-electrons. 3. The requirement is the presence of an α-hydrogen atom on an sp^3 hybridized carbon adjacent to an sp^2 hybridized carbon. 4. It is distinct from resonance, which involves π-electrons or lone pairs.

Final Answer: Hyperconjugation involves the delocalization of σ-electrons of the C-H bond of an alkyl group attached to an unsaturated system.

Answer: (A)

Q5.

Solution

Concept:
Biphenyls can exhibit atropisomerism (optical activity due to restricted rotation) if they are substituted at the ortho positions with bulky groups. These groups prevent the two benzene rings from becoming coplanar, leading to a chiral, non-planar conformation provided the substituents on each ring are different.

Solution:
1. For a biphenyl to be optically active, the rotation about the single bond connecting the two rings must be restricted by bulky ortho-substituents. 2. 2,2'-dinitrobiphenyl-6,6'-dicarboxylic acid has four bulky groups (two $-NO_2$ and two $-COOH$) at all four ortho positions. 3. These groups cause significant steric hindrance, forcing the rings to stay perpendicular to each other. 4. Since each ring is unsymmetrically substituted (one $-NO_2$ and one $-COOH$ at ortho positions), the molecule lacks a plane of symmetry and is chiral. 5. Simple biphenyl or para-substituted biphenyls (like 4,4'-dichlorobiphenyl) are either planar or have free rotation, making them optically inactive.

Final Answer: The optically active biphenyl is 2,2'-dinitrobiphenyl-6,6'-dicarboxylic acid.

Answer: (B)

Q6.

Solution

Concept:
Ozonolysis is a reaction used to locate the position of double bonds in alkenes. When an alkene is treated with ozone (O_3) followed by reductive cleavage with Zinc dust and water (Zn/H_2O), the double bond is completely broken, and an oxygen atom is attached to each of the originally double-bonded carbon atoms, forming carbonyl compounds (aldehydes or ketones).

Solution:
1. The formation of formaldehyde ($HCHO$) as a product of ozonolysis specifically indicates that one of the carbons in the double bond was bonded to two hydrogen atoms. 2. The structure required for this is $R - CH = CH_2$. 3. The $-CH = CH_2$ group is known as the vinyl group. 4. Upon ozonolysis:

$$R - CH = CH_2 + O_3 \xrightarrow{Zn/H_2O} R - CHO + HCHO$$

5. Therefore, the presence of formaldehyde confirms that the original alkene contained a terminal double bond or a vinyl group.

Final Answer: The result confirms the presence of a vinyl group.

Answer: (B)

Q7.

Solution

Concept:
The Birch reduction is an organic reaction used to convert aromatic rings into 1,4-cyclohexadienes. It utilizes a solution of an alkali metal (usually sodium or lithium) in liquid ammonia in the presence of an alcohol (like ethanol or methanol).

Solution:
1. The reaction begins with the transfer of an electron from the sodium metal to the benzene ring to form a radical anion. 2. This radical anion is then protonated by the alcohol (ethanol). 3. A second electron is transferred to form a carbanion, which is again protonated by the alcohol. 4. In the case of unsubstituted benzene, the two hydrogen atoms are added at the 1 and 4 positions. 5. This yields 1,4-cyclohexadiene as the major product because the resulting unconjugated system is the kinetic product of the reaction mechanism.

Final Answer: The major product formed is 1,4-cyclohexadiene.

$\boxed{\textbf{Answer: (C)}}$

Q8.

Solution

Concept:
Electrophilic addition of hydrogen halides (HX) to alkenes typically follows Markovnikov's rule. However, if the intermediate carbocation can rearrange to a more stable form (e.g., from secondary to tertiary), a rearrangement will occur via a hydride or alkyl shift.

Solution:
1. The starting material is 3-methylbut-1-ene: $CH_3 - CH(CH_3) - CH = CH_2$. 2. Step 1: Protonation of the double bond. The H^+ adds to C1 to form a more stable secondary carbocation at C2:

$$CH_3 - CH(CH_3) - CH^+ - CH_3 \text{ (Secondary Carbocation)}$$

3. Step 2: Carbocation rearrangement. A 1,2-hydride shift occurs from the adjacent tertiary carbon (C3) to C2. This results in a much more stable tertiary carbocation:

$$CH_3 - C^+(CH_3) - CH_2 - CH_3 \text{ (Tertiary Carbocation)}$$

4. Step 3: Nucleophilic attack. The bromide ion (Br^-) attacks the tertiary carbocation to form 2-bromo-2-methylbutane. 5. This rearrangement explains why the product is not the expected secondary halide.

Final Answer: This occurs primarily because of 1,2-hydride shift to form a more stable carbocation.

$\boxed{\textbf{Answer: (C)}}$

Q9.

Solution

Concept:
Ammoniacal silver nitrate ($[Ag(NH_3)_2]NO_3$), also known as Tollen's reagent, is used to distinguish between terminal and internal alkynes. Terminal alkynes possess an acidic hydrogen atom attached to the triply bonded carbon, which reacts with the silver complex.

Solution:
1. Terminal alkynes (alk-1-ynes) react with Tollen's reagent to form a white precipitate of silver acetylides. 2. The reaction for a general terminal alkyne is:

$$R-C\equiv C-H+[Ag(NH_3)_2]^+\rightarrow R-C\equiv C-Ag\downarrow\ \text{(White ppt)}+NH_3+NH_4^+$$

3. Ethyne ($H-C\equiv C-H$) has two terminal hydrogens and reacts to form $Ag-C\equiv C-Ag$. 4. Propyne ($CH_3-C\equiv C-H$) has one terminal hydrogen and reacts to form $CH_3-C\equiv C-Ag$. 5. But-2-yne ($CH_3-C\equiv C-CH_3$) is an internal alkyne with no acidic acetylenic hydrogens and thus does not react. 6. Since both Ethyne and Propyne are terminal alkynes, both will produce the precipitate.

Final Answer: Both (B) and (C) will produce a white precipitate.

$\boxed{\textbf{Answer: (D)}}$

Q10.

Solution

Concept:
The S_N2 (Substitution Nucleophilic Bimolecular) reaction rate is highly sensitive to the nature of the solvent. This reaction involves a single-step mechanism with a transition state where the nucleophile attacks while the leaving group departs.

