MHT-CET Chemistry Sample Paper-12

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

Instructions

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

Q1. Which of the following molecules represents the most stable conformation of 1,2-dichloroethane?

(A) Anti-form
(B) Gauche-form
(C) Partially eclipsed
(D) Fully eclipsed

Q2. The number of optical isomers possible for a compound with the formula $CH_3 - CH(OH) - CH(OH) - CH_3$ is:

(A) 2
(B) 3
(C) 4
(D) 0

Q3. In the reaction of propene with HBr in the presence of benzoyl peroxide, the major product is formed via which intermediate?

(A) 2° Carbocation

(B) 1° Carbocation

(C) 2° Free radical

(D) 1° Free radical

Q4. Identify 'Z' in the sequence: $CH_3CH_2Cl \xrightarrow{KCN} X \xrightarrow{H_3O^+} Y \xrightarrow{PCl_5} Z.$

(A) Propanoyl chloride

(B) Ethanoyl chloride

(C) Acetyl chloride

(D) Chloropropanone

Q5. Which reagent is best suited for the conversion of hexan-1-ol to hexanal?

(A) $KMnO_4/H^+$

(B) $K_2Cr_2O_7/H^+$

(C) PCC (Pyridinium chlorochromate)

(D) CrO_3 in H_2SO_4

Q6. The Boiling point of ethyl alcohol is much higher than that of dimethyl ether, though both have the same molecular weight. This is due to:

(A) Resonance

(B) Inductive effect

(C) Intermolecular hydrogen bonding

(D) Intramolecular hydrogen bonding

Q7. The increasing order of acidity among Phenol, p-Nitrophenol, and p-Cresol is:

(A) p-Cresol < Phenol < p-Nitrophenol

(B) Phenol < p-Cresol < p-Nitrophenol

(C) p-Nitrophenol < Phenol < p-Cresol

(D) p-Cresol < p-Nitrophenol < Phenol

Q8. Cannizzaro's reaction is NOT given by:

(A) Formaldehyde

(B) Benzaldehyde

(C) Acetaldehyde

(D) Trimethylacetaldehyde

Q9. In the Hinsberg test, a secondary amine reacts with benzenesulphonyl chloride to give a product that is:

(A) Soluble in alkali

(B) Insoluble in alkali

(C) Soluble in HCl

(D) A clear solution

Q10. The glycosidic linkage present in Maltose is:

(A) α-1,4-linkage

(B) β-1,4-linkage

(C) α-1,6-linkage

(D) β-1,2-linkage

Q11. Which of the following is a condensation polymer?

(A) PVC

(B) Teflon

(C) Dacron (Terylene)

(D) Polystyrene

Q12. The geometry of SF_4 molecule according to VSEPR theory is:

(A) Tetrahedral

(B) Square planar

(C) See-saw

(D) Trigonal bipyramidal

Q13. Which of the following coordination compounds exhibits linkage isomerism?

(A) $[Co(NH_3)_5Cl]Cl_2$

(B) $[Co(NH_3)_5(NO_2)]Cl_2$

(C) $[Co(en)_3]Cl_3$

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

Q14. The hybridization of Central Atom in $[Ni(CN)_4]^{2-}$ is:

(A) sp^3

(B) dsp^2

(C) sp^3d^2

(D) d^2sp^3

Q15. Which of the following p-block elements does not show an oxidation state higher than +2?

(A) Sn

(B) Pb

(C) Ge

(D) Si

Q16. The shape of XeF_2 molecule is:

(A) Linear

(B) Bent

(C) V-shaped

(D) T-shaped

Q17. Which d-block element has the highest melting point?

(A) Cr

(B) Mo

(C) W (Tungsten)

(D) Mn

Q18. The most basic oxide among the following is:

(A) Al_2O_3

(B) Na_2O

(C) SO_3

(D) Cl_2O_7

Q19. How many atoms are present in 0.5 moles of Magnesium?

(A) 6.022×10^{23}

(B) 3.011×10^{23}

(C) 1.204×10^{24}

(D) 3.011×10^{22}

Q20. The number of radial nodes in a $3p$ orbital is:

(A) 0

(B) 1

(C) 2

(D) 3

Q21. An ionic compound has a unit cell consisting of A ions at the corners and B ions on the centers of the faces of the cube. The empirical formula for this compound would be:

(A) AB

(B) A_2B

(C) AB_3

(D) A_3B

Q22. The value of Henry's constant K_H is:

(A) Greater for gases with higher solubility

(B) Greater for gases with lower solubility

(C) Constant for all gases

(D) Not related to the solubility of gases

Q23. For the reaction $A + B \rightarrow C$, the rate law is $Rate = k[A]^2[B]$. If the volume of the vessel is reduced to one-third of its original volume, the rate of reaction will increase by a factor of:

(A) 9

(B) 3

(C) 27

(D) 6

Q24. In the electrolysis of aqueous $NaCl$ solution, which gas is liberated at the anode?

(A) Oxygen

(B) Hydrogen

(C) Chlorine

(D) Sodium vapor

Q25. The work done during expansion of a gas from a volume of 4 dm^3 to 6 dm^3 against a constant external pressure of 3 atm is (1 $L\ atm = 101.32\ J$):

(A) $-6\ J$

(B) $-608\ J$

(C) $+304\ J$

(D) $-202\ J$

Q26. Which of the following is an example of an extensive property?

(A) Viscosity

(B) Surface Tension

(C) Enthalpy

(D) Temperature

Q27. The conjugate base of $H_2PO_4^-$ is:

(A) H_3PO_4

(B) HPO_4^{2-}

(C) PO_4^{3-}

(D) $H_4PO_4^+$

Q28. Which of the following elements has the highest second ionization enthalpy?

(A) B

(B) C

(C) N

(D) O

Q29. The formal charge on the central oxygen atom in the Ozone (O_3) molecule is:

(A) 0

(B) +1

(C) -1

(D) +2

Q30. Which of the following transition metal ions is colorless in aqueous solution?

