MHT-CET Chemistry Sample Paper-16

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. The most stable conformation of meso-butane-2,3-diol is the gauche form rather than the anti form. This unusual stability is primarily attributed to:

(A) Steric repulsion between the two methyl groups.

(B) Intramolecular hydrogen bonding between the hydroxyl groups.

(C) The absence of torsional strain in the gauche position.

(D) Dipole-dipole attraction between the C-O bonds.

Q2. Which of the following molecules will exhibit the highest rate of electrophilic aromatic substitution when treated with CH_3COCl in the presence of anhydrous $AlCl_3$?

(A) Nitrobenzene

(B) Chlorobenzene

(C) Acetanilide

(D) Ethyl benzoate

Q3. An organic compound with the molecular formula C_6H_{12} (A) is optical active. Upon catalytic hydrogenation, it yields an optically inactive compound C_6H_{14} (B). Compound A is:

(A) 3-Methylpent-1-ene

(B) 2-Methylpent-1-ene

(C) 3-Methylpent-2-ene

(D) 4-Methylpent-1-ene

Q4. Identify the major product formed when 3,3-dimethylbutan-2-ol is heated with concentrated H_2SO_4:

(A) 3,3-Dimethylbut-1-ene

(B) 2,3-Dimethylbut-2-ene

(C) 2,3-Dimethylbut-1-ene

(D) 2,2-Dimethylbutane

Q5. The total number of stereoisomers possible for the compound 2,3-dichlorobutane is:

(A) 2

(B) 3

(C) 4

(D) 6

Q6. When 1-butyne is treated with $HgSO_4/H_2SO_4$, the major product formed is:

(A) Butanal

(B) Butan-2-one

(C) Butan-1-ol

(D) Butan-2-ol

Q7. The correct order of increasing acidic strength among the following hydrocarbons is:

(A) $CH_4 < CH_2 = CH_2 < C_6H_6 < CH \equiv CH$

(B) $CH_4 < C_6H_6 < CH_2 = CH_2 < CH \equiv CH$

(C) $CH \equiv CH < CH_2 = CH_2 < C_6H_6 < CH_4$

(D) $C_6H_6 < CH_4 < CH_2 = CH_2 < CH \equiv CH$

Q8. Ozonolysis of an alkene followed by treatment with Zn/H_2O yields a mixture of methanal and 2-methylpropanal. The alkene is:

(A) 2-Methylbut-2-ene

(B) 3-Methylbut-1-ene

(C) 2-Methylbut-1-ene

(D) 2,3-Dimethylbut-2-ene

Q9. Which of the following compounds will react fastest with aqueous $AgNO_3$ to form a precipitate?

(A) Chlorobenzene

(B) Vinyl chloride

(C) Benzyl chloride

(D) Bromobenzene

Q10. In the following reaction sequence, identify 'C':
$C_2H_5OH \xrightarrow{PCl_5} A \xrightarrow{alc.KOH} B \xrightarrow{Br_2/CCl_4} C$

(A) 1,2-Dibromoethane

(B) 1,1-Dibromoethane

(C) Ethyl bromide

(D) Ethyne

Q11. The major product of the reaction between p-nitrobromobenzene and sodium ethoxide in ethanol at high temperature is:

(A) p-Nitrophenol

(B) p-Nitroethoxybenzene

(C) p-Bromophenol

(D) Nitrobenzene

Q12. The reaction of neopentyl alcohol with concentrated HCl yields mainly:

(A) Neopentyl chloride

(B) 2-Chloro-2-methylbutane

(C) 2-Chloro-3-methylbutane

(D) 1-Chloro-2,2-dimethylpropane

Q13. When phenol is treated with excess bromine water, the product formed is:

(A) 2-Bromophenol

(B) 4-Bromophenol

(C) 2,4,6-Tribromophenol

(D) 2,4-Dibromophenol

Q14. Which of the following will not undergo the Reimer-Tiemann reaction?

(A) Phenol

(B) m-Cresol

(C) Nitrobenzene

(D) o-Cresol

Q15. Identify the product 'Z' in the following sequence:

$$Benzene \xrightarrow{CH_3Cl/AlCl_3} X \xrightarrow{KMnO_4/OH^-} Y \xrightarrow{PCl_5} Z$$

(A) Benzyl chloride

(B) Benzoyl chloride

(C) Chlorobenzene

(D) Benzaldehyde

Q16. Which of the following alcohols will give a positive Iodoform test and also turn an acidified $K_2Cr_2O_7$ solution green?

(A) Methanol

(B) Ethanol

(C) Isopropyl alcohol

(D) Benzyl alcohol

Q17. The major product of the reaction between propanal and dilute $NaOH$ followed by heating is:

(A) 2-Methylpent-2-enal

(B) Hex-2-enal

(C) 2-Methylpentanal

(D) Pent-2-enal

Q18. Which of the following compounds is most reactive towards nucleophilic addition reactions?

(A) CH_3CHO

(B) $PhCHO$

(C) CH_3COCH_3

(D) $PhCOPh$

Q19. The reduction of a nitrile with $SnCl_2$ and HCl followed by hydrolysis to give an aldehyde is known as:

(A) Rosenmund reduction

(B) Stephen reduction

(C) Etard reaction

(D) Gatterman-Koch reaction

Q20. When benzaldehyde is treated with concentrated KOH, it undergoes:

(A) Aldol condensation

(B) Cannizzaro reaction

(C) Perkin reaction

(D) Benzoin condensation

Q21. The correct order of basic strength of methyl substituted amines in aqueous solution is:

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

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

Q22. Aniline on treatment with $NaNO_2$ and HCl at $0 - 5^{\circ}C$ followed by reaction with $CuCN$ gives:

(A) Chlorobenzene

(B) Benzonitrile

(C) Benzylamine

(D) Nitrobenzene

Q23. Hinsberg's reagent (benzene sulphonyl chloride) reacts with which of the following to form a product that is insoluble in alkali?

(A) Primary amine

(B) Secondary amine

(C) Tertiary amine

(D) Quaternary ammonium salt

Q24. Which of the following is a non-reducing sugar?

(A) Glucose

(B) Fructose

(C) Lactose

(D) Sucrose

Q25. The protein responsible for blood clotting is:

(A) Albumin

(B) Globulin

(C) Fibrinogen

(D) Haemoglobin

Q26. Which of the following is an example of a thermosetting polymer?

(A) Polythene

(B) PVC

(C) Bakelite

(D) Nylon-6,6

Q27. The geometry and magnetic nature of $[Ni(CN)_4]^{2-}$ are:

(A) Tetrahedral and diamagnetic

(B) Square planar and diamagnetic

(C) Square planar and paramagnetic

(D) Tetrahedral and paramagnetic

Q28. The value of crystal field stabilization energy (CFSE) for a d^4 high spin octahedral complex is:

(A) $-1.6\Delta_o$

(B) $-0.6\Delta_o$

(C) $-1.2\Delta_o$

(D) $-0.4\Delta_o$

Q29. In which of the following molecules are all bonds NOT equal?

(A) CH_4

(B) BF_3

(C) PCl_5

(D) SF_6

Q30. The hybridisation of the central atom in XeF_2 and XeF_4 respectively are:

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

(B) sp^3, sp^3d

(C) sp^3d, sp^3d

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

Q31. Which of the following pairs is isostructural?

(A) SF_4 and XeF_4

(B) SO_4^{2-} and BF_4^-

(C) NH_3 and NO_3^-

(D) ClF_3 and BF_3

Q32. The correct order of bond angle is:

(A) $H_2O > NH_3 > CH_4$

(B) $CH_4 > NH_3 > H_2O$

(C) $NH_3 > H_2O > CH_4$

(D) $CH_4 > H_2O > NH_3$

Q33. Which of the following oxoacids of phosphorus contains a $P - P$ bond and has the phosphorus in +4 oxidation state?

