MHT-CET Chemistry Sample Paper-19

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. Identify the most stable carbocation among the following:

(A) $(CH_3)_3C^+$

(B) $(C_6H_5)_3C^+$

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

(D) $(C_6H_5)_2CH^+$

Q2. How many structural isomers are possible for the molecular formula $C_4H_{10}O$?

(A) 4

(B) 5

(C) 7

(D) 8

Q3. The correct order of acid strength for: (i) Phenol, (ii) p-Nitrophenol, (iii) m-Nitrophenol, (iv) p-Methylphenol is:

(A) ii > iii > i > iv

(B) ii > iv > iii > i

(C) iv > i > iii > ii

(D) i > ii > iii > iv

Q4. Which of the following compounds will undergo Cannizzaro reaction?

(A) Acetaldehyde

(B) Propionaldehyde

(C) Benzaldehyde

(D) Acetone

Q5. In the reaction: Ethyne + Water (dil. H_2SO_4, $HgSO_4$) $\rightarrow$ A. The product A is:

(A) Ethanol

(B) Acetone

(C) Acetaldehyde

(D) Ethylene glycol

Q6. The monomer of Neoprene is:

(A) Isoprene

(B) Chloroprene

(C) Acrylonitrile

(D) Vinyl chloride

Q7. Which of the following is a non-reducing sugar?

(A) Glucose

(B) Fructose

(C) Maltose

(D) Sucrose

Q8. According to VSEPR theory, the shape of ClF_3 molecule is:

(A) Trigonal planar

(B) Pyramidal

(C) T-shaped

(D) Tetrahedral

Q9. The formal charge on the central oxygen atom in Ozone (O_3) is:

(A) 0

(B) +1

(C) -1

(D) +2

Q10. The IUPAC name of $K_3[Fe(CN)_6]$ is:

(A) Potassium ferricyanide

(B) Potassium hexacyanoiron(III)

(C) Potassium hexacyanoferrate(III)

(D) Potassium hexacyanoferrate(II)

Q11. Which among the following is an outer orbital complex?

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

(B) $[Mn(CN)_6]^{3-}$

(C) $[Fe(H_2O)_6]^{3+}$

(D) $[Co(ox)_3]^{3-}$

Q12. The most basic oxide among the following is:

(A) Na_2O

(B) Al_2O_3

(C) SiO_2

(D) P_4O_{10}

Q13. The element with the highest electron gain enthalpy in Group 16 is:

(A) O

(B) S

(C) Se

(D) Te

Q14. The oxidation state of Cr in CrO_5 is:

(A) +10

(B) +6

(C) +4

(D) +5

Q15. What is the amount of work done when 2 moles of an ideal gas expand from 10 L to 20 L at 300 K against a constant pressure of 1 atm?

(A) -1013 J

(B) -2026 J

(C) -10.13 J

(D) -3039 J

Q16. The pH of 0.001 M $NaOH$ solution is:

(A) 3

(B) 11

(C) 10

(D) 13

Q17. In a cell: $Zn \mid Zn^{2+}(1M) \parallel Cu^{2+}(1M) \mid Cu$, the E°_{cell} is 1.10 V. If $E^{\circ}(Zn^{2+}/Zn) = -0.76$ V, then $E^{\circ}(Cu^{2+}/Cu)$ is:

(A) 0.34 V

(B) -0.34 V

(C) 1.86 V

(D) -1.86 V

Q18. The number of atoms per unit cell in a Face-Centered Cubic (FCC) lattice is:

(A) 1

(B) 2

(C) 4

(D) 6

Q19. Which of the following shows the highest boiling point?

(A) n-Pentane

(B) Isopentane

(C) Neopentane

(D) n-Butane

Q20. The reagent used for Clemmensen reduction is:

(A) $LiAlH_4$

(B) $NaBH_4$

(C) Zn-Hg / Conc. HCl

(D) $NH_2 - NH_2$ / KOH

Q21. Gabriel Phthalimide synthesis is used for the preparation of:

(A) Primary aliphatic amines

(B) Primary aromatic amines

(C) Secondary amines

(D) Tertiary amines

Q22. The secondary structure of protein is stabilized by:

(A) Peptide bonds

(B) Hydrogen bonds

(C) Glycosidic bonds

(D) Phosphodiester bonds

Q23. Which gas is evolved when PCl_5 reacts with water?

(A) Cl_2

(B) PH_3

(C) HCl

(D) O_2

Q24. The magnetic moment of Mn^{2+} ion ($Z = 25$) is:

(A) 5.92 BM

(B) 4.90 BM

(C) 3.87 BM

(D) 1.73 BM

Q25. Bond order of N_2^+ is:

(A) 3.0

(B) 2.5

(C) 2.0

(D) 1.5

Q26. Lucas reagent is a mixture of:

(A) Conc. HCl + Anhydrous $ZnCl_2$

(B) Conc. HNO_3 + Conc. H_2SO_4

(C) Dil. HCl + $ZnCl_2$

(D) Conc. HCl + $KMnO_4$

Q27. Phenol reacts with Bromine water to give:

(A) o-Bromophenol

(B) p-Bromophenol

(C) 2,4,6-Tribromophenol

(D) m-Bromophenol

Q28. The rate constant of a first-order reaction is 0.0693 min^{-1}. The half-life of the reaction is:

(A) 10 min

(B) 100 min

(C) 69.3 min

(D) 0.693 min

Q29. Which of the following transitions in the Hydrogen atom emits a photon of the highest energy?

(A) n=2 to n=1

(B) n=4 to n=3

(C) n=3 to n=2

(D) n=5 to n=4

Q30. Isocyanide test is used to detect:

(A) Primary amines

(B) Secondary amines

(C) Tertiary amines

(D) Nitro compounds

Q31. Williamson's synthesis involves:

(A) S_N1 mechanism

(B) S_N2 mechanism

(C) $E1$ mechanism

(D) $E2$ mechanism

Q32. The enzyme that converts glucose to ethyl alcohol is:

(A) Diastase

(B) Maltase

(C) Zymase

(D) Invertase

Q33. Which of the following contains a P-P bond?

(A) $H_4P_2O_7$

(B) $H_4P_2O_6$

(C) $H_4P_2O_5$

(D) $(HPO_3)_3$

Q34. The Lanthanoid contraction is responsible for the fact that:

(A) Zr and Hf have same radius

(B) Zr and Zn have same radius

(C) Zr and Y have same radius

(D) Zr and Nb have same radius

Q35. The coordination number of Co in $[Co(en)_3]^{3+}$ is:

(A) 3

(B) 4

(C) 6

(D) 2

Q36. An intensive property among the following is:

(A) Mass

(B) Volume

(C) Enthalpy

(D) Temperature

Q37. For a spontaneous process at all temperatures:

(A) ΔH is -ve, ΔS is +ve

(B) ΔH is +ve, ΔS is -ve

(C) ΔH is -ve, ΔS is -ve

(D) ΔH is +ve, ΔS is +ve

Q38. The unit of molar conductivity is:

(A) $S\ cm^2\ mol^{-1}$

(B) $S\ cm\ mol^{-1}$

(C) $S\ cm^2\ mol$

(D) $S^{-1}\ cm^2\ mol^{-1}$

Q39. Terylene is a condensation polymer of ethylene glycol and:

(A) Adipic acid

(B) Terephthalic acid

(C) Phthalic acid

(D) Salicylic acid

Q40. Which of the following is most reactive towards nucleophilic addition?

(A) HCHO

(B) CH_3CHO

(C) CH_3COCH_3

(D) $C_6H_5COCH_3$

Q41. Reimer-Tiemann reaction converts phenol to:

(A) Salicylaldehyde

(B) Salicylic acid

(C) Benzene

(D) Picric acid

Q42. How many P-OH bonds are present in Orthophosphoric acid?

(A) 1

(B) 2

(C) 3

(D) 4

Q43. Which of the following is a diamagnetic ion?

(A) Cu^{2+}

(B) Ni^{2+}

(C) Ti^{4+}

(D) Co^{2+}

Q44. The boiling point of water is higher than H_2S because of:

(A) Molecular weight

(B) Hydrogen bonding

(C) Van der Waals forces

(D) Ionic bonding

Q45. The percentage of empty space in a Body-Centered Cubic (BCC) unit cell is:

(A) 32%

(B) 48%

(C) 26%

(D) 74%

Q46. Oxidation of 1-propanol with alkaline $KMnO_4$ gives:

(A) Propanal

(B) Propanoic acid

(C) Propanone

(D) Propane

Q47. Hoffmann Bromamide degradation of Acetamide gives:

(A) Methylamine

(B) Ethylamine

(C) Aniline

(D) Ammonia

Q48. The hybridization of Carbon in Ethene is:

(A) sp

(B) sp^2

(C) sp^3

(D) dsp^2

Q49. Which of the following is a neutral amino acid?

(A) Lysine

(B) Glycine

(C) Aspartic acid

(D) Arginine

Q50. The solubility of a gas in a liquid is directly proportional to its partial pressure. This is:

(A) Raoult's Law

(B) Henry's Law

(C) Dalton's Law

(D) Gay-Lussac's Law

Detailed Solutions

Q1.