(A) Ti^{4+}

(B) V^{3+}

(C) Cr^{3+}

(D) Fe^{3+}

Q31. The most acidic hydrogen is present in:

(A) Ethane

(B) Ethyne

(C) Ethene

(D) Benzene

Q32. Identify the product formed when benzaldehyde reacts with concentrated $NaOH$ solution:

(A) Benzyl alcohol and Sodium benzoate

(B) Cinnamic acid

(C) Sodium phenoxide

(D) Benzophenone

Q33. The IUPAC name of the complex $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$ is:

(A) Diamminechlorido(methylamine)platinum(II) chloride

(B) Diamminechloro(aminomethane)platinum(II) chloride

(C) Chloridodiamminemethylamineplatinum(II) chloride

(D) Diamminechloromethylamineplatinum(II) chloride

Q34. Glucose on prolonged heating with HI gives:

(A) n-Hexane

(B) Gluconic acid

(C) Saccharic acid

(D) Hexanoic acid

Q35. The monomers of Nylon-6,6 are:

(A) Adipic acid and Hexamethylenediamine

(B) Caprolactam

(C) Ethylene glycol and Phthalic acid

(D) Vinyl chloride

Q36. Which of the following p-block elements shows the property of catenation to the maximum extent?

(A) Silicon

(B) Germanium

(C) Carbon

(D) Lead

Q37. For a spontaneous process, the total entropy change (ΔS_{total}) must be:

(A) Equal to zero

(B) Less than zero

(C) Greater than zero

(D) Constant

Q38. The solubility product (K_{sp}) of $AgCl$ is 1.8×10^{-10}. Its solubility in 0.1 M $NaCl$ solution will be:

(A) 1.8×10^{-9} M

(B) 1.34×10^{-5} M

(C) 1.8×10^{-11} M

(D) 9×10^{-11} M

Q39. The number of lone pairs on Xe in XeF_4 is:

(A) 1

(B) 2

(C) 3

(D) 4

Q40. Rosenmund reduction is used for the preparation of:

(A) Alcohols

(B) Aldehydes

(C) Ketones

(D) Carboxylic acids

Q41. The order of reactivity of HX with alcohols is:

(A) $HCl > HBr > HI$

(B) $HI > HBr > HCl$

(C) $HBr > HCl > HI$

(D) $HI > HCl > HBr$

Q42. A first-order reaction is 50% complete in 30 minutes. How much time will it take for 75% completion?

(A) 45 min

(B) 60 min

(C) 90 min

(D) 120 min

Q43. Which of the following contains a coordinate covalent bond?

(A) NH_4^+

(B) $BaCl_2$

(C) HCl

(D) H_2O

Q44. The geometry of ClF_3 is:

(A) Trigonal planar

(B) Trigonal bipyramidal

(C) T-shaped

(D) Square pyramidal

Q45. Which of the following is most basic in aqueous solution?

(A) NH_3

(B) CH_3NH_2

(C) $(CH_3)_2NH$

(D) $(CH_3)_3N$

Q46. What is the oxidation number of Cobalt in $[Co(NH_3)_4(H_2O)Cl]Cl_2$?

(A) +2

(B) +3

(C) +4

(D) +1

Q47. The molarity of pure water is:

(A) 18

(B) 55.5

(C) 100

(D) 1

Q48. Which of the following is a paramagnetic species?

(A) O_2

(B) N_2

(C) H_2

(D) CO

Q49. Bakelite is formed by the reaction of Phenol and:

(A) Formaldehyde

(B) Acetaldehyde

(C) Ethylene glycol

(D) Melamine

Q50. The standard electrode potential of Zn^{2+}/Zn is $-0.76\,V$ and Fe^{2+}/Fe is $-0.44\,V$. The emf of the cell $Zn|Zn^{2+}(1M)||Fe^{2+}(1M)|Fe$ is:

(A) $+1.20\,V$

(B) $-0.32\,V$

(C) $+0.32\ V$

(D) $-1.20\ V$

Detailed Solutions

Q1.

Solution

Concept:

Conformational isomerism in alkanes involves the rotation around carbon-carbon single bonds. For 1,2-dichloroethane ($Cl - CH_2 - CH_2 - Cl$), the stability of different conformations is determined by the steric hindrance and electrostatic repulsions between the two chlorine atoms. The primary conformations are Anti, Gauche, and Eclipsed.

Solution:

1. In the Anti-conformation, the two bulky chlorine atoms are positioned at a dihedral angle of 180° from each other.
2. This arrangement minimizes the steric repulsion between the large chlorine atoms and reduces the dipole-dipole repulsion to the lowest possible level.
3. In the Gauche-conformation, the chlorine atoms are at a 60° angle. While this can sometimes be stabilized by hydrogen bonding in other molecules (like ethylene glycol), in 1,2-dichloroethane, the steric and dipole repulsions make it less stable than the Anti-form.
4. The Eclipsed forms (Fully and Partially) are the least stable due to maximum torsional strain and van der Waals repulsions as atoms are brought closest together.
5. Therefore, the Anti-form is the most stable conformation for 1,2-dichloroethane.

Final Answer: The most stable conformation is the Anti-form.

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

Q2.

Solution

Concept:

The number of optical isomers for a molecule depends on the number of chiral centers (n) and the symmetry of the molecule. The compound provided is Butane-2,3-diol: $CH_3 - CH(OH) - CH(OH) - CH_3$. This molecule contains two similar chiral carbons.

Solution:

1. Identify the chiral centers: Carbon-2 and Carbon-3 are both bonded to four different groups: $-H$, $-OH$, $-CH_3$, and the $-CH(OH)CH_3$ group. Thus, $n = 2$.
2. Check for symmetry: The molecule is symmetrical. It can be divided into two equal halves.
3. For a symmetrical molecule with an even number of chiral centers ($n = 2$):

$$\text{Number of Optically Active Isomers } (a) = 2^{(n-1)} = 2^{(2-1)} = 2^1 = 2$$

$$\text{Number of Meso Isomers } (m) = 2^{(n/2-1)} = 2^{(2/2-1)} = 2^0 = 1$$

4. The total number of optical isomers is the sum of optically active forms (enantiomers) and the meso form:

$$\text{Total isomers} = a + m = 2 + 1 = 3$$

5. The three isomers are the (d)-form, the (l)-form, and the meso-form (which is optically inactive due to an internal plane of symmetry).

Final Answer: The number of optical isomers is 3.

Answer: (B)

Q3.

Solution

Concept:
The addition of HBr to unsymmetrical alkenes like propene follows Markovnikov's rule (via carbocation). However, in the presence of peroxides (like benzoyl peroxide), the reaction follows the Anti-Markovnikov path, also known as the Kharasch effect or Peroxide effect. This specific mechanism proceeds via a free radical chain reaction.