(A) H_3PO_3

(B) $H_4P_2O_7$

(C) $H_4P_2O_6$

(D) H_3PO_4

Q34. The most acidic oxide among the following is:

(A) P_2O_5

(B) Sb_2O_5

(C) As_2O_5

(D) Bi_2O_5

Q35. The noble gas which is used in MRI (Magnetic Resonance Imaging) as a contrast agent is:

(A) He

(B) Ne

(C) Ar

(D) Xe

Q36. The property of d-block elements to act as catalysts is mainly due to:

(A) Small atomic size

(B) High enthalpy of atomization

(C) Ability to show variable oxidation states

(D) High ionization enthalpy

Q37. Which of the following lanthanoid ions is diamagnetic? ($At.no. Ce = 58, Sm = 62, Eu = 63, Yb = 70$)

(A) Ce^{4+}

(B) Sm^{3+}

(C) Eu^{3+}

(D) Yb^{3+}

Q38. For a first-order reaction, the time taken for 99.9% completion is approximately how many times the half-life?

(A) 2

(B) 5

(C) 10

(D) 100

Q39. The standard electrode potentials (E°) of Mg^{2+}/Mg, Zn^{2+}/Zn, and Cu^{2+}/Cu are −2.37 V, −0.76 V, and +0.34 V respectively. The correct order of reducing power is:

(A) $Mg > Zn > Cu$

(B) $Cu > Zn > Mg$

(C) $Zn > Mg > Cu$

(D) $Mg > Cu > Zn$

Q40. The molarity of pure water is:

(A) 18 M

(B) 55.5 M

(C) 100 M

(D) 1 M

Q41. The concentration of a sugar solution is 10% (w/v). If the osmotic pressure of this solution is 7.0 atm at 27°C, what is the approximate molar mass of the sugar? (R = 0.0821 L atm K^{-1} mol^{-1})

(A) 352 g/mol

(B) 180 g/mol

(C) 342 g/mol

(D) 150 g/mol

Q42. If the radius of the first Bohr orbit of Hydrogen atom is r, then the de Broglie wavelength of the electron in the third orbit is:

(A) $3\pi r$

(B) $6\pi r$

(C) $9\pi r$

(D) $1.5\pi r$

Q43. Which of the following processes represents a decrease in entropy?

(A) Dissolution of NH_4Cl in water.

(B) Sublimation of Iodine.

(C) Condensation of water vapor.

(D) Thermal expansion of an ideal gas.

Q44. For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, the degree of dissociation α at equilibrium is related to the equilibrium pressure P and equilibrium constant K_p as:

(A) $\alpha = \sqrt{\frac{K_p}{P+K_p}}$

(B) $\alpha = \sqrt{\frac{P}{P+K_p}}$

(C) $\alpha = \frac{K_p}{P}$

(D) $\alpha = \sqrt{K_p \cdot P}$

Q45. How much electricity in Faraday is required to produce 20 g of Calcium from molten $CaCl_2$? $(At.mass : Ca = 40)$

(A) 0.5 F

(B) 1.0 F

(C) 2.0 F

(D) 4.0 F

Q46. Which of the following amino acids is optically inactive?

(A) Alanine

(B) Valine

(C) Glycine

(D) Leucine

Q47. The formal charge on the central oxygen atom in the Ozone (O_3) molecule is:

(A) 0

(B) +1

(C) −1

(D) +2

Q48. The coordination number and oxidation state of Cr in $K_3[Cr(C_2O_4)_3]$ are respectively:

(A) 3 and +3

(B) 6 and +3

(C) 6 and +6

(D) 3 and 0

Q49. Which of the following is a condensation polymer?

(A) Neoprene

(B) Teflon

(C) Dacron (Terylene)

(D) Polystyrene

Q50. The rate constant for a reaction is 2.5×10^{-4} s^{-1}. The order of the reaction is:

(A) Zero order

(B) First order

(C) Second order

(D) Third order

Detailed Solutions

Q1.

Solution

Concept:

Conformational analysis and intramolecular forces.

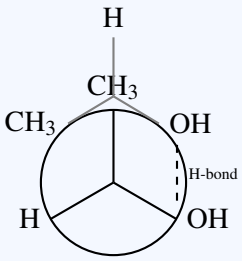
Solution:

Step 1: Identify the substituents on C_2 and C_3. Each carbon has a $-CH_3$, an $-OH$, and an $-H$.

Step 2: Compare the **anti** and **gauche** conformations. In the anti form, the $-OH$ groups are 180° apart, preventing interaction. In the gauche form, they are 60° apart.

Step 3: Evaluate the stabilizing forces. The proximity of the hydroxyl groups in the gauche position enables the formation of an **intramolecular hydrogen bond** (O-H $\cdots$ O).

Step 4: This hydrogen bonding lowers the potential energy of the gauche conformer significantly, making it more stable than the anti conformer despite the slight increase in steric strain between methyl groups.



Gauche Conformer

Final Answer:

Intramolecular hydrogen bonding

Answer: (B)

Q2.

Solution

Concept:

Friedel-Crafts Acylation is an electrophilic aromatic substitution (S_EAr) reaction. The rate of S_EAr is increased by Electron Donating Groups (EDGs) which increase electron density on the ring and decreased by Electron Withdrawing Groups (EWGs) which deactivate the ring.

Solution:

1. **Nitrobenzene:** The $-NO_2$ group is a very strong deactivating group (EWG). It usually prevents Friedel-Crafts reactions entirely. 2. **Chlorobenzene:** The $-Cl$ group is deactivating due to its strong $-I$ effect, despite being ortho/para directing. 3. **Acetanilide:** The $-NHCOCH_3$ group has a lone pair on Nitrogen that can delocalize into the ring ($+M$ effect). Although the carbonyl group pulls some electron density away from Nitrogen, the net effect is still strongly activating compared to Hydrogen or halogens. 4. **Ethyl benzoate:** The $-COOC_2H_5$ group is an EWG and deactivates the ring. 5. Comparing the four, Acetanilide has the highest electron density on the ring due to the resonance of the nitrogen lone pair.

Final Answer: Acetanilide will exhibit the highest rate of reaction.

Answer: (C)

Q3.

Solution

Concept:

For a molecule to be optically active, it must be chiral (possess a non-superimposable mirror image, usually containing a chiral center). Catalytic hydrogenation (H_2/Ni) reduces a double bond to a single bond. If the resulting alkane has a plane of symmetry or loses its chiral center, it becomes optically inactive (achiral).

Solution:

1. **3-Methylpent-1-ene:** Structure is $CH_2 = CH - CH(CH_3) - CH_2 - CH_3$. Carbon-3 is a chiral center (attached to H, CH_3, ethyl, and vinyl). 2. Upon hydrogenation, it becomes 3-methylpentane: $CH_3 - CH_2 - CH(CH_3) - CH_2 - CH_3$. 3. In 3-methylpentane, Carbon-3 is attached to H, CH_3, and two identical ethyl groups (CH_2CH_3). 4. Because it now has two identical groups, it is no longer chiral and the molecule becomes optically inactive. 5. Other options like 2-methylpent-1-ene are achiral to begin with.

Final Answer: The compound is 3-Methylpent-1-ene.

Answer: (A)

Q4.

Solution

Concept:

Acid-catalyzed dehydration of alcohols follows a carbocation mechanism. When a stable carbocation can be formed via rearrangement (1,2-shift), the reaction proceeds through the more stable intermediate. The major product is the most substituted alkene (Saytzeff's Rule).