Solution

Concept:

The stability of carbocations is primarily governed by the delocalization of the positive charge. This occurs through various electronic effects: inductive effect ($+I$), hyperconjugation, and resonance (mesomeric effect). Resonance is generally the most powerful stabilizing factor among these. When a positive charge is in conjugation with a π-system, such as a benzene ring, the charge is distributed over multiple atoms, significantly lowering the potential energy of the ion.

Solution:

1. In $(CH_3)_3C^+$ (tert-butyl carbocation), stability is provided by the $+I$ effect of three methyl groups and 9 hyperconjugative $C-H$ bonds.
2. In $CH_2=CH-CH_2^+$ (allyl carbocation), the positive charge is stabilized by resonance with one double bond, resulting in 2 resonating structures.
3. In $(C_6H_5)_2CH^+$ (benzhydryl carbocation), the charge is delocalized over two phenyl rings, providing extensive resonance stabilization.
4. In $(C_6H_5)_3C^+$ (triphenylmethyl carbocation), the positive charge is in direct conjugation with three phenyl rings. This allows the charge to be delocalized over the ortho and para positions of all three rings, leading to a total of 10 major resonating structures.
5. Because resonance stabilization increases with the number of phenyl groups, the triphenylmethyl carbocation is the most stable among the options provided.

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

Answer: (B)

Q2.

Solution

Concept:

Structural isomerism (constitutional isomerism) occurs when molecules have the same molecular formula but different connectivity. For $C_4H_{10}O$, we calculate the Degree of Unsaturation (DoU) to determine the types of functional groups possible.

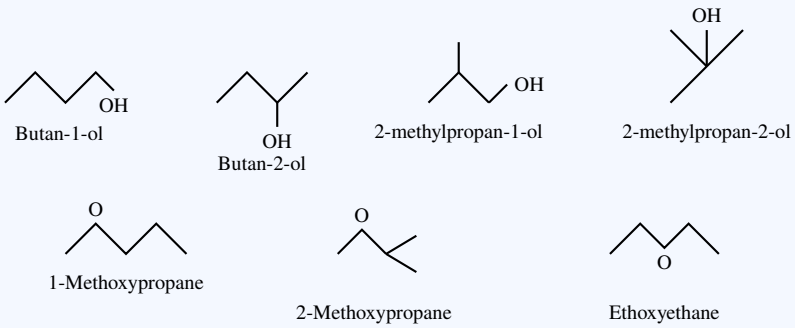
Solution:

Step 1: Calculate DoU. DoU = $\frac{2(4)+2-10}{2}$ = 0. The molecule is saturated (no rings or double bonds). It can only be an **alcohol** or an **ether**.

Step 2: Alcohols (4 isomers). These are formed by attaching an -OH group to the different butyl skeletons (n-butyl, sec-butyl, isobutyl, and tert-butyl).

Step 3: Ethers (3 isomers). These are formed by inserting an Oxygen atom between carbon chains: methyl-propyl, methyl-isopropyl, and diethyl.

Step 4: Total count is 4 + 3 = 7.



Final Answer:

$\boxed{7}$

Answer: (C)

Q3.

Solution

Concept:

The acidity of substituted phenols is determined by the stability of the resulting phenoxide ion. Electron-withdrawing groups (EWG) stabilize the phenoxide ion by dispersing the negative charge, thereby increasing acidity. Electron-donating groups (EDG) destabilize the phenoxide ion by intensifying the negative charge, thereby decreasing acidity. Common effects involved include the inductive effect (I) and the resonance/mesomeric effect (M).

Solution:

1. **p-Nitrophenol (ii):** The $-NO_2$ group is a strong EWG. At the para position, it exerts both $-I$ and $-M$ effects. The $-M$ effect directly delocalizes the negative charge from the oxygen, making it the most acidic.
2. **m-Nitrophenol (iii):** At the meta position, the $-NO_2$ group cannot exert a $-M$ effect due to the nature of resonance. However, it still exerts a strong $-I$ effect, making it more acidic than phenol but less than the para isomer.
3. **Phenol (i):** This has no substituents and serves as the baseline.
4. **p-Methylphenol (iv):** The $-CH_3$ group is an EDG due to the $+I$ effect and hyperconjugation. This destabilizes the phenoxide ion, making it less acidic than phenol.
5. Order: p-Nitrophenol > m-Nitrophenol > Phenol > p-Methylphenol (ii > iii > i > iv).

Final Answer: The correct order of acid strength is ii > iii > i > iv.

Answer: (A)

Q4.

Solution

Concept:

The Cannizzaro reaction is a disproportionation reaction specifically for aldehydes that do not have any α-hydrogen atoms. In the presence of a concentrated strong base (like 50%$NaOH$), one molecule of the aldehyde is reduced to a primary alcohol, while another is oxidized to the salt of a carboxylic acid. If an aldehyde has α-hydrogens, it undergoes Aldol Condensation instead because the base abstracts the acidic α-hydrogen.

Solution:

1. **Acetaldehyde (CH_3CHO):** Contains 3 α-hydrogens on the CH_3 group. It undergoes Aldol condensation.
2. **Propionaldehyde (CH_3CH_2CHO):** Contains 2 α-hydrogens on the CH_2 group. It undergoes Aldol condensation.
3. **Acetone (CH_3COCH_3):** This is a ketone with 6 α-hydrogens. It does not undergo the Cannizzaro reaction.
4. **Benzaldehyde (C_6H_5CHO):** The CHO group is attached to a benzene ring carbon that has no hydrogens. Since it lacks α-hydrogens, it undergoes the Cannizzaro reaction:

$$2C_6H_5CHO + NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COONa$$

Producing benzyl alcohol and sodium benzoate.

Final Answer: Benzaldehyde will undergo the Cannizzaro reaction.

Answer: (C)

Q5.

Solution

Concept:

The reaction of alkynes with water in the presence of sulfuric acid and mercuric sulfate is known as the Kucherov reaction. It is an electrophilic addition reaction. The Hg^{2+} ion acts as a catalyst by forming a complex with the triple bond, facilitating the addition of water. The initial product is an enol, which is unstable and undergoes tautomerization to form a carbonyl compound.

Solution:

1. Ethyne ($CH \equiv CH$) reacts with water ($H - OH$) in the presence of $dil.H_2SO_4$ and $HgSO_4$ catalyst.
2. Addition of one molecule of water across the triple bond yields Vinyl alcohol:

$$CH \equiv CH + H_2O \xrightarrow{HgSO_4/H_2SO_4} [CH_2 = CH - OH]$$

3. The compound $[CH_2 = CH - OH]$ is an enol (alkene + alcohol). Enols are generally unstable compared to their keto forms.
4. The enol undergoes keto-enol tautomerization, where the π-bond shifts to form a $C = O$ bond and the hydrogen shifts to the adjacent carbon:

$$CH_2 = CH - OH \rightleftharpoons CH_3 - CHO$$

5. The resulting stable product is Acetaldehyde (Ethanal).

Final Answer: The product A is Acetaldehyde.

Answer: (C)

Q6.

Solution

Concept:

Polymers are classified into several categories based on their origin, structure, and molecular forces. Synthetic rubbers like Neoprene are elastomers formed by the addition polymerization of substituted 1,3-butadiene derivatives. The properties of the polymer, such as its high resistance to chemical breakdown and oxidation, are largely determined by the nature of the substituent (halogen or alkyl group) present on the monomeric unit.

Solution:

1. Neoprene is a synthetic rubber also referred to as polychloroprene.
2. The formation of Neoprene involves the polymerization of the monomer 2-chloro-1,3-butadiene.
3. The chemical structure of this monomer consists of a butadiene chain with a chlorine atom substituted at the second carbon position:

$$CH_2 = C(Cl) - CH = CH_2$$

4. The common name for this specific molecule is Chloroprene.
5. During the polymerization reaction, the double bonds shift to allow the formation of a long chain:

$$n\ \mathrm{CH_2} = C(Cl) - CH = CH_2 \rightarrow -[CH_2 - C(Cl) = CH - CH_2]_n -$$

6. In contrast, Isoprene (2-methyl-1,3-butadiene) is the monomer for natural rubber, and Vinyl chloride is used for PVC. Therefore, Chloroprene is the unique monomeric unit for Neoprene.

Final Answer: The monomer of Neoprene is Chloroprene.

Answer: (B)

Q7.

Solution

Concept:

Carbohydrates are classified as reducing or non-reducing based on the presence of a free aldehydic or ketonic functional group. In a cyclic structure, this is identified by the presence of a hemiacetal or hemiketal group at the anomeric carbon. Reducing sugars can reduce mild oxidizing agents like Tollen's reagent (Ag^+ to Ag) or Fehling's solution (Cu^{2+} to Cu^+). In non-reducing sugars, these functional groups are involved in glycosidic linkages and are not free to act as reducing agents.