Solution:
1. Initiation Step: The peroxide undergoes homolytic cleavage to form alkoxy or benzoyloxy radicals, which then react with HBr to generate a Bromine radical ($Br^{\bullet}$).
2. Propagation Step (Addition): The $Br^{\bullet}$ radical attacks the alkene. It can attack at either carbon of the double bond.
3. If it attacks the terminal carbon (C_1), it produces a secondary (2°) free radical:

$$CH_3 - CH = CH_2 + Br^{\bullet} \rightarrow CH_3 - \dot{C}H - CH_2Br$$

4. If it attacks the middle carbon (C_2), it produces a primary (1°) free radical:

$$CH_3 - CH = CH_2 + Br^{\bullet} \rightarrow CH_3 - CHBr - \dot{C}H_2$$

5. Stability Trend: Secondary free radicals are more stable than primary free radicals due to greater hyperconjugation and inductive effect from alkyl groups.
6. Therefore, the reaction proceeds predominantly through the more stable 2° free radical intermediate.

Final Answer: The major product is formed via a 2° Free radical.

Answer: (C)

Q4.

Solution

Concept:

This is a multi-step organic conversion involving nucleophilic substitution, acid-catalyzed hydrolysis, and halogenation of a carboxylic acid.

Solution:

1. Step 1 (X): Ethyl chloride (CH_3CH_2Cl) reacts with KCN. The CN^- ion acts as a nucleophile, replacing the Cl atom.

$$CH_3CH_2Cl + KCN \rightarrow CH_3CH_2CN \text{ (Propanenitrile or Ethyl cyanide)} + KCl$$

So, $X = CH_3CH_2CN$.

2. Step 2 (Y): Hydrolysis of nitriles with dilute acid (H_3O^+) converts the cyanide group into a carboxylic acid group.

$$CH_3CH_2CN + 2H_2O + H^+ \rightarrow CH_3CH_2COOH \text{ (Propanoic acid)} + NH_4^+$$

So, $Y = CH_3CH_2COOH$.

3. Step 3 (Z): Propanoic acid reacts with Phosphorus pentachloride (PCl_5). The hydroxyl group $(-OH)$ of the acid is replaced by a Chlorine atom.

$$CH_3CH_2COOH + PCl_5 \rightarrow CH_3CH_2COCl \text{ (Propanoyl chloride)} + POCl_3 + HCl$$

So, $Z = CH_3CH_2COCl$.

Final Answer: The compound 'Z' is Propanoyl chloride.

Answer: (A)

Q5.

Solution

Concept:

The oxidation of primary alcohols can result in either aldehydes or carboxylic acids. To stop the oxidation at the aldehyde stage, a mild or controlled oxidizing agent is required. Strong oxidizing agents will further oxidize the aldehyde to a carboxylic acid.

Solution:

1. Hexan-1-ol ($CH_3(CH_2)_4CH_2OH$) is a primary alcohol.
2. $KMnO_4/H^+$ and $K_2Cr_2O_7/H^+$ are very strong oxidizing agents. They will oxidize hexan-1-ol directly to hexanoic acid.
3. CrO_3 in H_2SO_4 (Jones Reagent) is also a strong oxidant that typically yields carboxylic acids from primary alcohols.
4. PCC (Pyridinium chlorochromate) is a specialized mild reagent. It is a complex of chromium trioxide with pyridine and HCl. It specifically oxidizes primary alcohols to aldehydes and secondary alcohols to ketones without further oxidation.

$$CH_3(CH_2)_4CH_2OH \xrightarrow{PCC} CH_3(CH_2)_4CHO \text{ (Hexanal)}$$

5. This makes PCC the best-suited reagent for this specific transformation.

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

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

Q6.

Solution

Concept:
The boiling point of a substance is significantly influenced by the strength of the intermolecular forces holding the molecules together. For compounds with similar molecular weights, the presence of hydrogen bonding drastically increases the energy required to separate molecules into the gas phase.

Solution:
1. Ethyl alcohol (CH_3CH_2OH) and dimethyl ether (CH_3OCH_3) both have the same molecular formula C_2H_6O and a molecular weight of 46 g/mol.
2. In Ethyl alcohol, the hydrogen atom is directly attached to a highly electronegative oxygen atom. This creates a strong dipole and allows for the formation of intermolecular hydrogen bonds.
3. These hydrogen bonds form a network of associated molecules, requiring substantial thermal energy to break before the liquid can boil.
4. Dimethyl ether is a polar molecule but lacks a hydrogen atom bonded to an electronegative element (O, N, or F). Therefore, it only experiences weaker dipole-dipole interactions and London dispersion forces.
5. Because intermolecular hydrogen bonding is much stronger than dipole-dipole interactions, the boiling point of the alcohol is much higher ($78°C$) compared to the ether ($-24°C$).

Final Answer: This is due to intermolecular hydrogen bonding.

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

Q7.

Solution

Concept:
The acidity of substituted phenols depends on the nature of the substituent group attached to the benzene ring. Electron-withdrawing groups (EWG) increase acidity by stabilizing the phenoxide ion, while electron-donating groups (EDG) decrease acidity by destabilizing it.

Solution:
1. Phenol is the reference compound. The phenoxide ion is stabilized by resonance.
2. p-Nitrophenol: The nitro group ($-NO_2$) is a powerful electron-withdrawing group via both the $-I$ (inductive) and $-M$ (mesomeric/resonance) effects. It effectively delocalizes the negative charge on the phenoxide oxygen, making it the most acidic.
3. p-Cresol: The methyl group ($-CH_3$) is an electron-donating group due to the $+I$ effect and hyperconjugation. This increases the electron density on the ring and destabilizes the phenoxide ion, making p-Cresol less acidic than phenol.
4. Comparing the three: p-Nitrophenol (EWG) is the most acidic, followed by Phenol (no substituent), and p-Cresol (EDG) is the least acidic.
5. The increasing order of acidity is: p-Cresol < Phenol < p-Nitrophenol.

Final Answer: The correct order is p-Cresol < Phenol < p-Nitrophenol.

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

Q8.

Solution

Concept:

The Cannizzaro reaction is a disproportionation reaction (self-oxidation and reduction) of aldehydes that do not contain an α-hydrogen atom. When treated with a concentrated alkali solution, one molecule of the aldehyde is reduced to an alcohol, and another is oxidized to a carboxylic acid salt.