Solution:

1. Protonation of 3,3-dimethylbutan-2-ol ($CH_3 - C(CH_3)_2 - CH(OH) - CH_3$) and loss of water forms a 2° carbocation: $CH_3 - C(CH_3)_2 - CH^+ - CH_3$. 2. To increase stability, a **1,2-methyl shift** occurs from the adjacent quaternary carbon. 3. This forms a more stable 3° carbocation: $CH_3 - C^+(CH_3) - CH(CH_3) - CH_3$. 4. Deprotonation from this 3° cation follows Saytzeff's rule to give the most substituted alkene. 5. The resulting major product is 2,3-dimethylbut-2-ene.

Final Answer: The major product is 2,3-Dimethylbut-2-ene.

Answer: (B)

Q5.

Solution

Concept:

Stereoisomerism in compounds with multiple chiral centers and symmetry.

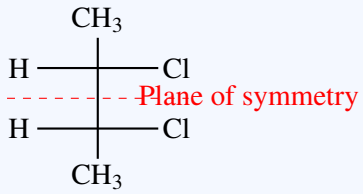
Solution:

Step 1: Identify chiral centers. 2,3-dichlorobutane ($CH_3CHClCHClCH_3$) has two chiral carbons at positions C_2 and C_3.

Step 2: Note that the molecule is symmetrical. Since the substituents on both chiral centers are identical (−H, −Cl, $-CH_3$, and the rest of the chain), the formula for the number of stereoisomers for a symmetrical molecule with n even chiral centers is: Total isomers = $2^{n-1} + 2^{(n/2)-1}$.

Step 3: Calculate using $n = 2$: Enantiomer pairs = $2^{2-1} = 2$ (the $(2R, 3R)$ and $(2S, 3S)$ pair). Meso compounds = $2^{(2/2)-1} = 2^0 = 1$ (the $(2R, 3S)$ form which is identical to $(2S, 3R)$).

Step 4: Total stereoisomers = 2 + 1 = 3. The meso form is optically inactive due to an internal plane of symmetry.



Meso-2,3-dichlorobutane

Final Answer:

3

Answer: (B)

Q6.

Solution

Concept:

Hydration of alkynes using Hg^{2+}/H_2SO_4 (Kucherov reaction) follows Markovnikov's rule to form an enol, which then tautomerizes to a more stable carbonyl compound.

Solution:

1. 1-Butyne ($CH_3 - CH_2 - C \equiv CH$) reacts with water in the presence of $HgSO_4$ and H_2SO_4. 2. According to Markovnikov's rule, the hydroxyl group (-OH) adds to the carbon with fewer hydrogens (C2). 3. This forms an unstable enol: $CH_3 - CH_2 - C(OH) = CH_2$. 4. The enol undergoes keto-enol tautomerism. The hydrogen from the oxygen moves to the terminal carbon, and the double bond shifts to the oxygen. 5. The final stable product is Butan-2-one ($CH_3 - CH_2 - CO - CH_3$).

Final Answer: The major product is Butan-2-one.

Answer: (B)

Q7.

Solution

Concept:

The acidic strength of hydrocarbons is determined by the hybridization of the carbon atom bearing the hydrogen. Higher s-character in the hybrid orbital makes the carbon more electronegative, which better stabilizes the conjugate base (carbanion).

Solution:

1. **Methane (CH_4):** sp^3 hybridized carbon (25%s-character). Least acidic. 2. **Ethene ($CH_2 = CH_2$):** sp^2 hybridized carbon (33%s-character). 3. **Benzene (C_6H_6):** sp^2 hybridized, but slightly more acidic than ethene due to resonance stabilization of the resulting carbanion (though still weak). 4. **Ethyne ($CH \equiv CH$):** sp hybridized carbon (50%s-character). Most electronegative carbon, making it the most acidic. 5. Thus, the order is $CH_4 < CH_2 = CH_2 < C_6H_6 < CH \equiv CH$.

Final Answer: The correct order is (A).

Answer: (A)

Q8.

Solution

Concept:

Ozonolysis followed by reduction cleaves the $C = C$ bond and replaces it with two $C = O$ bonds. To find the original alkene, remove the oxygen atoms from the products and join the carbons with a double bond.

Solution:

1. Products are: Methanal ($HCHO$) and 2-Methylpropanal ($CH_3-CH(CH_3)-CHO$). 2. Identify the carbonyl carbons: C from $HCHO$ and $C1$ from 2-methylpropanal. 3. Join them: $H_2C = CH-CH(CH_3)-CH_3$. 4. Number the longest chain starting from the double bond: 3-Methylbut-1-ene. 5. Verification: Ozonolysis of 3-methylbut-1-ene gives $HCHO$ and $(CH_3)_2CHCHO$.

Final Answer: The alkene is 3-Methylbut-1-ene.

Answer: (B)

Q9.

Solution

Concept:

Reaction with aqueous $AgNO_3$ tests for the ease of forming a carbocation (S_N1 mechanism). The more stable the resulting carbocation, the faster the precipitate (AgX) forms.

Solution:

1. **Chlorobenzene/Vinyl chloride:** The $C - Cl$ bond has partial double bond character due to resonance, making it very strong and difficult to break. No reaction under normal conditions. 2. **Bromobenzene:** Similar to chlorobenzene, the $C - Br$ bond is strong due to resonance. 3. **Benzyl chloride ($C_6H_5CH_2Cl$):** Ionization produces the benzyl carbocation ($C_6H_5CH_2^+$). 4. The benzyl carbocation is highly stabilized by resonance with the benzene ring. 5. Therefore, benzyl chloride reacts fastest to form a white precipitate of $AgCl$.

Final Answer: Benzyl chloride reacts fastest.

Answer: (C)

Q10.

Solution

Concept:

This sequence involves substitution, elimination, and addition.

Solution:

1. **Step 1:** $C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl$ (Ethyl chloride, A). Alcohol is converted to alkyl halide. 2. **Step 2:** $C_2H_5Cl + alc.KOH \xrightarrow{\Delta} CH_2 = CH_2$ (Ethene, B). Dehydrohalogenation (elimination) occurs. 3. **Step 3:** $CH_2 = CH_2 + Br_2/CCl_4 \rightarrow Br - CH_2 - CH_2 - Br$ (1,2-Dibromoethane, C). Anti-addition of bromine across the double bond. 4. Product C is 1,2-Dibromoethane.

Final Answer: The product C is 1,2-Dibromoethane.

Answer: (A)

Q11.

Solution

Concept:

Nucleophilic Aromatic Substitution (S_NAr) typically requires strong electron-withdrawing groups at ortho or para positions to stabilize the anionic intermediate (Meisenheimer complex). Alkoxides act as nucleophiles.

Solution:

1. In p-nitrobromobenzene, the $-NO_2$ group is at the para position relative to the Bromine atom. 2. The $-NO_2$ group strongly withdraws electron density through resonance ($-M$ effect). 3. When the ethoxide ion ($CH_3CH_2O^-$) attacks the carbon bearing the bromine, the negative charge is delocalized onto the oxygen atoms of the nitro group. 4. This stabilizes the transition state, allowing the Bromine to leave as Br^-. 5. The product formed is p-nitroethoxybenzene (also known as p-nitrophenetole).

Final Answer: The major product is p-Nitroethoxybenzene.

Answer: (B)

Q12.

Solution

Concept:

The reaction of primary alcohols with HCl usually involves a carbocation intermediate if rearrangement can lead to a significantly more stable ion. Neopentyl alcohol is a classic case of 1,2-shift stabilization.