Solution:
1. S_N2 reactions are favored by polar aprotic solvents. These are solvents that have a dipole moment but lack an $O-H$ or $N-H$ bond, meaning they cannot form hydrogen bonds. 2. Examples of polar aprotic solvents include Dimethyl sulfoxide (DMSO), N,N-Dimethylformamide (DMF), and acetone. 3. In polar protic solvents (like water, ethanol, methanol), the nucleophile is strongly solvated via hydrogen bonding. This creates a "solvent cage" around the nucleophile, making it less reactive and stable. 4. In polar aprotic solvents like DMSO, the cation of the reagent is solvated, but the anion (the nucleophile) is not effectively solvated because there is no acidic hydrogen to bond with it. 5. This results in "naked" or desolvated nucleophiles which have much higher energy and reactivity, significantly increasing the S_N2 reaction rate.

Final Answer: The rate is highest in Dimethyl sulfoxide (DMSO).

$\boxed{\textbf{Answer: (C)}}$

Q11.

Solution

Concept:

Nucleophilic substitution reactions at a chiral center can proceed via two main pathways: S_N1 or S_N2. The S_N2 (Substitution Nucleophilic Bimolecular) mechanism involves a backside attack by the nucleophile on the carbon atom bearing the leaving group. This simultaneous bond-breaking and bond-forming process leads to a complete reversal of the spatial arrangement of groups around the carbon atom.

Solution:

1. (R)-2-bromooctane is a secondary alkyl halide. With a strong nucleophile like aqueous NaOH (OH^-), the reaction primarily follows the S_N2 mechanism. 2. In the S_N2 mechanism, the hydroxide ion attacks from the side opposite to the bromine atom. 3. As the C-OH bond forms, the C-Br bond breaks in a single concerted step through a pentacoordinate transition state. 4. Because the attack is strictly from the backside, the configuration of the chiral center is flipped. 5. Therefore, the (R) configuration is converted entirely into the (S) configuration. This phenomenon is known as Walden Inversion.

Final Answer: The stereochemical outcome is 100% inversion of configuration.

Answer: (A)

Q12.

Solution

Concept:

The Wurtz-Fittig reaction is an extension of the Wurtz reaction. It involves the reaction of an aryl halide and an alkyl halide with sodium metal in the presence of dry ether to form an alkyl-substituted aromatic compound (alkylarene).

Solution:

1. The reactants given are Bromobenzene (C_6H_5Br) and Methyl bromide (CH_3Br). 2. When treated with sodium in dry ether, the sodium atoms react with the halogen atoms of both molecules. 3. The reaction can be represented as:

$$C_6H_5 - Br + 2Na + Br - CH_3 \xrightarrow{dry\ ether} C_6H_5 - CH_3 + 2NaBr$$

4. The phenyl group (C_6H_5) from bromobenzene couples with the methyl group (CH_3) from methyl bromide. 5. The resulting product is Methylbenzene, commonly known as Toluene. 6. This method is specifically useful for synthesizing homologous series of benzene.

Final Answer: The product 'X' is Toluene.

Answer: (B)

Q13.

Solution

Concept:
The Lucas test is used to distinguish between primary, secondary, and tertiary alcohols. It employs the Lucas reagent, which is a mixture of concentrated HCl and anhydrous $ZnCl_2$. The reaction involves the formation of an alkyl chloride, which is insoluble in the reagent and appears as turbidity (cloudiness).

Solution:
1. The reaction rate depends on the stability of the carbocation intermediate formed: $3^\circ > 2^\circ > 1^\circ$. 2. Tertiary alcohols react immediately, showing turbidity at room temperature. 3. Secondary alcohols react within 5 to 10 minutes upon slight warming. 4. Primary alcohols, such as Propan-1-ol ($CH_3CH_2CH_2OH$), do not react with Lucas reagent at room temperature because the primary carbocation is too unstable to form under these conditions. 5. Turbidity for primary alcohols only appears upon significant heating. 6. Thus, at room temperature, the solution remains clear.

Final Answer: No turbidity appears at room temperature.

Answer: (C)

Q14.

Solution

Concept:
The oxidation of primary alcohols can lead to either aldehydes or carboxylic acids depending on the strength of the oxidizing agent. Strong oxidizing agents like $KMnO_4$ or $K_2Cr_2O_7$ usually oxidize primary alcohols all the way to carboxylic acids because the aldehyde intermediate is easily oxidized further in the presence of water.

Solution:
1. To stop the oxidation at the aldehyde stage, a mild and selective anhydrous oxidizing agent is required. 2. Pyridinium chlorochromate (PCC), which is a complex of chromium trioxide with pyridine and HCl, is the most common reagent for this purpose. 3. PCC is used in non-aqueous solvents like dichloromethane (CH_2Cl_2), which prevents the formation of aldehyde hydrates that are necessary for further oxidation to carboxylic acids. 4. Alkaline $KMnO_4$ and acidified $K_2Cr_2O_7$ are strong oxidants that produce carboxylic acids. 5. CrO_3 in aqueous H_2SO_4 (Jones reagent) also typically oxidizes primary alcohols to acids.

Final Answer: The most efficient reagent is Pyridinium chlorochromate (PCC).

Answer: (C)

Q15.

Solution

Concept:

The Reimer-Tiemann reaction is the treatment of phenol with chloroform ($CHCl_3$) in the presence of an aqueous alkali (like NaOH) to introduce an aldehyde group ($-CHO$) at the ortho position of the benzene ring, forming salicylaldehyde.

Solution:

1. In the first step, the base (NaOH) abstracts an acidic proton from chloroform ($CHCl_3$) to form the trichloromethide ion ($: CCl_3^-$). 2. This ion then undergoes α-elimination of a chloride ion (Cl^-) to generate a highly reactive, neutral species called dichlorocarbene ($: CCl_2$). 3. Dichlorocarbene acts as an electrophile because the carbon atom has only six electrons in its valence shell. 4. The phenoxide ion (formed from phenol in the basic medium) then undergoes electrophilic attack by the dichlorocarbene at the ortho position. 5. Subsequent hydrolysis leads to the formation of the aldehyde group.

Final Answer: The reactive intermediate is Dichlorocarbene ($: CCl_2$).

Answer: (A)

Q16.

Solution

Concept:

The reaction of alkyl aryl ethers with concentrated hydrohalic acids (like HI) involves the cleavage of the ether linkage. In the case of anisole (methoxybenzene), there are two different carbon-oxygen bonds: the $O - CH_3$ bond and the $O - C_6H_5$ (phenyl-oxygen) bond. Due to resonance, the lone pairs on oxygen are delocalized into the benzene ring, giving the phenyl-oxygen bond partial double bond character and making it significantly stronger and shorter.