Solution:

1. **Glucose:** An aldohexose with a free aldehyde group at C1 in its open-chain form. It is a reducing sugar.
2. **Fructose:** A ketohexose which, despite being a ketone, acts as a reducing sugar because it undergoes tautomerization to an aldose in alkaline conditions (Enediol rearrangement).
3. **Maltose:** A disaccharide composed of two α-D-glucose units. The glycosidic bond is $(1 \rightarrow 4)$, meaning the anomeric carbon (C1) of the second glucose unit remains free. Thus, it is a reducing sugar.
4. **Sucrose:** A disaccharide composed of α-D-glucose and β-D-fructose. The linkage is formed between the C1 of glucose and the C2 of fructose. Since C1 and C2 are the respective anomeric (reducing) carbons for these molecules, both functional groups are "locked" in the glycosidic bond.
5. Because sucrose lacks a free hemiacetal or hemiketal group, it cannot reduce Tollen's or Fehling's reagents.

Final Answer: Sucrose is a non-reducing sugar.

Answer: (D)

Q8.

Solution

Concept:

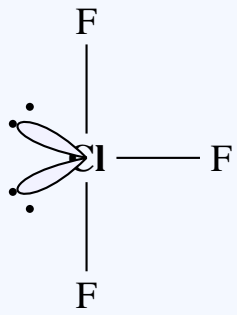
According to VSEPR theory, the geometry of a molecule is determined by the total number of valence shell electron pairs (Steric Number) around the central atom. Repulsions follow the order: $lp - lp > lp - bp > bp - bp$.

Solution:

Step 1: Find the total valence electrons for ClF_3. $Cl = 7$ (Group 17) $3 \times F = 3 \times 7 = 21$ Total = 28 electrons.

Step 2: Determine the Steric Number (SN). Bond Pairs $(bp) = 3$ Lone Pairs $(lp) = \frac{28-(3\times8)}{2} = \frac{4}{2} = 2$ SN = 3 + 2 = 5.

Step 3: Determine Geometry and Shape. For SN = 5, the electron geometry is **trigonal bipyramidal**. To minimize $lp - lp$ repulsions, the two lone pairs occupy the equatorial positions. The remaining three F atoms occupy the two axial and one equatorial positions, resulting in a **T-shaped** molecular geometry.



T-shaped Geometry

Final Answer:

T-shaped

Answer: (C)

Q9.

Solution

Concept:

Formal charge is a theoretical charge assigned to an atom in a molecule, assuming that electrons in all chemical bonds are shared equally. It helps in identifying the most stable Lewis structure. The formula for calculating formal charge (FC) is:

$$\text{FC} = [V] - [L] - \frac{1}{2}[B]$$

Where: V = Valence electrons in the free atom. L = Number of non-bonding (lone) electrons. B = Number of bonding electrons.

Solution:

1. Ozone (O_3) has a bent structure with a central oxygen atom (O_b) connected to two terminal oxygen atoms (O_a and O_c).
2. In one of the major resonance structures: - The central oxygen atom is connected to one terminal oxygen via a double bond and to the other via a single bond.
3. For the central oxygen atom ($O_{central}$): - Valence electrons (V) = 6. - It has 1 lone pair, so non-bonding electrons (L) = 2. - It is involved in 3 bonds (one double and one single), so bonding electrons (B) = 6.
4. Calculation:

$$\text{FC} = 6 - 2 - \frac{1}{2}(6) = 6 - 2 - 3 = +1$$

5. The terminal oxygen with the single bond has a charge of -1, and the terminal oxygen with the double bond has a charge of 0. The total charge is $+1 + (-1) + 0 = 0$.

Final Answer: The formal charge on the central oxygen atom in Ozone is +1.

Answer: (B)

Q10.

Solution

Concept:

IUPAC naming of coordination compounds follows a standardized set of rules. The cation is named first, followed by the anion. Inside the coordination sphere, ligands are listed alphabetically with numerical prefixes (like hexa-). The name of the central metal atom is followed by its oxidation state in Roman numerals in parentheses. If the complex ion is an anion, the metal's name must end with the suffix "-ate."

Solution:

1. The compound is $K_3[Fe(CN)_6]$. Here, K^+ is the cation (Potassium) and $[Fe(CN)_6]^{3-}$ is the complex anion.
2. Within the complex anion: - The ligand is CN^- (Cyanido or Cyano). - There are 6 ligands, so the prefix is "hexacyano".
3. To find the oxidation state of Iron (Fe): - $3(+1) + x + 6(-1) = 0$ - $3 + x - 6 = 0 \Rightarrow x = +3$.
4. Since the complex part is an anion, the metal Iron takes its Latin name "Ferrum" with the suffix "-ate", becoming "Ferrate".
5. Assembling the name: - Cation: Potassium - Ligands: hexacyano - Metal: ferrate - Oxidation state: (III)
6. Full name: Potassium hexacyanoferrate(III).

Final Answer: The IUPAC name of $K_3[Fe(CN)_6]$ is Potassium hexacyanoferrate(III).

Answer: (C)

Q11.

Solution

Concept:

Complexes are classified as inner orbital or outer orbital based on the d-orbitals used in hybridization. This is governed by the strength of the ligands (Spectrochemical series). Strong field ligands (like CN^- or NH_3 with certain metals) cause pairing of electrons, allowing the use of inner $(n-1)d$ orbitals (d^2sp^3 hybridization). Weak field ligands (like H_2O or F^-) do not cause pairing, so the metal uses outer nd orbitals (sp^3d^2 hybridization).

Solution:

1. $[Co(NH_3)_6]^{3+}$: Co^{3+} is a d^6 system. NH_3 acts as a strong field ligand here, causing pairing. It uses inner $3d$ orbitals. It is an inner orbital complex.
2. $[Mn(CN)_6]^{3-}$: Mn^{3+} is a d^4 system. CN^- is a very strong ligand, causing pairing and using inner $3d$ orbitals. It is an inner orbital complex.
3. $[Fe(H_2O)_6]^{3+}$: Fe^{3+} is a d^5 system. H_2O is a weak field ligand. It cannot force the 5 unpaired electrons to pair up. Therefore, the $3d$ orbitals are unavailable for hybridization. The metal must use the outer $4d$ orbitals, resulting in sp^3d^2 hybridization.
4. $[Co(ox)_3]^{3-}$: Oxalate is generally a strong enough ligand for Co^{3+} to cause pairing, leading to an inner orbital complex.
5. Since $[Fe(H_2O)_6]^{3+}$ uses the outer $4d$ shell, it is an outer orbital complex.

Final Answer: $[Fe(H_2O)_6]^{3+}$ is an outer orbital complex.

Answer: (C)

Q12.

Solution

Concept:

The nature of oxides (acidic, basic, or amphoteric) follows a periodic trend. Generally, metallic oxides are basic, while non-metallic oxides are acidic. Across a period from left to right, the metallic character decreases and electronegativity increases, causing the oxides to transition from strongly basic to amphoteric and finally to strongly acidic. Down a group, the basic character of oxides increases as the metallic character increases.

Solution:

1. Na_2O: Sodium is an alkali metal (Group 1). Its oxide reacts vigorously with water to form $NaOH$, a strong base. It is a strongly basic oxide.
2. Al_2O_3: Aluminum is in Group 13. Its oxide shows both acidic and basic properties (reacts with both acids and bases), making it amphoteric.
3. SiO_2: Silicon is a metalloid/non-metal in Group 14. Its oxide is weakly acidic.
4. P_4O_{10}: Phosphorus is a non-metal in Group 15. Its oxide reacts with water to form phosphoric acid, making it a strongly acidic oxide.
5. Comparing the positions in Period 3 (Na, Al, Si, P), Sodium is the most electropositive element, making its oxide the most basic.

Final Answer: The most basic oxide is Na_2O.

Answer: (A)

Q13.

Solution

Concept:

Electron gain enthalpy ($\Delta_{eg}H$) is the energy change when an electron is added to a neutral gaseous atom. Generally, it becomes more negative across a period and less negative down a group. However, an anomaly exists in the second and third periods. Atoms of the second period (like Oxygen) are very small, leading to high inter-electronic repulsions when an extra electron is added, which makes the electron gain enthalpy less negative than expected.

Solution:

1. In Group 16 (Chalcogens), the elements are O, S, Se, Te, Po.
2. Oxygen (O) has a very small atomic size. The addition of an electron into the compact $2p$ subshell results in significant electron-electron repulsion.
3. Sulfur (S) has a larger atomic size than oxygen. The $3p$ subshell is more spread out, so the added electron experiences much less repulsion from the existing electrons.
4. Consequently, Sulfur releases more energy upon gaining an electron compared to Oxygen.
5. As we move further down from Sulfur to Selenium and Tellurium, the atomic size increases further, and the effective nuclear charge felt by the incoming electron decreases, making the electron gain enthalpy less negative again.
6. Therefore, Sulfur has the highest (most negative) electron gain enthalpy in Group 16.

Final Answer: The element with the highest electron gain enthalpy in Group 16 is S.

Answer: (B)

Q14.

Solution

Concept:

The oxidation state is the formal charge an atom would bear if all bonds were ionic. In molecules with peroxide linkages ($-O-O-$), oxygen has an oxidation state of -1, whereas in normal oxides, it is -2.