Solution:

1. Requirement: For an aldehyde to undergo the Cannizzaro reaction, the carbon atom adjacent to the carbonyl group (the α-carbon) must not have any hydrogen atoms attached to it.
2. Formaldehyde ($HCHO$): Has no α-carbon, hence no α-hydrogen. It gives the Cannizzaro reaction.
3. Benzaldehyde (C_6H_5CHO): The α-carbon is part of the benzene ring and has no hydrogens. It gives the Cannizzaro reaction.
4. Trimethylacetaldehyde ($(CH_3)_3CCHO$): The α-carbon is quaternary (bonded to three methyl groups) and has no hydrogens. It gives the Cannizzaro reaction.
5. Acetaldehyde (CH_3CHO): The α-carbon has three hydrogen atoms (α-hydrogens). Instead of Cannizzaro, aldehydes with α-hydrogens undergo the Aldol Condensation in the presence of base.

Final Answer: Cannizzaro's reaction is NOT given by Acetaldehyde.

Answer: (C)

Q9.

Solution

Concept:

The Hinsberg test is used to distinguish between primary, secondary, and tertiary amines using benzenesulphonyl chloride ($C_6H_5SO_2Cl$). The solubility of the resulting sulphonamide in alkali depends on the presence of an acidic hydrogen on the nitrogen atom.

Solution:

1. Primary Amines ($R-NH_2$): React to form N-alkylbenzenesulphonamide. This compound has an acidic hydrogen on the nitrogen atom. Because of this acidic hydrogen, it reacts with $NaOH$ to form a soluble salt. Thus, the product is soluble in alkali.
2. Secondary Amines (R_2NH): React with benzenesulphonyl chloride to form N,N-dialkylbenzenesulphonamide.

$$C_6H_5SO_2Cl + R_2NH \rightarrow C_6H_5SO_2NR_2 + HCl$$

3. In this product, the nitrogen atom has no remaining hydrogen atoms.
4. Because it lacks an acidic hydrogen, the N,N-dialkylbenzenesulphonamide cannot react with $NaOH$ to form a salt.
5. Consequently, the product remains insoluble in the alkali solution.

Final Answer: The product is insoluble in alkali.

Answer: (B)

Q10.

Solution

Concept:

Maltose, also known as malt sugar, is a disaccharide formed from two units of glucose. The linkage between these monosaccharide units is called a glycosidic linkage, which involves the condensation of hydroxyl groups.

Solution:

1. Maltose is composed of two α-D-glucose units.

2. The linkage occurs between the C_1 (anomeric carbon) of the first α-D-glucose unit and the C_4 of the second α-D-glucose unit.

3. Since the first glucose unit is in the α-configuration, the bond formed is an α-glycosidic bond.

4. This specific connection is referred to as an α-1,4-glycosidic linkage.

5. Because one anomeric carbon (on the second glucose) remains free, maltose is a reducing sugar and can undergo mutarotation.

Final Answer: The glycosidic linkage is an α-1,4-linkage.

Answer: (A)

Q11.

Solution

Concept:

Polymers are classified into addition and condensation polymers based on their mode of polymerization. Condensation polymerization involves the repetitive reaction between two different bi-functional or tri-functional monomeric units with the elimination of small molecules like water, alcohol, or hydrogen chloride.

Solution:

1. PVC (Polyvinyl chloride): Formed by the addition polymerization of vinyl chloride ($CH_2 = CHCl$). No small molecules are eliminated.

2. Teflon (Polytetrafluoroethene): Formed by the addition polymerization of tetrafluoroethene ($CF_2 = CF_2$).

3. Polystyrene: Formed by the addition polymerization of styrene ($C_6H_5CH = CH_2$).

4. Dacron (Terylene): It is a polyester formed by the condensation of ethylene glycol and terephthalic acid.

5. During this reaction, water molecules are eliminated as the ester linkage ($-COO-$) is formed between the monomers.

$$n\ HO - CH_2CH_2 - OH + n\ HOOC - C_6H_4 - COOH \rightarrow \text{Dacron} + (2n-1)H_2O$$

Final Answer: The condensation polymer is Dacron (Terylene).

Answer: (C)

Q12.

Solution

Concept:

The Valence Shell Electron Pair Repulsion (VSEPR) theory predicts the geometry of a molecule based on the number of bonding pairs and lone pairs of electrons around the central atom. The total steric number determines the electron geometry, while the arrangement of atoms determines the molecular shape.

Solution:

1. Central Atom: Sulfur (S), which belongs to Group 16 and has 6 valence electrons.
2. Bonding: S forms 4 single bonds with 4 Fluorine atoms, using 4 electrons.
3. Lone Pairs: The remaining 2 electrons form 1 lone pair.
4. Steric Number: 4 (bond pairs) + 1 (lone pair) = 5.
5. For a steric number of 5, the electron geometry is trigonal bipyramidal.
6. According to VSEPR, the lone pair occupies an equatorial position to minimize repulsions. This results in a molecular shape known as "See-saw."

Final Answer: The geometry (shape) is See-saw.

Answer: (C)

Q13.

Solution

Concept:

Linkage isomerism occurs in coordination compounds containing ambidentate ligands. An ambidentate ligand is a ligand that can coordinate to the central metal atom through two different atoms. Common examples include NO_2^- (nitro/nitrito), SCN^- (thiocyanato/isothiocyanato), and CN^- (cyano/isocyano).

Solution:

1. $[Co(NH_3)_5Cl]Cl_2$: Contains ammonia and chloride ligands, neither of which are ambidentate. It shows ionization isomerism.
2. $[Co(NH_3)_5(NO_2)]Cl_2$: Contains the nitro group (NO_2^-). The NO_2^- ligand can bind to Co via the Nitrogen atom (nitro) or via the Oxygen atom (nitrito, $-ONO$).
3. Because NO_2^- is an ambidentate ligand, this complex exists as two linkage isomers: the nitro-form and the nitrito-form.
4. $[Co(en)_3]Cl_3$: Shows optical isomerism but lacks ambidentate ligands.
5. $[Pt(NH_3)_2Cl_2]$: Shows geometric isomerism (cis/trans).

Final Answer: The compound is $[Co(NH_3)_5(NO_2)]Cl_2$.

Answer: (B)

Q14.

Solution

Concept:

The hybridization of the central metal ion in a complex is determined by its coordination number and the strength of the ligands (Crystal Field Theory). Strong field ligands like CN^- cause pairing of electrons, often leading to inner orbital complexes.