Solution:

1. Initial Protonation: When anisole is treated with concentrated HI, the oxygen atom is protonated to form an oxonium ion:

$$C_6H_5 - O^+(H) - CH_3$$

2. Nucleophilic Attack: The iodide ion (I^-) is a strong nucleophile. It must attack one of the carbon atoms attached to the oxygen. 3. Bond Strength Consideration: The bond between the oxygen and the phenyl ring has partial double bond character (resonance stabilization) and the phenyl carbon is sp^2 hybridized. This bond is very difficult to break. 4. S_N2 Mechanism: Consequently, the iodide ion attacks the less hindered methyl group via an S_N2 mechanism. 5. Resulting Products: The $O - CH_3$ bond breaks, resulting in the formation of phenol (C_6H_5OH) and methyl iodide (CH_3I). 6. Even at high temperatures with excess HI, the phenol formed does not easily convert to iodobenzene because the $C - OH$ bond in phenol also has partial double bond character.

Final Answer: The cleavage yields $C_6H_5OH + CH_3I$.

Answer: (B)

Q17.

Solution

Concept:
Cross-aldol condensation occurs between two different carbonyl compounds. When one of the reactants lacks α-hydrogens (like benzaldehyde), it cannot form an enolate ion and must act as the electrophile. The other reactant (acetophenone), which has α-hydrogens, forms the enolate. This specific reaction between an aromatic aldehyde and an aliphatic-aromatic ketone is often called the Claisen-Schmidt reaction.

Solution:
1. Formation of Enolate: Acetophenone ($C_6H_5COCH_3$) contains three α-hydrogens on the methyl group. In the presence of dilute NaOH, one hydrogen is abstracted to form a resonance-stabilized enolate ion:

$$[C_6H_5 - CO - CH_2]^-$$

2. Nucleophilic Addition: This enolate ion attacks the carbonyl carbon of benzaldehyde (C_6H_5CHO), which lacks α-hydrogens. 3. Formation of Aldol: The addition produces a β-hydroxy ketone intermediate:

$$C_6H_5 - CH(OH) - CH_2 - CO - C_6H_5$$

4. Dehydration: Upon heating (which is usually part of the procedure), the β-hydroxy ketone undergoes dehydration to form an α, β-unsaturated carbonyl compound. 5. Structure of Product: The elimination of water results in the formation of 1,3-diphenylprop-2-en-1-one (commonly known as Benzalacetophenone or Chalcone).

$$C_6H_5 - CH = CH - CO - C_6H_5$$

Final Answer: The product is 1,3-diphenylprop-2-en-1-one.

Answer: (A)

Q18.

Solution

Concept:
The Cannizzaro reaction is a chemical reaction that involves the base-induced disproportionation of an aldehyde that lacks a hydrogen atom in the alpha position. Disproportionation is a specific type of redox reaction where the same substance is both oxidized and reduced.

Solution:
1. Requirement: Benzaldehyde (C_6H_5CHO) has no α-hydrogen atoms (the carbon adjacent to the carbonyl group is part of the benzene ring and has no hydrogens). 2. Mechanism: When treated with concentrated NaOH (50%), a hydroxide ion attacks the carbonyl carbon of one benzaldehyde molecule. 3. Hydride Shift: A hydride ion (H^-) is then transferred from this intermediate to a second benzaldehyde molecule. 4. Oxidation and Reduction: - The molecule that loses the hydride is oxidized to a carboxylic acid (which then reacts with the base to form sodium benzoate). - The molecule that receives the hydride is reduced to an alcohol (benzyl alcohol). 5. Chemical Equation:

$$2C_6H_5CHO + NaOH(conc.) \rightarrow C_6H_5COONa + C_6H_5CH_2OH$$

6. This reaction is the standard way to distinguish aldehydes without α-hydrogens from those that can undergo aldol condensation.

Final Answer: The reaction is known as the Cannizzaro reaction.

Answer: (B)

Q19.

Solution

Concept:
The Clemmensen reduction is a reaction used to reduce the carbonyl group ($> C = O$) of aldehydes or ketones to a methylene group ($> CH_2$). This effectively converts the carbonyl compound into an alkane. The reagent used is zinc amalgam ($Zn - Hg$) in the presence of concentrated hydrochloric acid (HCl).

Solution:
1. Identification: Propanone (acetone) has the formula $CH_3-CO-CH_3$. It is a simple three-carbon ketone. 2. Reaction Site: The carbonyl group is at the C2 position. 3. Transformation: Under the acidic conditions of the Clemmensen reduction, the oxygen of the carbonyl group is removed and replaced by two hydrogen atoms. 4. Carbon Skeleton: Since the carbon skeleton remains intact during the reduction, the three-carbon chain of propanone yields a three-carbon alkane. 5. Final Product:

$$CH_3 - CO - CH_3 \xrightarrow{Zn-Hg/conc.HCl} CH_3 - CH_2 - CH_3$$

The resulting product is propane. 6. Note: This reaction is particularly useful for ketones that are stable toward strong acids.

Final Answer: This reaction is categorized as Clemmensen reduction.

Answer: (B)

Q20.

Solution

Concept:
The synthesis involving HCN addition followed by hydrolysis is a two-step sequence used to increase the carbon chain length and introduce multiple functional groups. The first step is a nucleophilic addition to a carbonyl, and the second step is the chemical transformation of the nitrile functional group.
Solution:
1. Step 1 (Cyanohydrin Formation): Hydrogen cyanide (HCN) adds to the carbonyl group ($> C = O$) of an aldehyde or ketone. The CN^- ion attacks the carbonyl carbon, and the oxygen is protonated, forming a cyanohydrin:

$$R_2C = O + HCN \rightarrow R_2C(OH)CN$$

2. Step 2 (Hydrolysis): The nitrile group ($-CN$) is sensitive to acidic hydrolysis. When heated with dilute mineral acid (H^+/H_2O), the $-CN$ group is converted into a carboxylic acid group ($-COOH$).

$$R_2C(OH)CN + 2H_2O + H^+ \rightarrow R_2C(OH)COOH + NH_4^+$$

3. Product Analysis: The resulting compound has a hydroxyl group ($-OH$) and a carboxyl group ($-COOH$) attached to the same carbon atom. 4. Classification: In organic chemistry nomenclature, the carbon atom attached to the functional group (in this case, the $-COOH$) is the α-carbon. Since the $-OH$ is on that same carbon, the product is an α-hydroxy acid. 5. Example: Acetaldehyde → Lactose precursor (Lactic acid).
Final Answer: The process produces α-hydroxy acid.