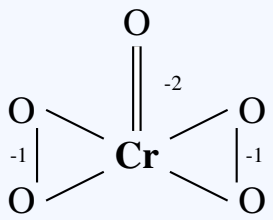
Solution:

Step 1: Analyze the structure of CrO_5. Chromium(VI) oxide peroxide (CrO_5) has a "butterfly" structure. It contains one double-bonded oxygen atom ($Cr = O$) and two peroxide groups.

Step 2: Assign oxidation states to oxygen. - The oxo oxygen (double-bonded) = -2. - The four peroxide oxygens = -1 each.

Step 3: Calculate the oxidation state of Cr (x). The sum of oxidation states in a neutral molecule is zero: $x + [1 \times (-2)] + [4 \times (-1)] = 0\ x - 2 - 4 = 0\ x = +6$

Step 4: Note on common errors. Calculating based purely on the formula CrO_5 without knowing the structure would lead to $x + 5(-2) = 0 \Rightarrow x = +10$, which is impossible as Chromium only has 6 valence electrons.



Butterfly Structure of CrO_5

Final Answer:

$\boxed{+6}$

Answer: (B)

Q15.

Solution

Concept:

Work done during the expansion of a gas against a constant external pressure is called irreversible pressure-volume work. The formula for this work is:

$$W = -P_{ext}\Delta V$$

where P_{ext} is the external pressure and ΔV is the change in volume ($V_{final} - V_{initial}$). To convert the result from $L \cdot atm$ to Joules, the conversion factor 1 L · atm = 101.325 J is used.

Solution:

1. Given values: - External pressure (P_{ext}) = 1 atm - Initial volume (V_1) = 10 L - Final volume (V_2) = 20 L
2. Calculate the change in volume (ΔV):

$$\Delta V = V_2 - V_1 = 20\text{ L} - 10\text{ L} = 10\text{ L}$$

3. Calculate work in $L \cdot atm$:

$$W = -P_{ext}\Delta V = -(1\text{ atm}) \times (10\text{ L}) = -10\text{ L} \cdot \text{atm}$$

4. Convert to Joules:

$$W = -10 \times 101.325\text{ J} = -1013.25\text{ J}$$

5. Rounding to the nearest given option, we get −1013 J. The negative sign indicates work is done by the system (expansion).

Final Answer: The amount of work done is -1013 J.

Answer: (A)

Q16.

Solution

Concept:

The pH of a solution is a measure of its acidity or alkalinity, defined as the negative logarithm of the hydrogen ion concentration. For basic solutions, we first calculate the pOH using the hydroxide ion concentration $[OH^-]$, and then use the relationship:

$$pH + pOH = 14 \text{ (at 298 K)}$$

where $pOH = -\log_{10}[OH^-]$. For a strong base like $NaOH$, it dissociates completely in water.

Solution:

1. $NaOH$ is a strong base, so it dissociates completely: $NaOH \rightarrow Na^+ + OH^-$
2. The concentration of OH^- ions is equal to the molarity of the $NaOH$ solution: $[OH^-] = 0.001 \text{ M} = 10^{-3} \text{ M}$
3. Calculate the pOH:

$$pOH = -\log_{10}[OH^-] = -\log_{10}(10^{-3}) = 3$$

4. Use the relation between pH and pOH:

$$pH = 14 - pOH = 14 - 3 = 11$$

5. Thus, the solution is basic with a pH of 11.

Final Answer: The pH of 0.001 M $NaOH$ solution is 11.

Answer: (B)

Q17.

Solution

Concept:

The standard electromotive force (EMF) of a galvanic cell, E°_{cell}, is the difference between the standard reduction potentials of the cathode and the anode. The formula is:

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

In a shorthand cell notation $Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$, the left side represents the anode (oxidation) and the right side represents the cathode (reduction).

Solution:

1. Identify the electrodes from the cell notation: - Anode: Zn/Zn^{2+} - Cathode: Cu^{2+}/Cu
2. Given values: - $E^\circ_{\text{cell}} = 1.10$ V - $E^\circ_{\text{anode}} = E^\circ(Zn^{2+}/Zn) = -0.76$ V
3. Apply the formula:

$$E^\circ_{\text{cell}} = E^\circ(Cu^{2+}/Cu) - E^\circ(Zn^{2+}/Zn)$$

$$1.10 \text{ V} = E^\circ(Cu^{2+}/Cu) - (-0.76 \text{ V})$$

4. Solve for $E^\circ(Cu^{2+}/Cu)$:

$$1.10 \text{ V} = E^\circ(Cu^{2+}/Cu) + 0.76 \text{ V}$$

$$E^\circ(Cu^{2+}/Cu) = 1.10 \text{ V} - 0.76 \text{ V} = 0.34 \text{ V}$$

Final Answer: The standard reduction potential $E^\circ(Cu^{2+}/Cu)$ is 0.34 V.

Answer: (A)

Q18.

Solution

Concept:

In a unit cell, atoms are shared between adjacent cells. The contribution of an atom depends on its location: * **Corner atom:** Shared by 8 unit cells (contributes $1/8$). * **Face-centered atom:** Shared by 2 unit cells (contributes $1/2$).

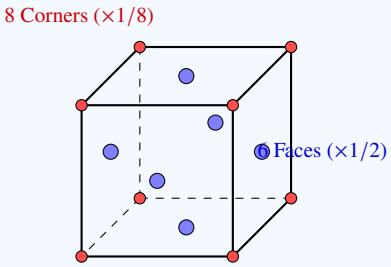
Solution:

Step 1: Count the atoms at the corners. An FCC unit cell has 8 corners. Each corner atom contributes $\frac{1}{8}$ to the cell. Contribution from corners $= 8 \times \frac{1}{8} = 1$ atom.

Step 2: Count the atoms at the face centers. An FCC unit cell has 6 faces. Each face-centered atom contributes $\frac{1}{2}$ to the cell. Contribution from faces $= 6 \times \frac{1}{2} = 3$ atoms.

Step 3: Calculate the total number of atoms (Z). $Z =$ (Corners contribution)+(Faces contribution)

$Z = 1 + 3 = 4$ atoms.



FCC Unit Cell

Final Answer:

$$\boxed{4}$$

Answer: (C)

Q19.

Solution

Concept:

The boiling point of organic compounds, specifically alkanes, depends on the strength of intermolecular Van der Waals forces. These forces are affected by two main factors: 1. **Molecular Weight:** As the number of carbons increases, boiling point increases. 2. **Surface Area (Branching):** For isomers (same molecular weight), boiling point decreases with increased branching because branching reduces surface area and makes the molecule more spherical, leading to weaker attractive forces.

Solution:

1. **Compare Carbon count:** - n-Pentane, Isopentane, and Neopentane all have 5 carbons (C_5H_{12}). - n-Butane has only 4 carbons (C_4H_{10}). - Therefore, n-Butane will have the lowest boiling point.

2. **Compare Isomers (C_5H_{12}):** - **n-Pentane:** Long, straight chain. It has the maximum surface area. - **Isopentane:** One branch. Surface area is slightly reduced. - **Neopentane:** Two branches, very compact and spherical. Minimum surface area.

3. Since n-Pentane has the greatest surface area, it experiences the strongest Van der Waals forces, resulting in the highest boiling point among the options.

Final Answer: n-Pentane shows the highest boiling point.

Answer: (A)

Q20.

Solution

Concept:

Clemmensen reduction is a chemical reaction used to reduce carbonyl groups (aldehydes and ketones) to methylene groups (alkanes). This reaction is particularly useful for aryl-alkyl ketones. The reduction is carried out under strongly acidic conditions using a specific metal amalgam as the reducing agent.

Solution:

1. The reaction is:

$$R - CO - R' \xrightarrow{\text{Reagent}} R - CH_2 - R'$$

2. The specific reagent for Clemmensen reduction is zinc amalgam and concentrated hydrochloric acid:

$$\text{Zn-Hg / Conc. HCl}$$

3. Let's look at the other options: - $LiAlH_4$ and $NaBH_4$ are hydride reducing agents that reduce carbonyls to alcohols. - $NH_2 - NH_2$ / KOH is the reagent for Wolff-Kishner reduction, which also reduces carbonyls to alkanes but under basic conditions.

4. Therefore, Zn-Hg / Conc. HCl is the correct reagent for Clemmensen reduction.

Final Answer: The reagent used for Clemmensen reduction is Zn-Hg / Conc. HCl.

Answer: (C)

Q21.

Solution

Concept:

Gabriel Phthalimide synthesis is a versatile chemical reaction used to prepare pure primary amines. It involves the reaction of phthalimide with ethanolic potassium hydroxide to form potassium phthalimide, which then reacts with an alkyl halide via an S_N2 mechanism to form N-alkylphthalimide. Finally, alkaline hydrolysis or treatment with hydrazine yields the primary amine. This method is specifically designed to avoid the formation of secondary or tertiary amines (over-alkylation).