Solution:

1. Oxidation State: In $[Ni(CN)_4]^{2-}$, let x be the oxidation state of Ni. $x + 4(-1) = -2 \Rightarrow x = +2$.
2. Electronic Configuration: Ni is $[Ar]3d^8 4s^2$. Therefore, Ni^{2+} is $[Ar]3d^8$.
3. Ligand Nature: CN^- is a very strong field ligand.
4. Pairing: The 8 electrons in the $3d$ subshell are forced to pair up due to the strong ligand field. This leaves one $3d$ orbital vacant.
5. Hybridization: The coordination number is 4. The vacant orbitals involved are one $3d$, one $4s$, and two $4p$ orbitals.
6. This results in dsp^2 hybridization, which corresponds to a square planar geometry.

Final Answer: The hybridization is dsp^2.

Answer: (B)

Q15.

Solution

Concept:

In p-block elements, especially in Groups 13, 14, and 15, the stability of the higher oxidation state decreases down the group, while the stability of the lower oxidation state increases. This is known as the Inert Pair Effect—the reluctance of the ns^2 electrons to participate in bonding.

Solution:

1. Group 14 Elements: Si, Ge, Sn, Pb. The general valence configuration is ns^2np^2.
2. Possible Oxidation States: +4 (using all valence electrons) and +2 (due to inert pair effect).
3. Down the Group: Si and Ge are stable in the +4 state. Sn shows both +2 and +4.
4. For Lead (Pb), the inert pair effect is most prominent. The +2 oxidation state is much more stable than the +4 state.
5. While Pb can form some +4 compounds (like PbO_2), the question asks which element "does not show an oxidation state higher than +2" effectively in a stable or common context, or which is limited by the effect.
6. However, looking at the options and standard CET logic regarding the most restricted heavy metal, Pb is the classic example where +2 is the dominant and often the only stable state for many reactions.

Final Answer: The element is Pb.

Answer: (B)

Q16.

Solution

Concept:

The molecular geometry of Xenon difluoride (XeF_2) is determined by the VSEPR theory. We must count the total number of valence electrons and determine the steric number (bond pairs + lone pairs) to find the arrangement of electrons around the central Xenon atom.

Solution:

1. Central Atom: Xenon (Xe) is a noble gas with 8 valence electrons.
2. Bonding: It forms 2 single bonds with 2 Fluorine atoms, using 2 electrons.
3. Lone Pairs: The remaining 6 electrons form 3 lone pairs.
4. Steric Number: 2 (bond pairs) + 3 (lone pairs) = 5.
5. Electron Geometry: A steric number of 5 corresponds to a trigonal bipyramidal arrangement.
6. Molecular Shape: To minimize electron repulsion, the 3 lone pairs occupy the equatorial positions (at 120° to each other). The 2 Fluorine atoms occupy the axial positions (180° apart).
7. This results in a straight line arrangement of the $F - Xe - F$ atoms, giving a Linear molecular geometry.

Final Answer: The shape of XeF_2 is Linear.

Answer: (A)

Q17.

Solution

Concept:

The melting points of d-block (transition) elements generally increase up to the middle of the series and then decrease. This is because the melting point depends on the strength of the metallic bond, which is determined by the number of unpaired d-electrons available for delocalization.

Solution:

1. In the transition series, metals like Chromium (Cr), Molybdenum (Mo), and Tungsten (W) have a high number of unpaired electrons (d^5s^1 configuration).
2. These unpaired electrons facilitate strong inter-atomic metallic bonding and covalent character within the lattice.
3. As we move down the group (Group 6: $Cr \longrightarrow Mo \longrightarrow W$), the atomic size increases, but the $5d$ orbitals of Tungsten provide even more effective overlapping and stronger bonding compared to $3d$ or $4d$.
4. Tungsten (W) has the highest melting point ($3422°C$) among all metals because of its extremely strong inter-atomic bonds.
5. Manganese (Mn), despite being in the middle, has an abnormally low melting point due to its stable half-filled configuration which results in weaker metallic bonding.

Final Answer: The d-block element with the highest melting point is W (Tungsten).

Answer: (C)

Q18.

Solution

Concept:

The acid-base character of oxides follows a periodic trend. Generally, oxides of metals are basic, oxides of metalloids are amphoteric, and oxides of non-metals are acidic. Across a period (left to right), the basicity decreases and acidity increases as the metallic character decreases.

Solution:

1. Na_2O (Sodium Oxide): Sodium is an alkali metal (Group 1). Its oxide reacts vigorously with water to form a strong base ($NaOH$). It is highly basic.

2. Al_2O_3 (Aluminium Oxide): Aluminium is a metal, but its oxide is amphoteric, meaning it reacts with both acids and bases.

3. SO_3 (Sulfur Trioxide): Sulfur is a non-metal. Its oxide reacts with water to form a strong acid (H_2SO_4). It is acidic.

4. Cl_2O_7 (Dichlorine Heptoxide): Chlorine is a non-metal. This is the anhydride of perchloric acid, one of the strongest acids. It is highly acidic.

5. Comparing these, Na_2O is the most basic because sodium is the most electropositive element among the choices.

Final Answer: The most basic oxide is Na_2O.

Answer: (B)

Q19.

Solution

Concept:

The mole concept relates the mass of a substance to the number of constituent particles (atoms, molecules, or ions). One mole of any substance contains Avogadro's number ($N_A = 6.022 \times 10^{23}$) of particles.

Solution:

1. Given: Number of moles (n) = 0.5 mol of Magnesium (Mg).

2. Relationship: Number of atoms = $n \times N_A$.

3. Calculation:

$$\text{Number of atoms} = 0.5 \times 6.022 \times 10^{23}$$

$$\text{Number of atoms} = 3.011 \times 10^{23}$$

4. Since Magnesium is a monoatomic metal in its elemental form, the number of atoms is exactly half of Avogadro's number.

Final Answer: The number of atoms is 3.011×10^{23}.

Answer: (B)

Q20.

Solution

Concept:
Nodes are regions in an orbital where the probability of finding an electron is zero. There are two types: radial nodes (spherical) and angular nodes (planar). The number of nodes depends on the principal quantum number (n) and the azimuthal quantum number (l).

Solution:
1. Formula for Radial Nodes: Radial Nodes = $n - l - 1$.
2. For a $3p$ orbital: - Principal quantum number (n) = 3. - Azimuthal quantum number (l) for a p-orbital = 1.
3. Calculation:

$$\text{Radial Nodes} = 3 - 1 - 1$$

$$\text{Radial Nodes} = 1$$

4. Note: The number of angular nodes is equal to l (which is 1 for p), and the total number of nodes is $n - 1$ (which is 2 for $3p$).

Final Answer: The number of radial nodes is 1.

Answer: (B)

Q21.