Answer: (A)

Q21.

Solution

Concept: The Hell-Volhard-Zelinsky (HVZ) reaction is a specific halogenation reaction for carboxylic acids. It targets the α-hydrogen atoms—the hydrogens attached to the carbon atom adjacent to the carboxyl group.
Solution: 1. **Reaction Mechanism:** Carboxylic acids having at least one α-hydrogen react with chlorine or bromine in the presence of a small amount of red phosphorus. 2. **Role of Red Phosphorus:** Red phosphorus reacts with the halogen to form PX_3 (like PBr_3), which converts a small amount of the acid to an acid halide. The acid halide then undergoes enolization and halogenation at the α-carbon. 3. **Product:** The end result is the replacement of an α-hydrogen with a halogen atom (Cl or Br), yielding an α-halo carboxylic acid. 4. **Other Options:** The Hunsdiecker reaction produces alkyl halides from silver salts of carboxylic acids. The Stephen reaction reduces nitriles to aldehydes. The Etard reaction oxidizes toluene to benzaldehyde.
Final Answer: The reaction is the Hell-Volhard-Zelinsky reaction.

Answer: (A)

Q22.

Solution

Concept: The basicity of amines in aqueous solution depends on three competing factors: the inductive effect ($+I$), solvation (hydrogen bonding with water), and steric hindrance.

Solution: 1. **Inductive Effect:** Alkyl groups are electron-donating, which increases electron density on Nitrogen, suggesting the order: $3^\circ > 2^\circ > 1^\circ > NH_3$. 2. **Solvation Effect:** Substituted ammonium ions are stabilized by hydrogen bonding with water. More hydrogens on Nitrogen mean better solvation: $NH_3 > 1^\circ > 2^\circ > 3^\circ$. 3. **Steric Hindrance:** Large alkyl groups hinder the approach of protons and the formation of the solvent cage. 4. **Combined Result for Methyl Amines:** For the methyl group ($-CH_3$), the size is small enough that solvation and inductive effects balance such that the secondary amine is the most basic. The experimental order is:

$$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$$

(Secondary > Primary > Tertiary > Ammonia). *Note: For ethyl groups, the order changes to $2^\circ > 3^\circ > 1^\circ > NH_3$.*

Final Answer: The correct order is $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$.

Answer: (A)

Q23.

Solution

Concept: The reaction of an amide with bromine and a strong base (NaOH or KOH) is known as the **Hoffmann Bromamide Degradation** reaction. This reaction is a "degradation" because the resulting amine has one fewer carbon atom than the starting amide.

Solution: 1. **Reactant:** Propanamide has three carbons: $CH_3 - CH_2 - CONH_2$. 2. **Reaction:** When treated with Br_2 and KOH, the carbonyl group ($C = O$) is removed from the molecule in the form of carbonate (K_2CO_3). 3. **Product Formation:** The alkyl group (ethyl) originally attached to the carbonyl migrates to the nitrogen atom. 4. **Result:** $CH_3-CH_2-CONH_2 \xrightarrow{Br_2/KOH} CH_3-CH_2-NH_2$ (Ethylamine). 5. The carbon chain "shortens" from 3 carbons in the amide to 2 carbons in the amine.

Final Answer: The primary amine formed is Ethylamine.

Answer: (A)

Q24.

Solution

Concept: The Gabriel phthalimide synthesis is a method designed to produce pure primary amines without the risk of over-alkylation (which often happens during the direct ammonolysis of alkyl halides).

Solution: 1. **Mechanism:** Phthalimide is treated with KOH to form potassium phthalimide. This salt then undergoes a nucleophilic substitution (S_N2 reaction) with an alkyl halide (RX) to form N-alkylphthalimide. 2. **Hydrolysis:** Subsequent hydrolysis (or treatment with hydrazine) releases the primary amine. 3. **Limitations:** - It is used for **Primary Aliphatic Amines**. - It **cannot** be used to prepare primary aromatic amines (like aniline) because aryl halides do not undergo the necessary S_N2 reaction with the phthalimide anion due to partial double bond character of the $C - X$ bond and electronic repulsion.

Final Answer: It is a method for the preparation of Primary aliphatic amines.

Answer: (A)

Q25.

Solution

Concept: Disaccharides are formed by the condensation of two monosaccharides via a glycosidic bond. The specific type of linkage (α or β) and the carbon numbers involved define the sugar.

Solution: 1. **Composition:** Lactose (milk sugar) is composed of one molecule of β-D-galactose and one molecule of β-D-glucose. 2. **The Linkage:** The bond is formed between the anomeric carbon (C1) of the galactose unit and the C4 carbon of the glucose unit. 3. **Stereochemistry:** Since the galactose is in the β-anomeric form, the linkage is specifically a **β-1,4-glycosidic linkage**. 4. **Comparison:** - Maltose has an α-1,4-glycosidic linkage between two glucose units. - Sucrose has an α-1,2-glycosidic linkage between glucose and fructose.

Final Answer: The units are connected by a β-1,4-glycosidic linkage.

Answer: (B)

Q26.

Solution

Concept: Polymers are classified based on their mode of polymerization into addition polymers and condensation polymers. Addition polymers are formed by the repeated addition of monomer molecules possessing double or triple bonds without the elimination of small molecules.

Solution: 1. **Polyvinyl chloride (PVC):** Formed by the addition polymerization of vinyl chloride ($CH_2 = CHCl$). No small molecules are eliminated during the process. 2. **Nylon-6,6:** A condensation polymer formed by the reaction of adipic acid and hexamethylenediamine with the elimination of water molecules. 3. **Terylene (Dacron):** A condensation polymer (polyester) formed from ethylene glycol and terephthalic acid with the loss of water. 4. **Bakelite:** A condensation polymer formed from phenol and formaldehyde.

Final Answer: Polyvinyl chloride (PVC) is an addition polymer.

Answer: (C)

Q27.

Solution

Concept: The secondary structure of a protein refers to the local folding of the polypeptide chain into specific shapes like the α-helix or β-pleated sheet.