Solution:

1. Phthalimide is first treated with KOH to create a nucleophile (potassium phthalimide).
2. This nucleophile reacts with an alkyl halide ($R - X$). Because the nucleophile is bulky and the reaction follows an S_N2 path, it works best with primary alkyl halides.
3. Importantly, aryl halides do not undergo this reaction because the $C - X$ bond in aryl halides has partial double bond character due to resonance, making them unreactive toward nucleophilic substitution.
4. Thus, while it produces primary aliphatic amines, it cannot be used to prepare primary aromatic amines (like aniline).
5. The final hydrolysis releases the $R - NH_2$ group.

Final Answer: Gabriel Phthalimide synthesis is used for the preparation of Primary aliphatic amines.

Answer: (A)

Q22.

Solution

Concept:

Proteins have four levels of structure. While the **primary structure** is the linear sequence of amino acids held by covalent peptide bonds, the **secondary structure** refers to local folding patterns like α-helices and β-pleated sheets.

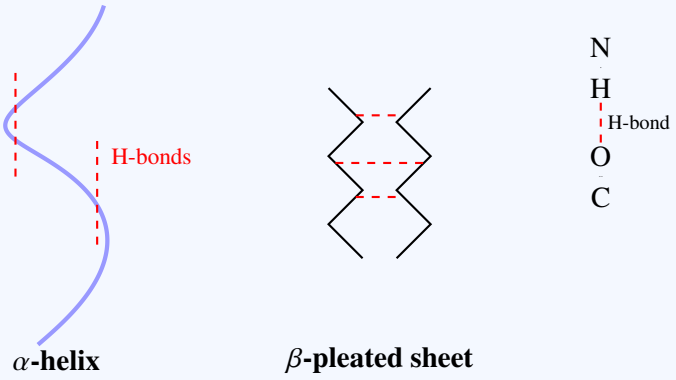
Solution:

Step 1: Identify the stabilization mechanism. Secondary structures are formed when the atoms of the polypeptide backbone (excluding the side chains/R-groups) interact via **hydrogen bonding**.

Step 2: Interaction details. The hydrogen bond forms between the partially negative oxygen atom of a carbonyl group ($C = O$) and the partially positive hydrogen atom of an amide group ($N - H$).

Step 3: Specific Patterns. * **α-helix:** Hydrogen bonds form within a single strand, parallel to the helix axis. * **β-pleated sheet:** Hydrogen bonds form between adjacent segments of the polypeptide chain that lie side-by-side.

Step 4: Conclusion. Since these structures rely specifically on the repeating $C = O$ and $N - H$ groups of the backbone, hydrogen bonds are the primary stabilizing force.



Final Answer:

Hydrogen bonds

Answer: (B)

Q23.

Solution

Concept:

Phosphorus pentachloride (PCl_5) is a highly reactive inorganic compound that undergoes vigorous hydrolysis. The reaction occurs in two stages depending on the amount of water provided. Initially, it forms phosphorus oxychloride ($POCl_3$), and with excess water, it eventually forms orthophosphoric acid (H_3PO_4). Throughout this process, the chlorine atoms from the PCl_5 are released in a specific gaseous form.

Solution:

1. When PCl_5 reacts with a limited amount of water, the reaction is:

$$PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$$

2. If excess water is present, the $POCl_3$ further reacts:

$$POCl_3 + 3H_2O \rightarrow H_3PO_4 + 3HCl$$

3. The overall reaction for complete hydrolysis can be written as:

$$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$$

4. In both stages, the gas evolved is Hydrogen chloride (HCl).
5. Cl_2 gas is usually evolved during the thermal decomposition of PCl_5, not during hydrolysis.

Final Answer: The gas evolved is HCl.

Answer: (C)

Q24.

Solution

Concept:

The magnetic moment (μ) of a transition metal ion can be calculated using the "spin-only" formula:

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

where n is the number of unpaired electrons and BM stands for Bohr Magneton. To find n, we must determine the electronic configuration of the ion by considering the atomic number and the oxidation state.

Solution:

1. The atomic number of Manganese (Mn) is 25. Its ground-state electronic configuration is: $[Ar]3d^5 4s^2$
2. In the Mn^{2+} ion, two electrons are removed from the $4s$ orbital. The configuration becomes: $[Ar]3d^5$
3. The $3d$ subshell has five orbitals. According to Hund's rule, electrons fill them singly first. Therefore, Mn^{2+} has 5 unpaired electrons ($n = 5$).
4. Applying the formula:

$$\mu = \sqrt{5(5+2)} = \sqrt{5 \times 7} = \sqrt{35}\ \text{BM}$$

5. The value of $\sqrt{35}$ is approximately 5.916 BM, which rounds to 5.92 BM.

Final Answer: The magnetic moment of Mn^{2+} is 5.92 BM.

Answer: (A)

Q25.

Solution

Concept:

According to Molecular Orbital (MO) Theory, the bond order is a measure of the stability and strength of a bond. It is calculated using the formula:

$$\text{Bond Order} = \frac{1}{2}(N_b - N_a)$$

where N_b is the number of electrons in bonding molecular orbitals and N_a is the number of electrons in antibonding molecular orbitals. For diatomic molecules like Nitrogen, we fill electrons according to the MO energy level diagram.

Solution:

1. A neutral Nitrogen molecule (N_2) has 14 electrons. Its MO configuration is: $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, (\pi 2p_x^2 = \pi 2p_y^2), \sigma 2p_z^2$ Bond Order = $\frac{1}{2}(10 - 4) = 3.0$.
2. The N_2^+ ion is formed by removing one electron from the highest occupied molecular orbital (HOMO), which is the $\sigma 2p_z$ bonding orbital.
3. So, N_2^+ has 13 electrons. The configuration becomes: $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, (\pi 2p_x^2 = \pi 2p_y^2), \sigma 2p_z^1$
4. Now, $N_b = 9$ and $N_a = 4$.
5. Calculating the bond order:

$$\text{Bond Order} = \frac{1}{2}(9 - 4) = \frac{5}{2} = 2.5$$

Final Answer: The bond order of N_2^+ is 2.5.

Answer: (B)

Q26.

Solution

Concept:

The Lucas test is a classic laboratory procedure used to distinguish between primary, secondary, and tertiary alcohols. It is based on the difference in the rate at which these alcohols react with the Lucas reagent to form alkyl chlorides. The reaction is a nucleophilic substitution (S_N1 for tertiary and secondary), and the formation of the alkyl chloride is indicated by the appearance of turbidity (cloudiness) in the solution, as alkyl halides are insoluble in the reagent.

Solution:

1. The Lucas reagent is a solution of anhydrous zinc chloride ($ZnCl_2$) in concentrated hydrochloric acid (HCl).
2. Zinc chloride acts as a Lewis acid catalyst, coordinating with the oxygen of the alcohol to make the hydroxyl group a better leaving group.
3. The reaction rates are as follows:

- **Tertiary alcohols:** React immediately, producing turbidity at room temperature.
- **Secondary alcohols:** React within 5 to 10 minutes.
- **Primary alcohols:** Do not react significantly at room temperature; turbidity only appears upon heating.

4. Among the given options, the mixture of Conc. HCl and Anhydrous $ZnCl_2$ correctly identifies the reagent.

Final Answer: Lucas reagent is a mixture of Conc. HCl + Anhydrous $ZnCl_2$.

Answer: (A)

Q27.

Solution

Concept:

Phenol is highly reactive toward electrophilic aromatic substitution due to the strong activating effect of the $-OH$ group. The lone pair on the oxygen atom is delocalized into the benzene ring through resonance, significantly increasing the electron density at the ortho and para positions. The extent of bromination of phenol depends heavily on the nature of the solvent used.

Solution:

1. Bromine water (Br_2/H_2O) is a highly polar medium.
2. In an aqueous medium, phenol ionizes to form the phenoxide ion ($C_6H_5O^-$). The phenoxide ion is even more activating than the neutral phenol molecule because the negative charge on oxygen is highly effective at donating electron density to the ring.
3. Because the ring is so strongly activated, substitution occurs at all available activated positions (both ortho and the para position) simultaneously.
4. The reaction is:

$$C_6H_5OH + 3Br_2 \xrightarrow{H_2O} C_6H_2Br_3OH + 3HBr$$

5. The product is 2,4,6-Tribromophenol, which appears as a characteristic white precipitate.
6. If a non-polar solvent like CS_2 or CCl_4 were used at low temperatures, mono-bromination (o- or p-bromophenol) would occur instead.

Final Answer: Phenol reacts with Bromine water to give 2,4,6-Tribromophenol.

Answer: (C)

Q28.

Solution

Concept:

The half-life ($t_{1/2}$) of a chemical reaction is the time required for the concentration of a reactant to decrease to half of its initial value. For a first-order reaction, the half-life is a constant and is independent of the initial concentration of the reactants. The relationship between the rate constant (k) and the half-life ($t_{1/2}$) is derived from the integrated rate law for first-order kinetics.

Solution:

1. The formula for the half-life of a first-order reaction is:

$$t_{1/2} = \frac{\ln(2)}{k} \approx \frac{0.693}{k}$$

2. Given the rate constant $k = 0.0693\ \text{min}^{-1}$.
3. Substitute the value of k into the formula:

$$t_{1/2} = \frac{0.693}{0.0693\ \text{min}^{-1}}$$

4. Solving the calculation:

$$t_{1/2} = 10\ \text{min}$$

5. Thus, it takes 10 minutes for the concentration of the reactant to be reduced by 50

Final Answer: The half-life of the reaction is 10 min.