Solution:

1. Neopentyl alcohol is $(CH_3)_3C-CH_2OH$. 2. Protonation and loss of water yields the neopentyl carbocation: $(CH_3)_3C-CH_2^+$. This is a 1° carbocation. 3. To increase stability, a **1,2-methyl shift** occurs from the adjacent quaternary carbon to the carbocation center. 4. This results in a 3° carbocation: $CH_3-C^+(CH_3)-CH_2-CH_3$ (tert-pentyl cation). 5. The nucleophile (Cl^-) then attacks this 3° carbocation. 6. The final major product is 2-Chloro-2-methylbutane.

Final Answer: The product is 2-Chloro-2-methylbutane.

Answer: (B)

Q13.

Solution

Concept:

Phenol is highly activated toward electrophilic aromatic substitution due to the $+M$ effect of the $-OH$ group. In polar solvents like water, phenol ionizes to the phenoxide ion, which is even more reactive.

Solution:

1. Bromine water (Br_2/H_2O) provides a highly polar medium. 2. In this medium, phenol exists in equilibrium with the phenoxide ion ($C_6H_5O^-$). 3. The phenoxide ion is so strongly activating that substitution occurs at all available ortho and para positions simultaneously. 4. Bromine atoms replace the hydrogens at positions 2, 4, and 6. 5. This results in the formation of a white precipitate of 2,4,6-Tribromophenol.

Final Answer: The product is 2,4,6-Tribromophenol.

Answer: (C)

Q14.

Solution

Concept:

The Reimer-Tiemann reaction is used to introduce an aldehyde group (-CHO) onto an aromatic ring. It specifically requires an electron-rich aromatic ring, typically a phenol or a substituted phenol.

Solution:

1. The reaction involves the generation of dichlorocarbene (: CCl_2) which acts as the electrophile. 2. **Phenol, m-Cresol, and o-Cresol** are all phenolic compounds with electron-donating hydroxyl groups that activate the ring toward electrophilic attack. 3. **Nitrobenzene**, however, contains a strong electron-withdrawing group ($-NO_2$). 4. The nitro group deactivates the ring so severely that it cannot react with the relatively weak electrophile (dichlorocarbene). 5. Thus, nitrobenzene does not undergo the Reimer-Tiemann reaction.

Final Answer: Nitrobenzene will not undergo the reaction.

Answer: (C)

Q15.

Solution

Concept:

This is a multi-step synthesis involving Friedel-Crafts alkylation, oxidation of the side chain, and conversion of an acid to an acid chloride.

Solution:

1. **Step 1:** $Benzene + CH_3Cl \xrightarrow{AlCl_3} Toluene$ ($C_6H_5CH_3$, X). This is Friedel-Crafts alkylation. 2. **Step 2:** $Toluene \xrightarrow{KMnO_4/OH^-} BenzoicAcid$ (C_6H_5COOH, Y). Strong oxidizing agents like $KMnO_4$ oxidize any alkyl side chain (with at least one alpha-H) completely to a carboxylic acid group. 3. **Step 3:** $BenzoicAcid + PCl_5 \rightarrow BenzoylChloride$ (C_6H_5COCl, Z). The hydroxyl group of the acid is replaced by chlorine. 4. Product Z is Benzoyl chloride.

Final Answer: The product Z is Benzoyl chloride.

Answer: (B)

Q16.

Solution

Concept:

The Iodoform test is positive for compounds containing a methyl keto group (CH_3CO-) or alcohols that can be oxidized to a methyl keto group ($CH_3CH(OH)-$). Acidified $K_2Cr_2O_7$ is an oxidizing agent that turns from orange to green (Cr^{3+}) upon reacting with primary or secondary alcohols.

Solution:

1. **Methanol (CH_3OH):** Can be oxidized (turns $K_2Cr_2O_7$ green) but does not have the $CH_3CH(OH)-$ structure for a positive iodoform test. 2. **Ethanol (CH_3CH_2OH):** Contains the $CH_3CH(OH)-$ linkage. It is oxidized to acetaldehyde (CH_3CHO), which gives a positive iodoform test. Being a primary alcohol, it also reduces $K_2Cr_2O_7$, turning the solution green. 3. **Isopropyl alcohol ($CH_3CH(OH)CH_3$):** Contains the required linkage and is oxidized to acetone (CH_3COCH_3), giving a positive iodoform test. It also turns $K_2Cr_2O_7$ green. 4. **Comparison:** While both B and C fit, Ethanol is the most common example used for this dual property in basic organic tests. However, in most competitive contexts, Ethanol is the primary answer for "simplest alcohol" showing both.

Final Answer: Ethanol gives a positive Iodoform test and turns dichromate green.

Answer: (B)

Q17.

Solution

Concept:

Aldol condensation occurs in aldehydes or ketones with at least one α-hydrogen in the presence of a dilute base. Heating the aldol product causes dehydration to form an α,β-unsaturated aldehyde.

Solution:

1. Propanal (CH_3CH_2CHO) has two α-hydrogens on the second carbon. 2. In the presence of $NaOH$, one molecule forms a carbanion: $CH_3 - \bar{C}H - CHO$. 3. This carbanion attacks the carbonyl carbon of a second propanal molecule: $CH_3 - CH_2 - CH(OH) - CH(CH_3) - CHO$. 4. Upon heating, a molecule of water is lost between the α-carbon and β-carbon. 5. The double bond forms to create $CH_3 - CH_2 - CH = C(CH_3) - CHO$. 6. The IUPAC name for this product is 2-Methylpent-2-enal.

Final Answer: The major product is 2-Methylpent-2-enal.

Answer: (A)

Q18.

Solution

Concept:

Nucleophilic addition reactivity depends on two factors: (i) Electronic factors (higher positive charge on carbonyl carbon increases reactivity) and (ii) Steric factors (bulkier groups hinder the approach of the nucleophile).

Solution:

1. Aldehydes are generally more reactive than ketones because they have only one electron-donating alkyl group and less steric hindrance. 2. **Acetaldehyde (CH_3CHO):** Small methyl group, relatively high electrophilicity. 3. **Benzaldehyde ($PhCHO$):** The phenyl ring donates electron density through resonance, reducing the positive charge on the carbonyl carbon, making it less reactive than aliphatic aldehydes. 4. **Acetone (CH_3COCH_3):** Two electron-donating methyl groups and more steric hindrance than CH_3CHO. 5. **Benzophenone ($PhCOPh$):** Highly hindered and electronically deactivated by two phenyl rings. 6. Thus, Acetaldehyde is the most reactive.

Final Answer: Acetaldehyde (CH_3CHO) is most reactive.

Answer: (A)

Q19.

Solution

Concept:

This is a named reaction specifically used for the preparation of aldehydes from nitriles (alkyl cyanides) using specific reducing agents.

Solution:

1. The reaction involves the reduction of an alkyl cyanide ($R-CN$) with stannous chloride ($SnCl_2$) and gaseous HCl in ether. 2. This produces an intermediate imine hydrochloride ($R-CH=NH\cdot HCl$). 3. Hydrolysis of this imine with boiling water yields the corresponding aldehyde ($R-CHO$). 4. This specific sequence ($SnCl_2/HCl$ followed by H_2O) is known as the **Stephen reduction**. 5. Rosenmund reduction involves acid chlorides, while Etard involves toluene.

Final Answer: The reaction is known as Stephen reduction.

Answer: (B)

Q20.

Solution

Concept:

Aldehydes that do not have any α-hydrogens (like benzaldehyde or formaldehyde) cannot undergo Aldol condensation. Instead, they undergo a self-oxidation-reduction reaction in the presence of a concentrated strong base.

Solution:

1. Benzaldehyde (C_6H_5CHO) lacks α-hydrogens. 2. Treatment with concentrated KOH (50%) triggers a disproportionation reaction. 3. One molecule of benzaldehyde is reduced to Benzyl alcohol ($C_6H_5CH_2OH$). 4. Another molecule is oxidized to the Potassium salt of benzoic acid (C_6H_5COOK). 5. This specific process is called the **Cannizzaro reaction**. 6. Benzoin condensation requires KCN, and Perkin requires an acid anhydride.