Solution: 1. **Stabilizing Interaction:** In an α-helix, the polypeptide chain is coiled into a right-handed screw. 2. **Mechanism:** This structure is stabilized by intramolecular hydrogen bonds between the $-NH$ group of an amino acid residue and the $> C = O$ group of the fourth amino acid residue further down the chain. 3. **Peptide Bonds:** These define the primary structure (the sequence of amino acids). 4. **Disulfide Bridges:** These typically contribute to the tertiary and quaternary structures.

Final Answer: The secondary structure is primarily stabilized by hydrogen bonds.

Answer: (B)

Q28.

Solution

Concept: VSEPR (Valence Shell Electron Pair Repulsion) theory determines the spatial arrangement of electron pairs around a central atom to minimize repulsion.

Solution: 1. **Central Atom:** Xenon (Xe) has 8 valence electrons. 2. **Bonding:** It forms 2 sigma bonds with 2 Fluorine atoms, using 2 electrons. 3. **Lone Pairs:** The remaining 6 electrons form 3 lone pairs. 4. **Steric Number:** 2 (bond pairs) + 3 (lone pairs) = 5. 5. **Geometry:** A steric number of 5 corresponds to a **trigonal bipyramidal** electron geometry. 6. **Shape:** To minimize repulsion (LP-LP > LP-BP > BP-BP), the 3 lone pairs occupy the equatorial positions. The 2 Fluorine atoms occupy the axial positions, resulting in a **linear** molecular shape.

Final Answer: Geometry is trigonal bipyramidal and shape is linear.

Answer: (A)

Q29.

Solution

Concept: The dipole moment (μ) of a molecule is the vector sum of individual bond dipoles. It depends on both the electronegativity difference and the molecular geometry.

Solution: 1. **CCl_4:** Symmetrical tetrahedral shape; the four $C-Cl$ bond dipoles cancel out perfectly ($\mu = 0$). 2. **$CHCl_3$, CH_2Cl_2, CH_3Cl:** In these substituted methanes, the $C-Cl$ dipoles and $C-H$ dipoles reinforce each other to varying degrees. 3. **Trend:** As the number of chlorine atoms increases beyond one, the bond dipoles begin to oppose each other due to the tetrahedral angles (109.5°). 4. **Result:** CH_3Cl has the highest dipole moment because the single $C-Cl$ dipole is strongly supported by the $C-H$ dipoles without any opposing $C-Cl$ components. - $\mu(CH_3Cl) \approx 1.87\ D$ - $\mu(CH_2Cl_2) \approx 1.60\ D$ - $\mu(CHCl_3) \approx 1.01\ D$

Final Answer: CH_3Cl possesses the highest dipole moment.

Answer: (A)

Q30.

Solution

Concept: Bond Order (B.O.) can be determined using Molecular Orbital (MO) Theory: $B.O. = \frac{1}{2}(N_b - N_a)$, where N_b is the number of bonding electrons and N_a is the number of antibonding electrons.

Solution: 1. **O_2 (16 electrons):** Configuration ends in $(\pi^*2p_x)^1(\pi^*2p_y)^1$. $B.O. = \frac{10-6}{2} = 2.0$. 2. **$O_2^+$ (15 electrons):** One electron is removed from an antibonding π^* orbital. $B.O. = \frac{10-5}{2} = 2.5$. 3. **$O_2^-$ (17 electrons):** One electron is added to an antibonding π^* orbital. $B.O. = \frac{10-7}{2} = 1.5$. 4. **Comparison:** Higher bond order means a stronger, shorter bond. The order is $O_2^+(2.5) > O_2(2.0) > O_2^-(1.5)$.

Final Answer: The correct order is $O_2^+ > O_2 > O_2^-$.

Answer: (A)

Q31.

Solution

Concept: Lattice enthalpy ($\Delta_{lattice}H$) is the energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions. According to Coulomb's Law, lattice enthalpy is directly proportional to the product of the charges on the ions (q_1, q_2) and inversely proportional to the distance between them (r):

$$\Delta_{lattice}H \propto \frac{|q_1 \cdot q_2|}{r_0}$$

where r_0 is the sum of the radii of the cation and anion ($r_+ + r_-$).

Solution: 1. **Charge Factor:** In all given options (LiF, NaCl, KBr, RbI), the ions are univalent (charge is +1 and -1). Thus, the charge factor is constant. 2. **Size Factor:** We must look at the ionic sizes. Lattice enthalpy increases as the ionic radii decrease because the ions can get closer together, increasing the electrostatic attraction. 3. **Comparison:** - Cations: $Li^+ < Na^+ < K^+ < Rb^+$ (Group 1 trend) - Anions: $F^- < Cl^- < Br^- < I^-$ (Group 17 trend) 4. **Conclusion:** LiF consists of the smallest cation (Li^+) and the smallest anion (F^-) among the choices. This results in the smallest inter-nuclear distance and, consequently, the highest lattice enthalpy.

Final Answer: LiF is expected to have the highest lattice enthalpy.

Answer: (A)

Q32.

Solution

Concept: We use Molecular Orbital (MO) Theory to determine Bond Order (B.O.) and magnetic properties. Bond order increases when electrons are removed from antibonding orbitals or added to bonding orbitals. Paramagnetism occurs with unpaired electrons; diamagnetism occurs when all electrons are paired.

Solution: 1. **Analyzing** $NO \rightarrow NO^+$**:** - NO (15 electrons): Configuration is $\sigma^2_{1s}\sigma^{*2}_{1s}\sigma^2_{2s}\sigma^{*2}_{2s}\sigma^2_{2p_z}(\pi^2_{2p_x} = \pi^2_{2p_y})(\pi^{*1}_{2p_x})$. It has one unpaired electron in an antibonding orbital (π^*). It is **paramagnetic** with $B.O. = \frac{10-5}{2} = 2.5$. - NO^+ (14 electrons): The electron is removed from the antibonding π^* orbital. All electrons are now paired (**diamagnetic**). $B.O. = \frac{10-4}{2} = 3.0$. 2. **Other Options:** - $O_2 \rightarrow O_2^+$: Para → Para (B.O. increases from 2 to 2.5). - $N_2 \rightarrow N_2^+$: Dia → Para (B.O. decreases from 3 to 2.5). - $O_2 \rightarrow O_2^{2-}$: Para → Dia (B.O. decreases from 2 to 1).

Final Answer: In the transition $NO \rightarrow NO^+$, bond order increases and behavior changes from paramagnetic to diamagnetic.