Answer: (A)

Q29.

Solution

Concept:

In the Bohr model of the hydrogen atom, the energy of an electron in a specific orbit n is given by $E_n = -13.6/n^2$ eV. When an electron transitions from a higher energy level (n_{higher}) to a lower energy level (n_{lower}), a photon is emitted. The energy of the emitted photon (ΔE) corresponds to the difference in energy between these levels:

$$\Delta E = 13.6\left(\frac{1}{n_{lower}^2} - \frac{1}{n_{higher}^2}\right) \text{ eV}$$

Solution:

1. We evaluate the energy difference for each transition:
2. **n=2 to n=1:**

$$\Delta E = 13.6\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 13.6\,(1 - 0.25) = 13.6 \times 0.75 = 10.2 \text{ eV}$$

3. **n=3 to n=2:**

$$\Delta E = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 13.6\,(0.25 - 0.111) \approx 1.89 \text{ eV}$$

4. **n=4 to n=3:**

$$\Delta E = 13.6\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = 13.6\,(0.111 - 0.0625) \approx 0.66 \text{ eV}$$

5. **n=5 to n=4:**

$$\Delta E = 13.6\left(\frac{1}{4^2} - \frac{1}{5^2}\right) = 13.6\,(0.0625 - 0.04) \approx 0.31 \text{ eV}$$

6. The energy levels in a hydrogen atom are spaced further apart at lower values of n. Therefore, the transition to the ground state ($n = 1$) from the first excited state ($n = 2$) involves the largest energy gap.

Final Answer: The transition from n=2 to n=1 emits a photon of the highest energy.

Answer: (A)

Q30.

Solution

Concept:

The Isocyanide test, also known as the Carbylamine reaction, is a highly sensitive chemical test used to identify a specific class of amines. The reaction involves heating the amine with chloroform ($CHCl_3$) and ethanolic potassium hydroxide (KOH). The detection is based on the formation of an isocyanide (carbylamine), which possesses an extremely foul and easily recognizable odor.

Solution:

1. The general reaction is:

$$R - NH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} R - NC + 3KCl + 3H_2O$$

2. This reaction occurs only with primary amines ($R - NH_2$), whether they are aliphatic or aromatic.
3. Secondary and tertiary amines do not undergo this reaction because they do not have the two replaceable hydrogen atoms on the nitrogen atom required to form the $R - N \equiv C$ bond.
4. Therefore, this test is used as a diagnostic tool to distinguish primary amines from secondary and tertiary amines.

Final Answer: Isocyanide test is used to detect Primary amines.

Answer: (A)

Q31.

Solution

Concept:

Williamson's synthesis is an organic reaction used for the preparation of symmetrical and unsymmetrical ethers. It involves the nucleophilic attack of an alkoxide ion ($R - O^-$) on an alkyl halide ($R' - X$). The alkoxide acts as a strong nucleophile and the reaction proceeds in a single step where the bond formation and bond breaking occur simultaneously.

Solution:

1. The general equation is:

$$R - O^- Na^+ + R' - X \rightarrow R - O - R' + NaX$$

2. Since the nucleophile ($R - O^-$) attacks the alkyl halide from the side opposite to the leaving group (X^-) in a concerted manner, it follows the S_N2 (Substitution Nucleophilic Bimolecular) mechanism.
3. For the reaction to be successful and yield an ether, the alkyl halide ($R' - X$) must be primary (1°).
4. If a secondary or tertiary alkyl halide is used, the alkoxide (which is also a strong base) will favor an elimination reaction ($E2$) over substitution, leading to the formation of an alkene instead of an ether.
5. Therefore, the core mechanism that defines this synthesis is S_N2.

Final Answer: Williamson's synthesis involves S_N2 mechanism.

Answer: (B)

Q32.

Solution

Concept:

Fermentation is a biochemical process where complex organic compounds like sugars are broken down into simpler substances like alcohol or organic acids by the action of enzymes. Enzymes are biological catalysts produced by living organisms (like yeast). Different steps in the breakdown of starch or sugar into ethanol require specific enzymes tailored to each chemical transformation.

Solution:

1. In the production of ethanol from molasses (sucrose), the first step is the hydrolysis of sucrose into glucose and fructose, catalyzed by the enzyme **Invertase**.
2. The resulting glucose ($C_6H_{12}O_6$) is then converted into ethyl alcohol (C_2H_5OH) and carbon dioxide (CO_2).
3. The specific enzyme responsible for this final conversion of glucose into ethanol is **Zymase**, which is naturally found in yeast.

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

4. Other enzymes mentioned: - **Diastase** converts starch into maltose. - **Maltase** converts maltose into glucose.

Final Answer: The enzyme that converts glucose to ethyl alcohol is Zymase.

Answer: (C)

Q33.

Solution

Concept:

Oxoacids of phosphorus are compounds containing phosphorus, oxygen, and hydrogen. Phosphorus atoms in these acids are usually tetrahedrally coordinated. The presence of $P-P$, $P-O-P$, or $P-H$ bonds depends on the oxidation state of the phosphorus and the stoichiometry of the acid. Acids with phosphorus in a lower oxidation state (less than +5) often contain $P-P$ or $P-H$ bonds.

Solution:

1. $H_4P_2O_7$ (Pyrophosphoric acid): Contains a $P-O-P$ linkage. Both phosphorus atoms are in the +5 oxidation state.
2. $H_4P_2O_5$ (Pyrophosphorous acid): Contains a $P-O-P$ linkage and $P-H$ bonds. Phosphorus is in the +3 oxidation state.
3. $(HPO_3)_3$ (Cyclotrimetaphosphoric acid): A cyclic structure with alternating P and O atoms in the ring ($P-O-P$ linkages).
4. $H_4P_2O_6$ (Hypophosphoric acid): In this molecule, the two phosphorus atoms are directly linked to each other. Each phosphorus is also bonded to two $-OH$ groups and one oxo ($=O$) oxygen. The presence of the $P-P$ bond accounts for the +4 oxidation state of phosphorus.

Final Answer: $H_4P_2O_6$ contains a P-P bond.

Answer: (B)

Q34.

Solution

Concept:

Lanthanoid contraction refers to the steady decrease in the atomic and ionic radii of the lanthanoid elements (atomic numbers 58 to 71) as the atomic number increases. This is caused by the poor shielding effect of the $4f$ electrons. Because $4f$ electrons do not shield the outer electrons effectively from the increasing nuclear charge, the entire electron cloud is pulled closer to the nucleus.

Solution:

1. The Lanthanoid contraction occurs right before the beginning of the third transition series (5d series).
2. As a result, the elements of the second transition series ($4d$) and the third transition series ($5d$) that fall in the same group have nearly identical atomic radii.
3. For example, in Group 4: - Zirconium (Zr) belongs to the $4d$ series. - Hafnium (Hf) belongs to the $5d$ series.
4. Normally, Hf should be larger than Zr due to an extra shell. However, the contraction that occurs during the filling of the $4f$ subshell (between La and Hf) cancels out the expected increase in size.
5. Consequently, Zr and Hf have almost the same physical and chemical properties due to their nearly identical size.

Final Answer: The Lanthanoid contraction is responsible for the fact that Zr and Hf have same radius.

Answer: (A)

Q35.

Solution

Concept:

The coordination number (C.N.) of a central metal ion in a complex is the total number of coordinate bonds formed between the metal and the ligands. This is not always equal to the number of ligands if the ligands are polydentate (able to form more than one bond per molecule). Ethane-1,2-diamine (en) is a bidentate ligand, meaning each molecule has two nitrogen atoms with lone pairs that can bond to the metal.

Solution:

1. The complex is $[Co(en)_3]^{3+}$.
2. The ligand present is 'en' (ethylenediamine), which is $NH_2 - CH_2 - CH_2 - NH_2$.
3. Since 'en' is a bidentate ligand, it forms 2 coordinate bonds with the Cobalt (Co) ion.
4. There are 3 such 'en' ligands attached to the Cobalt ion.
5. Total coordinate bonds = $3 \times 2 = 6$.
6. Therefore, the coordination number of Co in this complex is 6, resulting in an octahedral geometry.

Final Answer: The coordination number of Co in $[Co(en)_3]^{3+}$ is 6.

Answer: (C)

Q36.

Solution

Concept:

In thermodynamics, properties of a system are classified as either intensive or extensive. An **intensive property** is a physical property of a system that does not depend on the system size or the amount of material in the system. In contrast, an **extensive property** is additive for subsystems; its value is proportional to the amount of matter present. If you divide a system into two parts, intensive properties remain the same in both parts, whereas extensive properties are halved.