Final Answer: It undergoes Cannizzaro reaction.

Answer: (B)

Q21.

Solution

Concept:

The basic strength of amines in aqueous solution is determined by three factors: 1. **Inductive effect ($+I$):** Alkyl groups increase electron density on Nitrogen. 2. **Solvation effect:** Hydrogen bonding with water stabilizes the conjugate acid. 3. **Steric hindrance:** Bulky groups hinder the approach of protons.

Solution:

1. For methyl-substituted amines, the $+I$ effect follows the order: $3^\circ > 2^\circ > 1^\circ$. 2. However, the solvation effect (stability via H-bonding) follows the opposite order: $1^\circ > 2^\circ > 3^\circ$, because the 1° cation has more Hydrogens to bond with water. 3. When these competing factors are combined for the methyl group, the secondary amine (2°) emerges as the strongest base because it has a favorable balance of $+I$ effect and solvation. 4. Tertiary amines (3°) are less basic than secondary and primary in aqueous medium because steric hindrance and poor solvation outweigh the $+I$ effect. 5. The specific experimental order for Methyl amines is: $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$.

Final Answer: The correct order is (A).

Answer: (A)

Q22.

Solution

Concept:

Aniline reacts with nitrous acid at low temperatures to form a stable diazonium salt. This salt can then undergo the Sandmeyer reaction, where the diazonium group is replaced by various nucleophiles using Copper(I) salts.

Solution:

1. **Step 1 (Diazotization):** Aniline ($C_6H_5NH_2$) reacts with $NaNO_2 + HCl$ at $0 - 5^\circ C$ to form Benzene diazonium chloride ($C_6H_5N_2^+Cl^-$). 2. **Step 2 (Sandmeyer Reaction):** The diazonium salt is treated with Cuprous cyanide ($CuCN$). 3. The $-N_2Cl$ group is substituted by the $-CN$ group. 4. Nitrogen gas (N_2) is evolved as a byproduct. 5. The resulting organic product is Benzonitrile (C_6H_5CN).

Final Answer: The product is Benzonitrile.

Answer: (B)

Q23.

Solution

Concept:

The Hinsberg test is used to distinguish between primary, secondary, and tertiary amines using Benzene sulphonyl chloride ($C_6H_5SO_2Cl$).

Solution:

1. **Primary Amines:** React to form an N-alkylbenzene sulphonamide. This product has an acidic hydrogen attached to Nitrogen, making it **soluble** in alkali (NaOH). 2. **Secondary Amines:** React to form an N,N-dialkylbenzene sulphonamide ($C_6H_5SO_2NR_2$). This product **lacks** an acidic hydrogen on the Nitrogen atom. 3. Because it lacks an acidic hydrogen, the resulting sulphonamide is **insoluble** in alkali (NaOH). 4. **Tertiary Amines:** Do not react with Hinsberg's reagent under standard conditions as they have no replaceable hydrogen on the Nitrogen.

Final Answer: Secondary amines form a product that is insoluble in alkali.

Answer: (B)

Q24.

Solution

Concept:

A sugar is ”reducing” if it has a free (or potentially free via mutarotation) aldehyde or ketone group in the form of a hemiacetal or hemiketal. If the anomeric carbons of the monosaccharide units are involved in a glycosidic bond, the sugar is non-reducing.

Solution:

1. **Glucose and Fructose:** Are monosaccharides with free anomeric carbons; they reduce Tollen's and Fehling's reagents. 2. **Lactose:** Is a disaccharide where one anomeric carbon is free (reducing). 3. **Sucrose:** Is a disaccharide composed of α-D-glucose and β-D-fructose. 4. In Sucrose, the glycosidic linkage is between C1 of glucose and C2 of fructose. 5. Since both anomeric carbons (the aldehyde group of glucose and the keto group of fructose) are tied up in the bond, there is no free carbonyl group. 6. Thus, Sucrose cannot reduce Fehling's or Tollen's reagent.

Final Answer: Sucrose is a non-reducing sugar.

Answer: (D)

Q25.

Solution

Concept:

Blood contains various proteins with specialized functions. Clotting (coagulation) is a complex process involving the conversion of soluble plasma proteins into insoluble fiber networks.

Solution:

1. **Albumin:** Primarily maintains osmotic pressure of the blood. 2. **Globulin:** Involved in defense mechanisms (antibodies). 3. **Haemoglobin:** Responsible for Oxygen and CO_2 transport. 4. **Fibrinogen:** This is a soluble plasma glycoprotein. During injury, the enzyme thrombin converts Fibrinogen into Fibrin. 5. Fibrin forms long, insoluble strands that entangle platelets to form a blood clot, preventing excessive bleeding.

Final Answer: Fibrinogen is the protein responsible for blood clotting.

Answer: (C)

Q26.

Solution

Concept:

Polymers are classified based on their thermal properties into thermoplastics and thermosetting plastics. Thermosetting polymers are those that, once molded and cooled, undergo a permanent chemical change (cross-linking) and cannot be remelted or reshaped.

Solution:

1. **Polythene and PVC:** These are thermoplastics. They consist of long linear or slightly branched chains held by weak intermolecular forces. They can be softened on heating and hardened on cooling repeatedly. 2. **Nylon-6,6:** This is a fiber-forming thermoplastic polyamide. 3. **Bakelite:** This is a phenol-formaldehyde resin. During the polymerization process, extensive cross-linking occurs between the polymer chains, forming a three-dimensional network. 4. Once this network is formed during the "setting" process (usually by heating), the polymer becomes infusible and insoluble. 5. Due to this rigid 3D structure, Bakelite is a classic example of a thermosetting polymer.

Final Answer: Bakelite is a thermosetting polymer.

Answer: (C)

Q27.

Solution

Concept:

Crystal Field Theory (CFT) and hybridization of coordination compounds.

Solution:

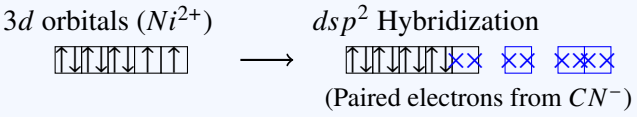
Step 1: Determine the oxidation state of Ni. Let x be the oxidation state: $x + 4(-1) = -2 \Rightarrow x = +2$. Nickel is in the Ni^{2+} state.

Step 2: Write the electronic configuration. Ni is $[Ar]3d^8 4s^2$, so Ni^{2+} is $[Ar]3d^8 4s^0$.

Step 3: Analyze the ligand strength. CN^- is a **strong field ligand**. According to Crystal Field Theory, it provides sufficient energy to force the pairing of electrons in the $3d$ orbitals.

Step 4: Determine hybridization. The $3d^8$ configuration pairs up, leaving one empty $3d$ orbital. This orbital, along with one $4s$ and two $4p$ orbitals, undergoes dsp^2 hybridization.

Step 5: Conclude geometry and magnetism. dsp^2 hybridization corresponds to **square planar** geometry. Since all electrons are paired, the complex is **diamagnetic**.



Final Answer:

Square planar and diamagnetic

Answer: (B)

Q28.

Solution

Concept:

Crystal Field Stabilization Energy (CFSE) for an octahedral complex is calculated by the formula: $CFSE = [-0.4n(t_{2g}) + 0.6n(e_g)]\Delta_o$, where n is the number of electrons in the respective orbitals.