Answer: (C)

Q33.

Solution

Concept: IUPAC nomenclature for coordination compounds follows specific rules: 1. Name the cation first. 2. Name ligands in alphabetical order. 3. Use Greek prefixes for quantity. 4. If the complex ion is an anion, the metal name ends in '-ate'. 5. Indicate the oxidation state of the metal in Roman numerals.

Solution: 1. **Identify the parts:** The cation is Potassium (K^+). The complex anion is $[Fe(CN)_6]^{3-}$. 2. **Oxidation State of Fe:** Let it be x.

$$3(+1) + x + 6(-1) = 0 \implies 3 + x - 6 = 0 \implies x = +3$$

3. **Naming the Complex Anion:** - Ligands: six cyanide groups → hexacyano. - Metal: Since the complex is an anion, Iron becomes 'ferrate'. - Complete anion: hexacyanoferrate(III). 4. **Full Name:** Potassium hexacyanoferrate(III). (Note: We do not say 'Tripotassium').

Final Answer: The correct IUPAC name is Potassium hexacyanoferrate(III).

Answer: (B)

Q34.

Solution

Concept: Geometrical isomerism (cis-trans) in square planar complexes typically occurs in complexes of the type $[MA_2B_2]$ or $[MA_2BC]$, where different spatial arrangements of the same ligands are possible relative to the central metal.

Solution: 1. $[Pt(NH_3)_3Cl]^+$**:** Type $[MA_3B]$. No geometrical isomers are possible because swapping any NH_3 with Cl results in an identical structure. 2. $[Pt(NH_3)Cl_3]^-$**:** Type $[MAB_3]$. Similarly, no geometrical isomers possible. 3. $[Pt(NH_3)_2Cl_2]$**:** Type $[MA_2B_2]$. This can exist as: - **cis-isomer:** The two Cl ligands are adjacent (90 degrees apart). - **trans-isomer:** The two Cl ligands are opposite (180 degrees apart). 4. $[Pt(NH_3)_4]^{2+}$**:** Type $[MA_4]$. All positions are occupied by identical ligands; no isomerism.

Final Answer: $[Pt(NH_3)_2Cl_2]$ can exhibit geometrical isomerism.

Answer: (C)

Q35.

Solution

Concept: In an octahedral crystal field, the d-orbitals split into two sets: the lower energy t_{2g} set (three orbitals) and the higher energy e_g set (two orbitals). The energy difference is denoted as Δ_o. Electrons in t_{2g} orbitals are stabilized by $-0.4\Delta_o$ each, while electrons in e_g orbitals are destabilized by $+0.6\Delta_o$ each.

Solution: 1. **High-spin d^4 configuration:** In a high-spin complex, the pairing energy is greater than the splitting energy ($P > \Delta_o$). Therefore, the fourth electron enters the e_g level rather than pairing up in the t_{2g} level. 2. **Electron Distribution:** The configuration is $t_{2g}^3 e_g^1$. 3. **CFSE Calculation:**

$$CFSE = [n(t_{2g}) \times (-0.4\Delta_o)] + [n(e_g) \times (+0.6\Delta_o)]$$

$$CFSE = [3 \times (-0.4\Delta_o)] + [1 \times (+0.6\Delta_o)]$$

$$CFSE = -1.2\Delta_o + 0.6\Delta_o = -0.6\Delta_o$$

Final Answer: The CFSE for a d^4 high-spin octahedral complex is $-0.6\Delta_o$.

Answer: (A)

Q36.

Solution

Concept: A complex is diamagnetic if all its electrons are paired. This depends on the oxidation state of the metal, its electronic configuration, and the strength of the ligands (which determines if the complex is high-spin or low-spin).

Solution: 1. $[Fe(CN)_6]^{3-}$**:** Fe^{3+} is d^5. CN^- is a strong field ligand (low spin), but d^5 always has at least one unpaired electron. (Paramagnetic). 2. $[Co(NH_3)_6]^{3+}$**:** Co^{3+} is d^6. NH_3 acts as a strong field ligand with Co^{3+}. In an octahedral field, the d^6 low-spin configuration is $t_{2g}^6 e_g^0$. All electrons are paired. (**Diamagnetic**). 3. $[NiCl_4]^{2-}$**:** Ni^{2+} is d^8. In a tetrahedral field (with weak Cl^-), the configuration has two unpaired electrons. (Paramagnetic). 4. $[Mn(H_2O)_6]^{2+}$**:** Mn^{2+} is d^5. H_2O is a weak field ligand (high spin), resulting in five unpaired electrons. (Paramagnetic).

Final Answer: $[Co(NH_3)_6]^{3+}$ is diamagnetic.

Answer: (B)

Q37.

Solution

Concept: Nitrogen oxides have distinct physical and magnetic properties based on their molecular structures and the presence of unpaired electrons.

Solution: 1. N_2O**:** Nitrous oxide is a colorless, diamagnetic gas. 2. NO**:** Nitric oxide is a colorless gas. While it is paramagnetic (odd electron molecule), it is not brown. 3. NO_2**:** Nitrogen dioxide contains an odd number of valence electrons ($5 + 6 \times 2 = 17$). The presence of one unpaired electron makes it **paramagnetic**. It is a well-known **brown-colored** gas. It can dimerize to colorless, diamagnetic N_2O_4. 4. N_2O_5**:** Dinitrogen pentoxide is a colorless solid (or gas when heated) and is diamagnetic.

Final Answer: NO_2 is a brown-colored paramagnetic gas.

Answer: (C)

Q38.

Solution

Concept: The hybridization of the central atom is determined by its steric number, which is the sum of the number of sigma (σ) bonds and the number of lone pairs on that atom.

$$\text{Steric Number} = \frac{1}{2}[V + M - C + A]$$

Where V = valence electrons of central atom, M = number of monovalent atoms, C = cationic charge, and A = anionic charge.

Solution: 1. **Central Atom:** Phosphorus (P) is in Group 15, so it has 5 valence electrons ($V = 5$). 2. **Monovalent Atoms:** There are 5 Chlorine atoms ($M = 5$). 3. **Calculation:** Steric Number = $\frac{1}{2}[5 + 5 - 0 + 0] = 5$. 4. **Hybridization:** A steric number of 5 corresponds to sp^3d hybridization. 5. **Geometry:** This results in a Trigonal Bipyramidal shape. Note that in the solid state, PCl_5 exists as $[PCl_4]^+[PCl_6]^-$, but the question specifies the gaseous state.