Solution:

1. **Mass:** This depends on the amount of matter. If you have more substance, the mass increases. It is an extensive property.
2. **Volume:** This also depends on the quantity of matter. More substance occupies more space. It is an extensive property.
3. **Enthalpy:** This is the total heat content of a system and is proportional to the amount of substance present. It is an extensive property.
4. **Temperature:** If you have a gallon of water at $25^\circ C$ and you pour it into two smaller cups, the temperature in each cup is still $25^\circ C$. It does not change regardless of the quantity. Therefore, it is an intensive property.
5. Other examples of intensive properties include density, pressure, and boiling point.

Final Answer: An intensive property among the following is Temperature.

Answer: (D)

Q37.

Solution

Concept:

The spontaneity of a process is determined by the Gibbs free energy change (ΔG), given by the Gibbs-Helmholtz equation:

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

For a process to be spontaneous, ΔG must be negative ($\Delta G < 0$). Whether ΔG is negative depends on the signs of the enthalpy change (ΔH) and entropy change (ΔS), as well as the absolute temperature (T).

Solution:

1. We analyze the condition where ΔG is always negative regardless of the value of T:
2. **Condition: ΔH is -ve and ΔS is +ve.** - In the equation $\Delta G = \Delta H - T\Delta S$, if ΔH is negative (exothermic) and ΔS is positive (increasing disorder), then the term $(-T\Delta S)$ will also be negative (since T in Kelvin is always positive). - Adding two negative values always results in a negative value. - Thus, ΔG will be negative at all temperatures.
3. **Other conditions:** - If ΔH is +ve and ΔS is -ve, ΔG is always positive (non-spontaneous). - If both are +ve, it is spontaneous only at high temperatures. - If both are -ve, it is spontaneous only at low temperatures.

Final Answer: For a spontaneous process at all temperatures, ΔH is -ve and ΔS is +ve.

Answer: (A)

Q38.

Solution

Concept:

Molar conductivity (Λ_m) is defined as the conducting power of all the ions produced by dissolving one mole of an electrolyte in solution. It is related to electrolytic conductivity (κ, kappa) and molarity (C) by the formula:

$$\Lambda_m = \frac{\kappa}{C}$$

To determine the units, we look at the standard units for conductivity and concentration.

Solution:

1. The unit of conductivity (κ) is Siemens per centimeter ($S\ \text{cm}^{-1}$ or $\Omega^{-1}\ \text{cm}^{-1}$).
2. The unit of molar concentration (C) is moles per volume. In this context, it is expressed as mol/cm^3 to maintain consistency with the conductivity units.
3. Substituting these into the formula:

$$\Lambda_m = \frac{S\ \text{cm}^{-1}}{\text{mol}\ \text{cm}^{-3}} = S\ \text{cm}^{-1}\ \text{cm}^3\ \text{mol}^{-1}$$

4. Simplifying the exponents:

$$\Lambda_m = S\ \text{cm}^2\ \text{mol}^{-1}$$

5. Therefore, option (A) provides the correct units for molar conductivity.

Final Answer: The unit of molar conductivity is $S\ \text{cm}^2\ \text{mol}^{-1}$.

Answer: (A)

Q39.

Solution

Concept:

Condensation polymers are formed by a series of condensation reactions between monomers with two different functional groups, often with the elimination of small molecules like water or methanol. Terylene, also known as Dacron, is a popular polyester. Polyesters are formed by the reaction of a diol (alcohol with two $-OH$ groups) and a dicarboxylic acid (acid with two $-COOH$ groups).

Solution:

1. Terylene is synthesized through the polymerization of two specific monomers.
2. One monomer is **Ethylene glycol** ($HO-CH_2-CH_2-OH$), which provides the diol component.
3. The other monomer must be a dicarboxylic acid that forms the "terephthalate" linkage.
4. **Terephthalic acid** (benzene-1,4-dicarboxylic acid) is the required monomer. It has two carboxyl groups at the para positions of the benzene ring.
5. When these react, an ester linkage ($-COO-$) is formed between each unit, creating a long-chain polyester:

$$nHO-(CH_2)_2-OH+nHOOC-C_6H_4-COOH \rightarrow \cdots-O-(CH_2)_2-O-CO-C_6H_4-CO-\ldots$$

6. Adipic acid is used for Nylon 6,6; Phthalic acid is used for Glyptal.

Final Answer: Terylene is a condensation polymer of ethylene glycol and terephthalic acid.

Answer: (B)

Q40.

Solution

Concept:

Nucleophilic addition is the characteristic reaction of carbonyl compounds (aldehydes and ketones). The rate of this reaction is influenced by two main factors: 1. **Inductive Effect:** Alkyl groups are electron-donating ($+I$). They increase the electron density on the carbonyl carbon, making it less electrophilic (less attractive to nucleophiles). 2. **Steric Hindrance:** Bulkier groups attached to the carbonyl carbon hinder the approach of the nucleophile, slowing down the reaction. Generally, aldehydes are more reactive than ketones because they have fewer alkyl groups.

Solution:

1. **HCHO (Formaldehyde):** It has two hydrogen atoms attached to the carbonyl carbon. It has the least $+I$ effect and the least steric hindrance.

2. CH_3CHO **(Acetaldehyde):** It has one methyl group which increases electron density via $+I$ and adds some steric bulk compared to hydrogen.

3. CH_3COCH_3 **(Acetone):** This is a ketone with two methyl groups. Both steric hindrance and the $+I$ effect are significantly higher than in aldehydes.

4. $C_6H_5COCH_3$ **(Acetophenone):** The large phenyl ring creates massive steric hindrance and resonance also stabilizes the carbonyl group, making it the least reactive.

5. Among all carbonyl compounds, Formaldehyde ($HCHO$) is the most reactive toward nucleophilic addition because its carbonyl carbon is the most "positive" and the most accessible.

Final Answer: HCHO is the most reactive towards nucleophilic addition.

Answer: (A)

Q41.

Solution

Concept:

Reactivity toward nucleophilic addition in carbonyl compounds is governed by two main factors: 1. **Electronic Factor:** Alkyl groups are electron-donating ($+I$ effect), which reduces the partial positive charge ($\delta+$) on the carbonyl carbon, making it less attractive to nucleophiles. 2. **Steric Factor:** Larger groups around the carbonyl carbon create "crowding," making it physically harder for a nucleophile to approach and bond.

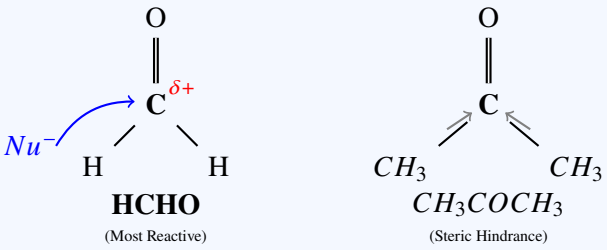
Solution:

Step 1: Analyze $HCHO$ (Formaldehyde). It has two tiny hydrogen atoms. It has the highest $\delta+$ charge and the least steric hindrance.

Step 2: Analyze CH_3CHO (Acetaldehyde). The methyl group ($+I$) reduces the electrophilicity of the carbon and adds slight bulk.

Step 3: Analyze CH_3COCH_3 (Acetone). Two methyl groups significantly reduce the positive charge and increase crowding.

Step 4: Analyze $C_6H_5COCH_3$ (Acetophenone). The bulky phenyl ring and the resonance effect (delocalization of the carbonyl π electrons into the ring) make it the least reactive among the choices.



Final Answer:

$$\boxed{HCHO}$$

Answer: (A)

Q42.

Solution

Concept:

The Reimer-Tiemann reaction involves the electrophilic aromatic substitution of phenol. When phenol is treated with chloroform ($CHCl_3$) and aqueous $NaOH$, a formyl group ($-CHO$) is introduced at the ortho position.

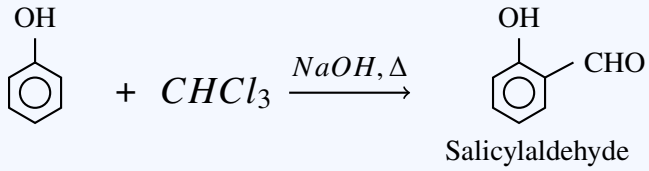
Solution:

Step 1: Generation of Dichlorocarbene (: CCl_2). Chloroform reacts with OH^- to undergo α-elimination, forming the neutral but highly electrophilic dichlorocarbene.

Step 2: Attack on Phenoxide. In the basic medium, phenol exists as the phenoxide ion, which is highly activated. The carbene attacks the ortho position.

Step 3: Hydrolysis. The intermediate substituted with two chlorine atoms is hydrolyzed to an aldehyde.

Step 4: Identification. The major product is 2-hydroxybenzaldehyde, commonly known as **Salicylaldehyde**.



Final Answer:

Salicylaldehyde

Answer: (A)

Q43.

Solution

Concept:

The magnetic property of an ion depends on the presence of unpaired electrons in its valence shell. An ion is **paramagnetic** if it contains one or more unpaired electrons. An ion is **diamagnetic** if all its electrons are paired. For transition metals, we look at the electronic configuration of the d-subshell after the required number of electrons have been removed to form the ion.

Solution:

1. Cu^{2+} $(Z = 29)$**:** Neutral Cu is $[Ar]3d^{10}4s^1$. Cu^{2+} is $[Ar]3d^9$. It has one unpaired electron. Thus, it is paramagnetic.