Solution:

1. For a d^4 ion in an octahedral field, the electrons first fill the lower energy t_{2g} level. 2. In a **high spin** complex, the pairing energy (P) is greater than the crystal field splitting (Δ_o). 3. Therefore, the fourth electron does not pair up in the t_{2g} level but instead moves to the higher energy e_g level. 4. The electronic configuration is $t_{2g}^3 e_g^1$. 5. Calculation:

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

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

6. Thus, the stabilization energy is $-0.6\Delta_o$.

Final Answer: The CFSE is $-0.6\Delta_o$.

Answer: (B)

Q29.

Solution

Concept:

In molecules where the central atom is surrounded by identical atoms and there are no lone pairs (or lone pairs are symmetrically arranged), all bond lengths are typically equal. However, in certain geometries like trigonal bipyramidal, different types of bonds exist.

Solution:

1. **CH_4 (Tetrahedral):** All four $C - H$ bonds are equivalent. 2. **BF_3 (Trigonal Planar):** All three $B - F$ bonds are equivalent. 3. **SF_6 (Octahedral):** All six $S - F$ bonds are equivalent. 4. **PCl_5 (Trigonal Bipyramidal):** Phosphorus is sp^3d hybridized. It has three **equatorial** $P - Cl$ bonds and two **axial** $P - Cl$ bonds. 5. The axial bonds suffer more repulsion from the equatorial bond pairs, making them longer and weaker than the equatorial bonds. 6. Therefore, in PCl_5, the bonds are not all equal.

Final Answer: In PCl_5, all bonds are not equal.

Answer: (C)

Q30.

Solution

Concept:

The hybridization of Xenon fluorides can be determined using the formula: $H = \frac{1}{2}[V+M-C+A]$, where V is valence electrons, M is monovalent atoms, C is cationic charge, and A is anionic charge.

Solution:

1. **For XeF_2:** - Valence electrons of $Xe = 8$. - Monovalent atoms $(F) = 2$. - $H = \frac{1}{2}[8+2] = 5$. - $H = 5$ corresponds to **sp^3d** hybridization (Linear shape due to 3 lone pairs). 2. **For XeF_4:** - Valence electrons of $Xe = 8$. - Monovalent atoms $(F) = 4$. - $H = \frac{1}{2}[8+4] = 6$. - $H = 6$ corresponds to **sp^3d^2** hybridization (Square planar shape due to 2 lone pairs). 3. The hybridizations are sp^3d and sp^3d^2 respectively.

Final Answer: The hybridizations are sp^3d and sp^3d^2.

Answer: (A)

Q31.

Solution

Concept:

Isostructural species are those that have the same shape and geometry, regardless of the chemical identity of the atoms. This is determined by the total number of valence electrons and the resulting hybridization and VSEPR shape.

Solution:

1. **Pair (A): SF_4 and XeF_4:** SF_4 has 4 bond pairs and 1 lone pair (See-saw), while XeF_4 has 4 bond pairs and 2 lone pairs (Square planar). Not isostructural. 2. **Pair (B): SO_4^{2-} and BF_4^-:** - For SO_4^{2-}: Sulfur has 6 valence electrons + 2 (charge) = 8. It forms 4 bonds with Oxygen. Steric number = 4 (Tetrahedral). - For BF_4^-: Boron has 3 valence electrons + 1 (charge) = 4. It forms 4 bonds with Fluorine. Steric number = 4 (Tetrahedral). - Since both have a steric number of 4 and 0 lone pairs, both are **Tetrahedral**. 3. **Pair (C): NH_3 and NO_3^-:** NH_3 is Pyramidal, while NO_3^- is Trigonal planar. 4. **Pair (D): ClF_3 and BF_3:** ClF_3 is T-shaped, while BF_3 is Trigonal planar.

Final Answer: SO_4^{2-} and BF_4^- are isostructural.

Answer: (B)

Q32.

Solution

Concept:

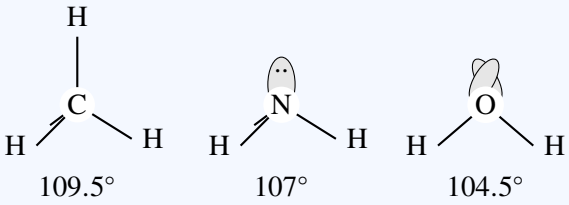
VSEPR Theory and Bond Angles.

Solution:

Step 1: Determine the hybridization and electronic geometry. All three central atoms (C, N, and O) are sp^3 hybridized, which ideally gives a tetrahedral bond angle of 109.5°.

Step 2: Count the lone pairs. * **CH_4**: 0 lone pairs. Geometry is perfect tetrahedral. Bond angle ≈ 109.5°. * **NH_3**: 1 lone pair. The lone pair-bond pair repulsion is stronger than bond pair-bond pair repulsion, squeezing the H-N-H angle to ≈ 107°. * **H_2O**: 2 lone pairs. Lone pair-lone pair repulsion is the strongest, further reducing the H-O-H angle to ≈ 104.5°.

Step 3: Compare the angles. Since increasing lone pairs decreases the bond angle: $CH_4(109.5°) > NH_3(107°) > H_2O(104.5°)$.



Final Answer:

$$\boxed{CH_4 > NH_3 > H_2O}$$

Answer: (B)

Q33.

Solution

Concept:

The properties of oxoacids of phosphorus depend on their molecular structures. A $P-P$ bond is found in "hypo" prefix acids where phosphorus atoms are directly linked.

Solution:

1. **H_3PO_3 (Phosphorous acid):** Phosphorus is in +3 state. Structure: $O = P(H)(OH)_2$. 2. **$H_4P_2O_7$ (Pyrophosphoric acid):** Contains $P-O-P$ linkage. Oxidation state is +5. 3. **$H_4P_2O_6$ (Hypophosphoric acid):** This acid is formed by the direct linkage of two P atoms ($P-P$ bond). 4. Oxidation state calculation for $H_4P_2O_6$: $4(+1)+2x+6(-2) = 0 \Rightarrow 4+2x-12 = 0 \Rightarrow 2x = 8 \Rightarrow x = +4$. 5. It satisfies both conditions: contains a $P-P$ bond and phosphorus is in +4 oxidation state.

Final Answer: The acid is $H_4P_2O_6$.

Answer: (C)

Q34.

Solution

Concept:

For oxides of the same group elements in the same oxidation state, acidity increases with the electronegativity of the central atom. As we move down the group, metallic character increases and electronegativity decreases, making the oxides more basic.

Solution:

1. Elements P, As, Sb, Bi belong to Group 15. 2. Phosphorus (P) is at the top of the group and is the most electronegative among the listed elements. 3. High electronegativity allows the central atom to better polarize the $O - H$ bond in its hydrated form, facilitating the release of H^+ ions. 4. P_2O_5 reacts with water to form H_3PO_4, a strong acid. Bi_2O_5 is unstable and much more basic/metallic in character. 5. Therefore, P_2O_5 is the most acidic oxide.

Final Answer: P_2O_5 is the most acidic oxide.

Answer: (A)

Q35.

Solution

Concept:

Certain noble gases have specialized applications in medicine due to their specific physical properties or isotopic characteristics.

Solution:

1. **Helium:** Used in diving tanks and as a coolant. 2. **Neon:** Used in discharge tubes and advertising signs. 3. **Argon:** Used to provide an inert atmosphere. 4. **Xenon (Xe):** Specifically, the isotope ^{129}Xe is used in hyperpolarized MRI to image the lungs and blood flow. 5. Xenon gas itself is also used as a contrast agent because it is non-toxic, lipophilic, and has a large range of chemical shifts that make it very sensitive to its environment during magnetic resonance imaging.

Final Answer: Xenon is used as a contrast agent in MRI.

Answer: (D)

Q36.

Solution

Concept:

The catalytic property of transition metals (d-block elements) is one of their most significant characteristics. This efficiency arises from their unique electronic configurations and surface properties.