Final Answer: The hybridization of phosphorus in PCl_5 (gaseous) is sp^3d.

Answer: (B)

Q39.

Solution

Concept: In oxyacids of phosphorus, the reducing power is directly related to the number of $P-H$ bonds present. The hydrogen atom directly attached to phosphorus ($P-H$) is responsible for the reducing property, whereas $O-H$ bonds contribute to acidity.

Solution: 1. H_3PO_4 **(Orthophosphoric acid):** Structure contains zero $P-H$ bonds. It is not a reducing agent. 2. H_3PO_3 **(Orthophosphorous acid):** Structure contains one $P-H$ bond. It acts as a reducing agent. 3. H_3PO_2 **(Hypophosphorous acid):** Structure contains two $P-H$ bonds. Having the highest number of $P-H$ bonds among common oxyacids, it is the strongest reducing agent. 4. $H_4P_2O_7$ **(Pyrophosphoric acid):** Structure contains zero $P-H$ bonds.

Final Answer: H_3PO_2 acts as the strongest reducing agent.

Answer: (C)

Q40.

Solution

Concept: Noble gases are monoatomic and non-polar. The only intermolecular forces acting between them are weak London dispersion forces (induced dipole-induced dipole interactions).

Solution: 1. **Atomic Size:** As we move down the group from He to Rn, the atomic size and the number of electrons increase. 2. **Polarizability:** Larger electron clouds are more easily distorted or "polarized." Therefore, polarizability increases with atomic size. 3. **Intermolecular Forces:** The magnitude of London dispersion forces is proportional to the polarizability of the atom. 4. **Boiling Point:** Stronger dispersion forces require more energy to overcome, leading to a consistent increase in boiling point down the group.

Final Answer: The increase is due to the increase in polarizability and London dispersion forces.

Answer: (B)

Q41.

Solution

Concept: The oxidation state of an atom in a molecule is determined by its bonding structure. For compounds containing peroxide bonds (O-O), calculating the oxidation state using the standard formula (x + algebraic sum = 0) often leads to incorrect results if the structure is not considered.
Solution: 1. **Structure of CrO_5:** Chromium pentoxide has a "butterfly" structure. It contains one $Cr = O$ double bond and two peroxide ($O - O$) linkages. 2. **Bond Analysis:** - One oxygen atom is attached via a double bond (Oxidation state = -2). - Four oxygen atoms are part of peroxide bonds (Oxidation state = -1 each). 3. **Calculation:** Let the oxidation state of Chromium be x.

$$x + [1 \times (-2)] + [4 \times (-1)] = 0$$

$$x - 2 - 4 = 0 \implies x = +6$$

Final Answer: The oxidation state of Chromium in CrO_5 is +6.

Answer: (B)

Q42.

Solution

Concept: The electronic configuration of lanthanides generally follows the filling of the $4f$ subshell. However, extra stability is associated with half-filled (f^7) and completely filled (f^{14}) subshells.
Solution: 1. **Atomic Number:** Gadolinium (Gd) has $Z = 64$. The nearest noble gas is Xenon ($Xe, Z = 54$). 2. **Expected vs. Actual:** Based on the Aufbau principle, one might expect $[Xe]4f^8 6s^2$. 3. **Stability Factor:** To achieve a more stable, exactly half-filled $4f$ subshell, one electron remains in or shifts to the $5d$ orbital. 4. **Configuration:** This results in $[Xe]4f^7 5d^1 6s^2$. This configuration provides maximum exchange energy and symmetry.
Final Answer: The correct configuration is $[Xe]4f^7 5d^1 6s^2$.

Answer: (A)

Q43.

Solution

Concept: Oxidation states represent the number of electrons an atom loses or gains. In transition metals, these electrons come from the outermost s orbital and the inner d orbital.

Solution: 1. **Orbital Energy:** In transition elements, the electrons are filled in the $(n-1)d$ and ns subshells. 2. **Energy Gap:** The energy difference between the $(n-1)d$ and ns orbitals is very small. 3. **Availability:** Because the gap is minimal, both sets of electrons can participate in chemical bond formation. 4. **Result:** This allows transition metals to lose varying numbers of electrons, leading to a wide range of oxidation states (e.g., Manganese can range from +2 to +7).

Final Answer: Transition metals exhibit variable oxidation states because the energy difference between (n-1)d and ns orbitals is very small.

Answer: (A)

Q44.

Solution

Concept: Electronegativity is the tendency of an atom to attract a shared pair of electrons towards itself. In the periodic table, electronegativity generally increases from left to right across a period and decreases down a group.

Solution: 1. **Period 2 Elements:** The elements given are Carbon ($Z = 6$), Nitrogen ($Z = 7$), Oxygen ($Z = 8$), and Fluorine ($Z = 9$). 2. **Trend:** As we move from Carbon to Fluorine, the nuclear charge increases while the number of shells remains the same. This increases the effective nuclear charge, pulling electrons more strongly. 3. **Pauling Scale:** Fluorine is the most electronegative element in the entire periodic table, with a value of approximately 4.0. 4. **Values:** Carbon (2.5), Nitrogen (3.0), Oxygen (3.5), Fluorine (4.0).

Final Answer: Fluorine has the highest electronegativity value.

Answer: (C)

Q45.

Solution

Concept: Isoelectronic species have the same number of electrons. For these species, the size is determined by the nuclear charge (Z). A higher nuclear charge pulls the same number of electrons closer to the nucleus, decreasing the radius.

Solution: 1. **Electron Count:** All species ($O^{2-}, F^-, Na^+, Mg^{2+}$) have 10 electrons. 2. **Nuclear Charge (Z):** - O^{2-} : $Z = 8$ - F^- : $Z = 9$ - Na^+ : $Z = 11$ - Mg^{2+} : $Z = 12$ 3. **Relationship:** Ionic radius $\propto \frac{1}{Z}$. 4. **Conclusion:** Mg^{2+} has the highest nuclear charge and smallest size, while O^{2-} has the lowest nuclear charge and largest size.

Final Answer: The correct increasing order is $Mg^{2+} < Na^+ < F^- < O^{2-}$.

Answer: (A)

Q46.