Solution

Concept:
The stoichiometry of a unit cell in a crystal lattice depends on the position of the atoms and their contribution to that specific cell. Atoms at corners are shared by 8 unit cells, while atoms at face centers are shared by 2 unit cells.

Solution:
1. Contribution of atoms at corners: Each atom at a corner contributes $\frac{1}{8}$ to the unit cell. Since there are 8 corners in a cube:

$$\text{Number of A atoms} = 8 \times \frac{1}{8} = 1$$

2. Contribution of atoms at face centers: Each atom at a face center contributes $\frac{1}{2}$ to the unit cell. A cube has 6 faces:

$$\text{Number of B atoms} = 6 \times \frac{1}{2} = 3$$

3. Ratio of atoms: The ratio of $A : B$ in the unit cell is $1 : 3$.
4. Empirical Formula: Based on the atom count, the simplest formula is AB_3.

Final Answer: The empirical formula is AB_3.

Answer: (C)

Q22.

Solution

Concept:

Henry's Law states that the partial pressure of a gas in the vapor phase (p) is proportional to the mole fraction of the gas (x) in the solution: $p = K_H \cdot x$. Here, K_H is the Henry's Law constant.

Solution:

1. Rearranging the Henry's Law equation for solubility (mole fraction):

$$x = \frac{p}{K_H}$$

2. Observation: For a given partial pressure (p), the mole fraction (x) is inversely proportional to the Henry's constant (K_H).

3. Higher K_H value: If K_H is large, the value of x (solubility) will be small.

4. Lower K_H value: If K_H is small, the value of x (solubility) will be large.

5. Therefore, a higher value of Henry's constant K_H indicates that the gas has lower solubility in the liquid.

Final Answer: K_H is greater for gases with lower solubility.

Answer: (B)

Q23.

Solution

Concept:

The rate of a reaction depends on the concentration of the reactants. Concentration is defined as moles per unit volume ($C = n/V$). If the volume of the reaction vessel changes, the concentrations of all gaseous or solution-phase reactants change inversely.

Solution:

1. Initial Rate Law: $R_1 = k[A]^2[B]$.

2. Effect of Volume: When volume (V) is reduced to $1/3$, the concentration ($C = n/V$) becomes 3 times the original concentration ($3C$).

3. New Concentrations: $[A]_{new} = 3[A]$ and $[B]_{new} = 3[B]$.

4. New Rate Calculation:

$$R_2 = k(3[A])^2(3[B])$$

$$R_2 = k(9[A]^2)(3[B])$$

$$R_2 = 27 \cdot (k[A]^2[B])$$

5. Comparison: $R_2 = 27 \cdot R_1$. The rate increases by a factor of 27.

Final Answer: The rate will increase by a factor of 27.

Answer: (C)

Q24.

Solution

Concept:
Electrolysis of aqueous solutions involves competition between ions at the electrodes. At the anode (positive electrode), oxidation occurs. The species with the lower oxidation potential (or more likely to lose electrons) will react first.

Solution:
1. Ions present: In aqueous $NaCl$, we have Na^+, Cl^-, H^+, and OH^- (from water).
2. At the Anode: Both Cl^- and H_2O (or OH^-) can be oxidized. - Oxidation of Cl^-: $2Cl^- \rightarrow Cl_2(g) + 2e^-$ - Oxidation of H_2O: $2H_2O \rightarrow O_2(g) + 4H^+ + 4e^-$
3. Overvoltage Factor: Although the standard reduction potentials suggest oxygen might evolve, the oxidation of water to O_2 is kinetically slow and requires a high "overvoltage."
4. Result: Due to this overvoltage, the discharge of Cl^- ions is preferred over the discharge of OH^- ions from water.
5. Therefore, Chlorine gas (Cl_2) is liberated at the anode.

Final Answer: Chlorine gas is liberated at the anode.

Answer: (C)

Q25.

Solution

Concept:
Work done (W) during the expansion of a gas against a constant external pressure (P_{ext}) is given by the formula for pressure-volume work. In thermodynamics, work done by the system (expansion) is traditionally assigned a negative sign.

Solution:
1. Formula: $W = -P_{ext} \cdot \Delta V = -P_{ext} \cdot (V_2 - V_1)$.
2. Given values: - $P_{ext} = 3\ atm$ - $V_1 = 4\ dm^3$ (equivalent to 4 L) - $V_2 = 6\ dm^3$ (equivalent to 6 L)
3. Calculation in $L \cdot atm$:

$$\Delta V = 6 - 4 = 2\ L$$

$$W = -3\ atm \times 2\ L = -6\ L \cdot atm$$

4. Conversion to Joules: Given 1 $L \cdot atm = 101.32\ J$.

$$W = -6 \times 101.32\ J$$

$$W = -607.92\ J \approx -608\ J$$

5. Reasoning: The negative sign indicates that work is done by the gas on the surroundings during expansion.

Final Answer: The work done is $-608\ J$.

Answer: (B)

Q26.

Solution

Concept:

Thermodynamic properties are classified into two types: Extensive and Intensive. Extensive properties depend on the amount of matter present in the system, whereas intensive properties are independent of the amount of matter.

Solution:

1. Viscosity: It is a measure of a fluid's resistance to flow. It depends on the nature of the liquid and temperature, not the quantity. Thus, it is an intensive property.

2. Surface Tension: This is the force per unit length acting on the surface of a liquid. It is independent of the total volume or mass. Thus, it is an intensive property.

3. Temperature: If you divide a system in thermal equilibrium into two parts, both parts remain at the same temperature. Thus, it is an intensive property.

4. Enthalpy (H): It is the total heat content of a system ($H = U + PV$). Since internal energy (U), pressure (P), and volume (V) are combined, and specifically internal energy and volume depend on the amount of substance, enthalpy is an extensive property. If you double the mass of a substance, its enthalpy also doubles.

Final Answer: The extensive property is Enthalpy.

Answer: (C)

Q27.

Solution

Concept:

According to the Brønsted-Lowry theory, an acid is a proton (H^+) donor and a base is a proton acceptor. When an acid loses a proton, the resulting species is called its conjugate base.

Solution:

1. Given species: Dihydrogen phosphate ion ($H_2PO_4^-$).

2. To find the conjugate base, we must remove one proton (H^+) from the species.

3. Reaction:

$$H_2PO_4^- \rightarrow H^+ + HPO_4^{2-}$$

4. Reasoning: Removing a positive charge (H^+) from a species with a -1 charge results in a species with a -2 charge.

5. Note: If we were asked for the conjugate acid, we would add a proton to get H_3PO_4. If we removed another proton from HPO_4^{2-}, we would get PO_4^{3-}.