Solution:

1. **Variable Oxidation States:** Transition metals can easily change their oxidation states by losing or gaining electrons from their $(n-1)d$ and ns orbitals. This allows them to form unstable intermediate complexes with reactants. 2. **Intermediate Formation:** By forming these intermediates, the metal provides a new reaction pathway with a lower activation energy (E_a), which increases the reaction rate. 3. **Surface Area:** In many cases (like finely divided Ni or Pt), they provide a large surface area for reactants to be adsorbed, bringing them closer together for the reaction to occur. 4. While size and ionization enthalpy play roles in general chemistry, the **ability to show variable oxidation states** is the primary reason they can act as chemical "links" or catalysts in redox and other complex reactions.

Final Answer: The property is mainly due to the ability to show variable oxidation states.

Answer: (C)

Q37.

Solution

Concept:

An ion or atom is diamagnetic if all its electrons are paired. If there is at least one unpaired electron, it is paramagnetic. For lanthanoids ($4f$ series), we must look at the Ln^{3+} or Ln^{4+} configurations.

Solution:

1. **Ce^{4+}:** Cerium ($Z = 58$) has the configuration $[Xe]4f^{1}5d^{1}6s^{2}$. When it loses 4 electrons to become Ce^{4+}, its configuration becomes $[Xe]4f^{0}$. Since the $4f$ shell is empty, there are no unpaired electrons. Thus, it is **diamagnetic**. 2. **Sm^{3+} ($Z = 62$):** $[Xe]4f^{6}6s^{2} \rightarrow Sm^{3+}$ is $[Xe]4f^{5}$. It has 5 unpaired electrons (Paramagnetic). 3. **Eu^{3+} ($Z = 63$):** $[Xe]4f^{7}6s^{2} \rightarrow Eu^{3+}$ is $[Xe]4f^{6}$. It has 6 unpaired electrons (Paramagnetic). 4. **Yb^{3+} ($Z = 70$):** $[Xe]4f^{14}6s^{2} \rightarrow Yb^{3+}$ is $[Xe]4f^{13}$. It has 1 unpaired electron (Paramagnetic). Note: Yb^{2+} would be diamagnetic ($4f^{14}$).

Final Answer: Ce^{4+} is diamagnetic.

Answer: (A)

Q38.

Solution

Concept:

For a first-order reaction, the integrated rate equation is $t = \frac{2.303}{k} \log \frac{[A]_0}{[A]_t}$. The half-life is given by $t_{1/2} = \frac{0.693}{k}$.

Solution:

1. For 99.9% completion, the remaining concentration $[A]_t$ is $100 - 99.9 = 0.1\%$ of $[A]_0$. $[A]_t = 0.001[A]_0$. 2. Substitute into the rate equation:

$$t_{99.9\%} = \frac{2.303}{k} \log \left(\frac{[A]_0}{0.001[A]_0} \right)$$

$$t_{99.9\%} = \frac{2.303}{k} \log(10^3) = \frac{2.303 \times 3}{k} = \frac{6.909}{k}$$

3. We know that $t_{1/2} = \frac{0.693}{k}$. 4. Divide the two equations:

$$\frac{t_{99.9\%}}{t_{1/2}} = \frac{6.909/k}{0.693/k} \approx 9.97 \approx 10$$

5. Thus, the time required is approximately 10 times the half-life.

Final Answer: The time taken is 10 times the half-life.

Answer: (C)

Q39.

Solution

Concept:

The reducing power of a metal is its ability to lose electrons (undergo oxidation). This is inversely proportional to its Standard Reduction Potential (E°). The more negative the E° value, the easier it is for the metal to be oxidized, and thus the stronger its reducing power.

Solution:

1. Given standard reduction potentials: - Mg^{2+}/Mg : -2.37 V - Zn^{2+}/Zn : -0.76 V - Cu^{2+}/Cu : $+0.34$ V 2. Compare the values: $-2.37 < -0.76 < +0.34$. 3. Magnesium has the most negative potential, meaning it is the strongest reducing agent (most reactive). 4. Copper has a positive potential, meaning it is the weakest reducing agent among the three. 5. Therefore, the order of reducing power is $Mg > Zn > Cu$.

Final Answer: The correct order is $Mg > Zn > Cu$.

Answer: (A)

Q40.

Solution

Concept:

Molarity (M) is defined as the number of moles of solute per liter of solution. For a pure substance like water, the substance acts as both the solute and the solvent.

Solution:

1. Consider 1 Liter (1000 mL) of pure water. 2. The density of water is 1 g/mL at standard conditions, so the mass of 1 L of water is 1000 g. 3. The molar mass of water (H_2O) is: $2(1)+16 = 18$ g/mol. 4. Number of moles in 1000 g:

$$n = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{1000}{18} \approx 55.55 \text{ moles}$$

5. Since these moles are present in 1 L, the molarity is 55.55 M (often rounded to 55.5 M or 55.6 M).

Final Answer: The molarity of pure water is 55.5 M.

Answer: (B)

Q41.

Solution

Concept:

The osmotic pressure (π) of a solution is a colligative property related to the molarity (M) of the solute by the formula:

$$\pi = CRT$$

where C is the molar concentration (n/V), R is the gas constant, and T is the absolute temperature in Kelvin.

Solution:

1. **Given Data:** - Concentration = 10% (w/v) $\Rightarrow$ 10 g of sugar in 100 mL of solution. - Therefore, in 1000 mL (1 L), the mass of sugar (w) = 100 g. - Osmotic pressure (π) = 7.0 atm. - Temperature (T) = 27°C = 27 + 273 = 300 K. - R = 0.0821 L atm K^{-1} mol^{-1}. 2. **Formula rearrangement:**

$$\pi = \frac{w}{m \times V} RT \Rightarrow m = \frac{w \times R \times T}{\pi \times V}$$

3. **Calculation:**

$$m = \frac{100 \times 0.0821 \times 300}{7.0 \times 1}$$

$$m = \frac{2463}{7} \approx 351.85 \text{ g/mol}$$

4. The calculated molar mass is approximately 352 g/mol.

Final Answer: The approximate molar mass of the sugar is 352 g/mol.

Answer: (A)

Q42.

Solution

Concept:

According to Bohr's theory, the angular momentum of an electron is quantized: $mvr = \frac{nh}{2\pi}$. According to de Broglie, the wavelength of an electron is $\lambda = \frac{h}{mv}$. Combining these gives the condition for a stationary orbit: $2\pi r_n = n\lambda$.

Solution:

1. The radius of the n^{th} Bohr orbit is given by $r_n = r_1 \times n^2$. 2. For the third orbit ($n = 3$), the radius $r_3 = r \times 3^2 = 9r$. 3. Using the relation $2\pi r_n = n\lambda$:

$$2\pi(9r) = 3 \times \lambda$$

4. Solve for λ:

$$18\pi r = 3\lambda$$

$$\lambda = \frac{18\pi r}{3} = 6\pi r$$

5. Thus, the de Broglie wavelength in the third orbit is $6\pi r$.

Final Answer: The de Broglie wavelength is $6\pi r$.

Answer: (B)

Q43.

Solution

Concept:

Entropy (S) is a measure of randomness or disorder. A decrease in entropy ($\Delta S < 0$) occurs when a system moves from a more disordered state (gas or liquid) to a more ordered state (liquid or solid).

Solution:

1. **Dissolution of NH_4Cl:** Solid salt breaks into ions in water, increasing randomness. $\Delta S > 0$. 2. **Sublimation of Iodine:** Solid Iodine turns into gas, significantly increasing randomness. $\Delta S > 0$. 3. **Thermal expansion of a gas:** Gas molecules occupy a larger volume, increasing the number of possible microstates. $\Delta S > 0$. 4. **Condensation of water vapor:** Water molecules move from a gaseous state (high disorder) to a liquid state (lower disorder). The molecules are more restricted in the liquid phase. 5. Therefore, condensation represents a decrease in entropy.