Solution

Concept: The elevation in boiling point (ΔT_b) is a colligative property defined by the formula:

$$\Delta T_b = K_b \times m$$

where m is the molality of the solution. Molality is further defined as:

$$m = \frac{\text{Mass of solute } (w_2) \times 1000}{\text{Molar mass of solute } (M_2) \times \text{Mass of solvent in g } (w_1)}$$

Solution: 1. **Calculate ΔT_b:** - Boiling point of solution (T_b) = $100.52°C$ - Boiling point of pure water (T_b°) = $100.00°C$ - $\Delta T_b = T_b - T_b^\circ = 100.52 - 100.00 = 0.52\ K$ (or $°C$) 2. **Given Data:** - Mass of solute (w_2) = $10\ g$ - Mass of solvent (w_1) = $100\ g$ - K_b for water = $0.52\ K\ kg\ mol^{-1}$ 3. **Substitute into the Molality equation:**

$$0.52 = 0.52 \times \frac{10 \times 1000}{M_2 \times 100}$$

4. **Simplify and Solve for M_2:** - Divide both sides by 0.52:

$$1 = \frac{10 \times 10}{M_2}$$

$$1 = \frac{100}{M_2}$$

$$M_2 = 100\ g\ mol^{-1}$$

Final Answer: The molar mass of the solute is $100\ g\ mol^{-1}$.

Answer: (A)

Q47.

Solution

Concept: According to Bohr's model of the atom, the radius of the n^{th} orbit (r_n) for a hydrogen-like species (a species with only one electron) is given by the formula:

$$r_n = a_o \times \frac{n^2}{Z}$$

where:

- a_o is the Bohr radius (0.529 Å).
- n is the principal quantum number (orbit number).
- Z is the atomic number of the species.

Solution: 1. **Identify the values for He^+:** - For Helium (He), the atomic number $Z = 2$. - We are looking for the radius of the **second** Bohr orbit, so $n = 2$. 2. **Substitute into the formula:**

$$r_2 = 0.529 \text{ Å} \times \frac{2^2}{2}$$

3. **Calculate:**

$$r_2 = 0.529 \text{ Å} \times \frac{4}{2}$$

$$r_2 = 0.529 \text{ Å} \times 2$$

$$r_2 = 1.058 \text{ Å}$$

Final Answer: The radius of the second Bohr orbit for He^+ is 1.058 Å.

Answer: (B)

Q48.

Solution

Concept: The spontaneity of a chemical reaction is determined by the change in Gibbs Free Energy (ΔG), as defined by the Gibbs-Helmholtz equation:

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

A reaction is spontaneous only if $\Delta G < 0$.

Solution: 1. **The Condition:** We need the reaction to be spontaneous ($\Delta G < 0$) at **high temperatures** and non-spontaneous ($\Delta G > 0$) at **low temperatures**. 2. **Analysis of Signs:** - If **ΔH is positive (+ve)**: The reaction is endothermic. The first term in the equation ($+\Delta H$) opposes spontaneity. - If **ΔS is positive (+ve)**: The second term ($-T\Delta S$) becomes increasingly negative as temperature (T) increases. 3. **Temperature Dependence:** - At **low T**, the magnitude of $T\Delta S$ is small. If ΔH is positive, then $\Delta G \approx \Delta H$, which is > 0 (non-spontaneous). - At **high T**, the magnitude of $T\Delta S$ becomes larger than ΔH. Since ΔS is positive, the term $-T\Delta S$ will dominate, making ΔG negative (spontaneous). 4. **Conclusion:** This specific temperature dependency (spontaneous only when hot) occurs when both enthalpy and entropy changes are positive.

Final Answer: The signs must be $\Delta H = +ve$ and $\Delta S = +ve$.

Answer: (A)

Q49.

Solution

Concept: The pH of an acidic buffer solution (a mixture of a weak acid and its salt with a strong base) is calculated using the **Henderson-Hasselbalch equation**:

$$pH = pK_a + \log_{10}\frac{[\text{Salt}]}{[\text{Acid}]}$$

Where pK_a is the negative logarithm of the acid dissociation constant, [Salt] is the concentration of the conjugate base, and [Acid] is the concentration of the weak acid.

Solution: 1. **Identify the Given Values:** - Concentration of Acid ($[CH_3COOH]$) = 0.1 M - Concentration of Salt ($[CH_3COONa]$) = 0.1 M - pK_a of acetic acid = 4.74 2. **Substitute into the Equation:**

$$pH = 4.74 + \log_{10}\left(\frac{0.1}{0.1}\right)$$

3. **Calculate:** - The ratio $\frac{0.1}{0.1} = 1$. - We know that $\log_{10}(1) = 0$. - Therefore, $pH = 4.74 + 0 = 4.74$. 4. **Conclusion:** When the concentration of the acid and its conjugate base are equal, the pH of the buffer is equal to its pK_a.

Final Answer: The pH of the buffer solution is 4.74.

Answer: (A)

Q50.

Solution

Concept: The standard EMF (E°) of a galvanic cell is the difference between the standard reduction potentials of the cathode and the anode.

$$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$$

In cell notation ($Anode||Cathode$), the species on the left (Zn) undergoes oxidation at the anode, and the species on the right (Fe) undergoes reduction at the cathode.

Solution: 1. **Identify the Electrodes:** - **Anode (Oxidation):** $Zn \rightarrow Zn^{2+} + 2e^-$ - **Cathode (Reduction):** $Fe^{2+} + 2e^- \rightarrow Fe$ 2. **Assign Potentials:** - $E^\circ_{Zn^{2+}/Zn} = -0.76\ V$ (Anode potential) - $E^\circ_{Fe^{2+}/Fe} = -0.44\ V$ (Cathode potential) 3. **Calculate the Cell EMF:**

$$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$$

$$E^\circ_{cell} = (-0.44\ V) - (-0.76\ V)$$

$$E^\circ_{cell} = -0.44 + 0.76$$

$$E^\circ_{cell} = +0.32\ V$$

4. **Conclusion:** Since the E°_{cell} is positive, the reaction is spontaneous as written.

Final Answer: The standard EMF (E°) for the cell is $0.32\ V$.

Answer: (C)

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	A	3	B	4	A	5	B
6	B	7	C	8	C	9	D	10	C
11	A	12	B	13	C	14	C	15	A
16	B	17	A	18	B	19	B	20	A
21	A	22	A	23	A	24	A	25	B
26	C	27	B	28	A	29	A	30	A
31	A	32	C	33	B	34	C	35	A
36	B	37	C	38	B	39	C	40	B
41	B	42	A	43	A	44	C	45	A
46	A	47	B	48	A	49	A	50	C