Final Answer: The conjugate base is HPO_4^{2-}.

Answer: (B)

Q28.

Solution

Concept:
Ionization enthalpy (IE) is the energy required to remove an electron from a gaseous atom or ion. The second ionization enthalpy (IE_2) refers to removing an electron from a unipositive cation (M^+). A very high IE_2 is observed when the first electron removal results in a stable, noble gas electronic configuration.

Solution:
1. Electronic Configurations: - Boron ($B, Z = 5$): $1s^2 2s^2 2p^1 \xrightarrow{-1e} 1s^2 2s^2$ - Carbon ($C, Z = 6$): $1s^2 2s^2 2p^2 \xrightarrow{-1e} 1s^2 2s^2 2p^1$ - Nitrogen ($N, Z = 7$): $1s^2 2s^2 2p^3 \xrightarrow{-1e} 1s^2 2s^2 2p^2$ - Oxygen ($O, Z = 8$): $1s^2 2s^2 2p^4 \xrightarrow{-1e} 1s^2 2s^2 2p^3$

2. Comparing the cations: - B^+ is $2s^2$ (Full subshell) - O^+ is $2s^2 2p^3$ (Half-filled p-subshell)

3. Periodic Trend: Generally, IE increases across a period. However, Oxygen's second ionization enthalpy is exceptionally high because O^+ has a half-filled $2p^3$ configuration, which is extra stable due to symmetry and exchange energy.

4. While B^+ is stable, the nuclear charge of Oxygen ($Z = 8$) is much higher than Boron ($Z = 5$), making the removal of a second electron from the stable O^+ much more difficult.

Final Answer: Oxygen has the highest second ionization enthalpy among the choices.

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

Q29.

Solution

Concept:

The formal charge (FC) is the charge assigned to an atom in a molecule, assuming that electrons in all chemical bonds are shared equally between atoms. The formula is:

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

where V = Valence electrons, L = Lone pair electrons, and B = Bonding electrons.

Solution:

1. Structure of Ozone (O_3): The central oxygen atom is double-bonded to one oxygen and single-bonded to another (with a coordinate bond or resonance).

2. Let's analyze the central Oxygen ($O_{central}$): - It forms a double bond (4 electrons) and a single bond (2 electrons). Total bond electrons (B) = 6. - It has one lone pair. Total lone pair electrons (L) = 2. - Valence electrons for Oxygen (V) = 6.

3. Calculation:

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

$$FC = 6 - 2 - 3 = +1$$

4. Check: The terminal oxygen with the double bond has $FC = 0$, and the terminal oxygen with the single bond has $FC = -1$. The total charge is $0 + 1 - 1 = 0$, which matches the neutral O_3 molecule.

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

Answer: (B)

Q30.

Solution

Concept:
The color of transition metal ions is typically due to $d - d$ transitions. For an ion to exhibit color, it must have at least one unpaired electron in the d-subshell (d^1 to d^9). Ions with completely empty (d^0) or completely filled (d^{10}) d-subshells are generally colorless.

Solution:
1. Ti^{4+} $(Z = 22)$: The neutral atom is $[Ar]3d^2 4s^2$. Removing four electrons gives $[Ar]3d^0$. Since there are no d-electrons, no $d - d$ transition is possible. It is colorless.
2. V^{3+} $(Z = 23)$: The neutral atom is $[Ar]3d^3 4s^2$. V^{3+} is $[Ar]3d^2$. It has 2 unpaired electrons and is colored (usually green).
3. Cr^{3+} $(Z = 24)$: The neutral atom is $[Ar]3d^5 4s^1$. Cr^{3+} is $[Ar]3d^3$. It has 3 unpaired electrons and is colored (violet/green).
4. Fe^{3+} $(Z = 26)$: The neutral atom is $[Ar]3d^6 4s^2$. Fe^{3+} is $[Ar]3d^5$. It has 5 unpaired electrons and is colored (yellow/brown).

Final Answer: The colorless ion is Ti^{4+}.

Answer: (A)

Q31.

Solution

Concept:
The acidity of hydrocarbons depends on the hybridization of the carbon atom to which the hydrogen is attached. The greater the s-character of the hybridized orbital, the more electronegative the carbon atom becomes. A more electronegative carbon can better stabilize the negative charge of the conjugate base (carbanion) formed after losing a proton.

Solution:
1. Ethane ($CH_3 - CH_3$): The carbons are sp^3 hybridized (25% s-character).
2. Ethene ($CH_2 = CH_2$): The carbons are sp^2 hybridized (33.3% s-character).
3. Ethyne ($CH \equiv CH$): The carbons are sp hybridized (50% s-character).
4. Electronegativity Trend: $sp > sp^2 > sp^3$.
5. Since the sp hybridized carbon in ethyne is the most electronegative, it exerts the strongest pull on the electron pair of the $C - H$ bond, making the hydrogen atom easily releasable as a proton (H^+).
6. Benzene: The carbons are sp^2 hybridized. While more acidic than ethane, it is much less acidic than ethyne.
7. Therefore, ethyne (acetylene) contains the most acidic hydrogen.

Final Answer: The most acidic hydrogen is present in Ethyne.

Answer: (B)

Q32.

Solution

Concept:
Aldehydes that do not have an α-hydrogen atom, such as benzaldehyde, undergo the Cannizzaro reaction when treated with concentrated alkali. This is a redox reaction where one molecule is reduced and another is oxidized simultaneously.

Solution:
1. Reactants: Benzaldehyde (C_6H_5CHO) and concentrated $NaOH$.
2. Observation: Benzaldehyde lacks α-hydrogens (the carbon adjacent to the carbonyl group is part of the aromatic ring and has no hydrogens).
3. Oxidation Half: One molecule of benzaldehyde is oxidized to the sodium salt of the corresponding carboxylic acid.

$$C_6H_5CHO + [O] \rightarrow C_6H_5COONa \text{ (Sodium benzoate)}$$

4. Reduction Half: Another molecule of benzaldehyde is reduced to the corresponding primary alcohol.

$$C_6H_5CHO + [H] \rightarrow C_6H_5CH_2OH \text{ (Benzyl alcohol)}$$

5. Overall Reaction:

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

6. The products are Benzyl alcohol and Sodium benzoate.

Final Answer: The products are Benzyl alcohol and Sodium benzoate.

Answer: (A)

Q33.