2. Ni^{2+} $(Z = 28)$**:** Neutral Ni is $[Ar]3d^8 4s^2$. Ni^{2+} is $[Ar]3d^8$. It has two unpaired electrons in the d-orbitals. It is paramagnetic.

3. Co^{2+} $(Z = 27)$**:** Neutral Co is $[Ar]3d^7 4s^2$. Co^{2+} is $[Ar]3d^7$. It has three unpaired electrons. It is paramagnetic.

4. Ti^{4+} $(Z = 22)$**:** Neutral Ti is $[Ar]3d^2 4s^2$. To form Ti^{4+}, all four valence electrons (two from $4s$ and two from $3d$) are removed. The electronic configuration becomes $[Ar]3d^0$, which is the same as the noble gas Argon.

5. Since there are no electrons in the d-shell of Ti^{4+}, there are no unpaired electrons. Therefore, it is diamagnetic.

Final Answer: Ti^{4+} is a diamagnetic ion.

Answer: (C)

Q44.

Solution

Concept:

The boiling point of a substance is the temperature at which its vapor pressure equals the external pressure. For simple covalent molecules, boiling points are usually determined by the strength of intermolecular forces. While Van der Waals forces (related to molecular weight) play a role, specific interactions like hydrogen bonding are much stronger and can significantly elevate the boiling point of a substance.

Solution:

1. Both Water (H_2O) and Hydrogen sulfide (H_2S) are hydrides of Group 16 elements.
2. H_2S has a higher molecular weight than H_2O, which would normally suggest a higher boiling point if only Van der Waals forces were involved.
3. However, Oxygen is much more electronegative than Sulfur.
4. In H_2O, the large electronegativity difference between O and H allows for the formation of strong intermolecular hydrogen bonds. Each water molecule can form up to four hydrogen bonds with neighboring molecules, creating a vast network.
5. H_2S cannot form effective hydrogen bonds because Sulfur's electronegativity is too low.
6. A large amount of thermal energy is required to break these hydrogen bonds in water before it can transition to the gas phase. This results in water having an unusually high boiling point ($100^\circ C$) compared to H_2S ($-60^\circ C$).

Final Answer: The boiling point of water is higher than H_2S because of Hydrogen bonding.

Answer: (B)

Q45.

Solution

Concept:

In a crystal lattice, the packing efficiency is the percentage of total space occupied by the constituent particles (atoms). The remaining space, which is not occupied by atoms, is called the empty space or void space. For different types of cubic unit cells, the packing efficiency varies based on the arrangement of atoms and the relationship between the atomic radius (r) and the unit cell edge length (a).

Solution:

1. In a Body-Centered Cubic (BCC) unit cell, atoms are present at the corners and one atom is at the center of the body.
2. The number of atoms per unit cell (Z) for BCC is 2.
3. The relationship between radius and edge length is:

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

4. The Packing Efficiency is calculated as:

$$\text{Packing Efficiency} = \frac{\text{Volume of 2 atoms}}{\text{Total volume of unit cell}} \times 100$$

$$\text{Packing Efficiency} = \frac{2 \times \frac{4}{3}\pi r^3}{a^3} \times 100 \approx 68\%$$

5. The percentage of empty space is the difference between the total volume (100%) and the packing efficiency:

$$\text{Empty Space} = 100\% - 68\% = 32\%$$

Final Answer: The percentage of empty space in a BCC unit cell is 32

Answer: (A)

Q46.

Solution

Concept:

The oxidation of alcohols depends on the type of alcohol (primary, secondary, or tertiary) and the strength of the oxidizing agent. Alkaline potassium permanganate ($KMnO_4$) is a very powerful oxidizing agent. Primary alcohols are initially oxidized to aldehydes, but since $KMnO_4$ is strong, the aldehyde is rapidly oxidized further to a carboxylic acid with the same number of carbon atoms. Secondary alcohols are oxidized to ketones, and tertiary alcohols are generally resistant to oxidation under normal conditions.

Solution:

1. 1-propanol ($CH_3CH_2CH_2OH$) is a primary alcohol.
2. When treated with alkaline $KMnO_4$, it undergoes oxidation.
3. The primary alcoholic group ($-CH_2OH$) is first converted to an aldehyde group ($-CHO$), forming propanal.
4. However, because the reaction medium is strongly oxidizing, propanal cannot be isolated. It immediately undergoes further oxidation.
5. The final stable product is propanoic acid (CH_3CH_2COOH):

$$CH_3CH_2CH_2OH \xrightarrow{\text{alk. } KMnO_4/\Delta} CH_3CH_2COOH$$

6. In the alkaline medium, it actually forms the salt (potassium propanoate), which yields propanoic acid upon acidification.

Final Answer: Oxidation of 1-propanol with alkaline $KMnO_4$ gives Propanoic acid.

Answer: (B)

Q47.

Solution

Concept:

The Hoffmann Bromamide degradation is a specific reaction used to convert an amide into a primary amine containing one less carbon atom than the starting amide. This is an important "step-down" reaction in organic synthesis. The reaction involves treating the amide with bromine (Br_2) in an aqueous or ethanolic solution of sodium hydroxide ($NaOH$) or potassium hydroxide (KOH). The carbonyl carbon of the amide is lost as a carbonate (Na_2CO_3).

Solution:

1. The starting material is Acetamide (CH_3CONH_2).
2. Acetamide has two carbon atoms in its structure.
3. The reaction involves the migration of the alkyl group (methyl group) from the carbonyl carbon to the nitrogen atom, accompanied by the removal of the carbonyl group ($C = O$).
4. The general reaction is:

$$R - CONH_2 + Br_2 + 4NaOH \rightarrow R - NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$$

5. For Acetamide ($R = CH_3$):

$$CH_3CONH_2 + Br_2 + 4NaOH \rightarrow CH_3NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$$

6. The product formed is Methylamine (CH_3NH_2), which has only one carbon atom.

Final Answer: Hoffmann Bromamide degradation of Acetamide gives Methylamine.

Answer: (A)

Q48.

Solution

Concept:

The hybridization of an atom is determined by the number of sigma (σ) bonds and lone pairs surrounding it (Steric Number). In hydrocarbons, carbon atoms can be sp^3, sp^2, or sp hybridized. A carbon atom forming four single bonds is sp^3 hybridized. A carbon atom forming one double bond and two single bonds is sp^2 hybridized. A carbon atom involved in a triple bond or two double bonds is sp hybridized.

Solution:

1. Ethene (ethylene) has the molecular formula C_2H_4.
2. Its structural formula is $CH_2 = CH_2$.
3. Each carbon atom in ethene is bonded to:
   - Two hydrogen atoms via two single (σ) bonds.
   - One other carbon atom via one double bond (consisting of one σ bond and one π bond).
4. Therefore, each carbon atom has a total of 3 sigma bonds and 0 lone pairs.
5. A steric number of 3 corresponds to sp^2 hybridization, which results in a trigonal planar geometry around each carbon atom with bond angles of approximately 120°.

Final Answer: The hybridization of Carbon in Ethene is sp^2.

Answer: (B)

Q49.

Solution

Concept:

Amino acids are classified as acidic, basic, or neutral based on the relative number of amino groups ($-NH_2$) and carboxyl groups ($-COOH$) in their structure. Neutral amino acids have an equal number of amino and carboxyl groups (usually one of each). Acidic amino acids have more carboxyl groups than amino groups. Basic amino acids have more amino groups than carboxyl groups.

Solution:

1. **Lysine:** Contains two amino groups and one carboxyl group. It is a basic amino acid.
2. **Arginine:** Contains multiple nitrogen-containing groups (guanidino group) and is strongly basic.
3. **Aspartic acid:** Contains two carboxyl groups and one amino group. It is an acidic amino acid.
4. **Glycine ($H_2N - CH_2 - COOH$):** It is the simplest amino acid. It contains exactly one amino group and one carboxyl group.
5. Since the basicity of the amino group and the acidity of the carboxyl group cancel each other out at its isoelectric point, Glycine is classified as a neutral amino acid.

Final Answer: Glycine is a neutral amino acid.

Answer: (B)

Q50.

Solution

Concept:

The behavior of gases dissolving in liquids is described by various gas laws. The solubility of a gas is affected by temperature and pressure. While temperature generally decreases solubility, increasing the pressure of the gas above the liquid increases the concentration of gas molecules dissolved in the liquid phase.

Solution:

1. **Raoult's Law:** Relates the vapor pressure of a solution to the mole fraction of the solvent. It applies to liquid-liquid mixtures.
2. **Dalton's Law:** States that the total pressure of a mixture of non-reacting gases is equal to the sum of the partial pressures of the individual gases.
3. **Gay-Lussac's Law:** States that the pressure of a given mass of gas is directly proportional to its absolute temperature at constant volume.
4. **Henry's Law:** Specifically states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the partial pressure of that gas above the liquid. It is expressed as $C = kP$, where C is the solubility and P is the partial pressure.

Final Answer: This is Henry's Law.

Answer: (B)

Answer Key

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