Final Answer: Condensation of water vapor represents a decrease in entropy.

Answer: (C)

Q44.

Solution

Concept:

For the dissociation of a gas $AB \rightleftharpoons A + B$, if we start with 1 mole and the degree of dissociation is α, the total moles at equilibrium are $(1-\alpha) + \alpha + \alpha = 1 + \alpha$.

Solution:

1. **Reaction:** $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ 2. **Moles at Equilibrium:** - PCl_5 : $1-\alpha$ - PCl_3 : α - Cl_2 : α - Total moles = $1+\alpha$ 3. **Partial Pressures:** - $p(PCl_3) = \frac{\alpha}{1+\alpha}P$, $p(Cl_2) = \frac{\alpha}{1+\alpha}P$, $p(PCl_5) = \frac{1-\alpha}{1+\alpha}P$ 4. **Equilibrium Constant:**

$$K_p = \frac{p(PCl_3)p(Cl_2)}{p(PCl_5)} = \frac{[\frac{\alpha}{1+\alpha}P]^2}{\frac{1-\alpha}{1+\alpha}P} = \frac{\alpha^2 P}{1-\alpha^2}$$

5. For small α or high K_p, we rearrange to solve for α: $\alpha^2 P = K_p(1-\alpha^2) \Rightarrow \alpha^2(P+K_p) = K_p$

$$\alpha = \sqrt{\frac{K_p}{P+K_p}}$$

Final Answer: The relationship is $\alpha = \sqrt{\frac{K_p}{P+K_p}}$.

Answer: (A)

Q45.

Solution

Concept:

According to Faraday's Laws, the charge required to deposit 1 mole of an element is equal to nF, where n is the number of electrons exchanged per atom (valency) and F is 1 Faraday (96500 C).

Solution:

1. The reduction of Calcium ions at the cathode is:

$$Ca^{2+} + 2e^- \rightarrow Ca(s)$$

2. This equation shows that 2 moles of electrons (2 F) are required to produce 1 mole of Calcium. 3. **Molar mass of Calcium:** 40 g/mol. 4. **Given mass:** 20 g. 5. Number of moles of Ca produced:

$$n = \frac{20\text{ g}}{40\text{ g/mol}} = 0.5\text{ mol}$$

6. **Electricity required:** Since 1 mole requires 2 F, then 0.5 mole requires:

$$0.5 \times 2\text{ F} = 1.0\text{ F}$$

Final Answer: 1.0 F of electricity is required.

Answer: (B)

Q46.

Solution

Concept:

An optically active compound is one that lacks a plane or center of symmetry. In the case of α-amino acids ($R - CH(NH_2)COOH$), the alpha-carbon is a chiral center if the 'R' group is different from the other three groups ($-H$, $-NH_2$, $-COOH$).

Solution:

1. **Alanine:** $R = -CH_3$. The α-carbon is attached to $H, CH_3, NH_2, COOH$. It is chiral and optically active. 2. **Valine:** $R = -CH(CH_3)_2$. The α-carbon is attached to four different groups. It is chiral and optically active. 3. **Leucine:** $R = -CH_2CH(CH_3)_2$. The α-carbon is attached to four different groups. It is chiral and optically active. 4. **Glycine:** $R = -H$. The structure is $H-CH(NH_2)COOH$. 5. In Glycine, the α-carbon is attached to two hydrogen atoms. Since it has two identical groups, the carbon atom is not a chiral center (achiral). 6. Consequently, Glycine is the only common α-amino acid that is optically inactive.

Final Answer: Glycine is optically inactive.

Answer: (C)

Q47.

Solution

Concept:

Formal charge is the charge assigned to an atom in a molecule, assuming that electrons in all chemical bonds are shared equally between atoms. It is calculated as: $FC = [V] - [L] - \frac{1}{2}[B]$, where V is valence electrons, L is lone pair electrons, and B is bonding electrons.

Solution:

1. The Lewis structure of Ozone (O_3) can be represented as a resonance hybrid of: $O = O^+ - O^-$ and $O^- - O^+ = O$. 2. In these structures, the central oxygen atom (let's call it O_b) is bonded to one oxygen by a double bond and to another by a single bond. 3. **Valence electrons (V) for O:** 6. 4. **For the central atom (O_b):** - It has 1 lone pair (2 electrons). So, $L = 2$. - It has 3 bonds (one double, one single), meaning it shares 6 electrons. So, $B = 6$. 5. **Calculation:**

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

6. Thus, the central oxygen atom carries a formal charge of +1.

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

Answer: (B)

Q48.

Solution

Concept:

Coordination number and oxidation state of central metal atoms in coordination compounds.

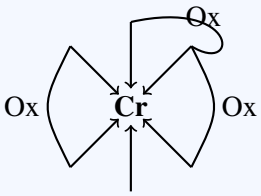
Solution:

Step 1: Identify the ligands. The ligand is the oxalate ion ($C_2O_4^{2-}$). Since it can donate two pairs of electrons from two different oxygen atoms, its denticity is 2 (bidentate).

Step 2: Calculate the coordination number (C.N.). C.N. = Number of ligands $\times$ Denticity = $3 \times 2 = 6$.

Step 3: Calculate the oxidation state (x) of Cr. The sum of oxidation states in $K_3[Cr(C_2O_4)_3]$ is zero. $3(K^+) + x + 3(C_2O_4^{2-}) = 0$ $3(+1) + x + 3(-2) = 0$ $3 + x - 6 = 0 \Rightarrow x = +3$.

Step 4: Thus, the coordination number is 6 and the oxidation state is +3.



Octahedral Geometry

Final Answer:

$$\boxed{6 \text{ and } +3}$$

Answer: (B)

Q49.

Solution

Concept:

Polymers are classified by their mode of polymerization. **Addition polymers** form by the repeated addition of monomer units without the loss of any small molecules. **Condensation polymers** form through a reaction between two functional groups, usually with the elimination of a small molecule like H_2O, NH_3, or HCl.

Solution:

1. **Neoprene:** Formed by the addition polymerization of chloroprene. 2. **Teflon:** Formed by the addition polymerization of tetrafluoroethene. 3. **Polystyrene:** Formed by the addition polymerization of styrene. 4. **Dacron (Terylene):** Formed by the reaction between ethylene glycol (alcohol) and terephthalic acid (carboxylic acid). 5. During this reaction, an ester linkage is formed, and a molecule of water (H_2O) is eliminated for every linkage created. 6. Because it involves the elimination of a small molecule, Dacron is a condensation polymer (specifically a polyester).

Final Answer: Dacron is a condensation polymer.

Answer: (C)

Q50.

Solution

Concept:

The units of the rate constant (k) depend on the order of the reaction. The general formula for the units of k is: Units = $(\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$, where n is the order of the reaction.

Solution:

1. Given $k = 2.5 \times 10^{-4}\ \text{s}^{-1}$. 2. The unit of the rate constant is simply **s^{-1}** (or time^{-1}). 3. Let's check the general formula for different orders: - If $n = 0$: $\text{mol L}^{-1}\ \text{s}^{-1}$ - If $n = 1$: $(\text{mol L}^{-1})^{0}\ \text{s}^{-1} = \text{s}^{-1}$ - If $n = 2$: $\text{L mol}^{-1}\ \text{s}^{-1}$ 4. Since the given unit matches the calculation for $n = 1$, the reaction must be of the first order. 5. In a first-order reaction, the rate depends linearly on the concentration of one reactant, and the time unit is independent of concentration.

Final Answer: The reaction is of the first order.

Answer: (B)

Answer Key

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