Solution

Concept:

IUPAC nomenclature for coordination compounds follows specific rules: ligands are named in alphabetical order, followed by the metal name with its oxidation state in Roman numerals, and finally the counter ion.

Solution:

1. Identify Ligands: - NH_3 is ammine (two 'm's). - Cl^- is chlorido. - NH_2CH_3 is methylamine or aminomethane.

2. Alphabetical Order: Ammine (a) comes before Chlorido (c), which comes before Methylamine (m).

3. Oxidation State of Pt (x): $x + 2(0) + 1(-1) + 1(0) = +1$ (charge of the coordination sphere) $x - 1 = 1 \Rightarrow x = +2$.

4. Complex Name Construction: - There are two ammines: Diammine. - One chloride: Chlorido. - One methylamine: (methylamine). - Metal: Platinum(II).

5. Full Name: Diamminechlorido(methylamine)platinum(II) chloride.

Final Answer: The IUPAC name is Diamminechlorido(methylamine)platinum(II) chloride.

Answer: (A)

Q34.

Solution

Concept:

The reaction of glucose with hydrogen iodide (HI) is a classic test used to determine the skeletal structure (carbon chain) of glucose. HI is a very strong reducing agent.

Solution:

1. Glucose is a six-carbon hydroxy-aldehyde (aldohexose).

2. When glucose is heated with HI and red phosphorus for a long duration, all the oxygen atoms (from hydroxyl and carbonyl groups) are removed and replaced by hydrogen.

3. The reaction results in the reduction of the entire molecule into a straight-chain alkane.

$$C_6H_{12}O_6 \xrightarrow{HI/\Delta} CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$$

4. The product formed is n-hexane.

5. This reaction proves that all six carbon atoms in glucose are linked in a straight chain.

Final Answer: Glucose on prolonged heating with HI gives n-Hexane.

Answer: (A)

Q35.

Solution

Concept:

Nylon-6,6 is a polyamide and a synthetic fiber. The "6,6" in its name indicates the number of carbon atoms present in each of its two monomeric units.

Solution:

1. Monomer 1: Adipic acid ($HOOC-CH_2-CH_2-CH_2-CH_2-COOH$). It contains 6 carbon atoms.
2. Monomer 2: Hexamethylenediamine ($H_2N-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-NH_2$). It also contains 6 carbon atoms.
3. Polymerization: The reaction is a condensation polymerization where the carboxylic group of adipic acid reacts with the amino group of the diamine, eliminating a water molecule to form an amide linkage ($-NH-CO-$).
4. Repeat Unit: $[-CO(CH_2)_4CONH(CH_2)_6NH-]_n$.
5. Caprolactam is the monomer for Nylon-6 (not 6,6). Ethylene glycol and Phthalic acid form Glyptal. Vinyl chloride forms PVC.

Final Answer: The monomers are Adipic acid and Hexamethylenediamine.

Answer: (A)

Q36.

Solution

Concept:

Catenation is the unique property of an element to form long chains or rings by linking with its own atoms through covalent bonds. In the p-block, this ability depends on the element-element bond strength. Stronger bonds favor more extensive catenation.

Solution:

1. Group 14 elements (Carbon family) exhibit catenation because they can form four covalent bonds.
2. The $C-C$ bond is exceptionally strong (348 kJ/mol) compared to $Si-Si$, $Ge-Ge$, or $Sn-Sn$ bonds.
3. As we move down the group, the atomic size increases, which leads to less effective orbital overlapping. Consequently, the bond enthalpy of the element-element bond decreases significantly.
4. Carbon can form long straight chains, branched chains, and complex rings (as seen in organic chemistry and allotropes like graphite and diamond).
5. While Silicon does show catenation (in silanes), it is limited to much shorter chains compared to Carbon.

Final Answer: Carbon shows catenation to the maximum extent.

Answer: (C)

Q37.

Solution

Concept:
The Second Law of Thermodynamics dictates the direction of spontaneous processes. It states that for any spontaneous process, the total entropy of the universe (system + surroundings) must increase.

Solution:
1. Entropy (S) is a measure of the degree of randomness or disorder in a system.
2. For a process to occur on its own (spontaneously), the total change in entropy (ΔS_{total}) must be positive.
3. $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$.
4. If $\Delta S_{total} > 0$, the process is spontaneous.
5. If $\Delta S_{total} < 0$, the process is non-spontaneous in the forward direction.
6. If $\Delta S_{total} = 0$, the system is at equilibrium.
7. This law explains why heat flows from hot to cold bodies and why gases expand into a vacuum.

Final Answer: The total entropy change must be greater than zero.

Answer: (C)

Q38.

Solution

Concept:
The Common Ion Effect describes the decrease in the solubility of an ionic compound when a salt containing one of its constituent ions is added to the solution. The solubility product (K_{sp}) remains constant at a given temperature.

Solution:
1. Dissociation of $AgCl$: $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$.
2. $K_{sp} = [Ag^+][Cl^-] = 1.8 \times 10^{-10}$.
3. In 0.1 M $NaCl$ solution: $NaCl$ is a strong electrolyte, so $[Cl^-]$ from $NaCl = 0.1\ M$.
4. Let 's' be the solubility of $AgCl$ in this solution. Then $[Ag^+] = s$ and $[Cl^-] = s + 0.1$.
5. Since $AgCl$ is sparingly soluble and the common ion concentration is high, s is very small compared to 0.1. Thus, $(s + 0.1) \approx 0.1$.
6. Substitute into the K_{sp} expression:

$$1.8 \times 10^{-10} = (s)(0.1)$$

$$s = \frac{1.8 \times 10^{-10}}{0.1} = 1.8 \times 10^{-9}\ M$$

7. This clearly shows how the presence of $NaCl$ has reduced the solubility of $AgCl$ compared to pure water.

Final Answer: The solubility is $1.8 \times 10^{-9}\ M$.

Answer: (A)

Q39.

Solution

Concept:

The number of lone pairs on the central atom is determined by the valence electrons of the atom and the number of electrons used in bonding. For Xenon tetrafluoride (XeF_4), we apply the VSEPR model.

Solution:

1. Central Atom: Xenon (Xe) has 8 valence electrons.
2. Bonding: It forms 4 single bonds with 4 Fluorine atoms. Each bond uses 1 electron from Xenon.
3. Electrons used in bonding = 4.
4. Remaining electrons on Xe: $8 - 4 = 4$ electrons.
5. Number of lone pairs: Since 2 electrons make 1 lone pair, 4 electrons make 2 lone pairs.
6. Geometry Note: With 4 bond pairs and 2 lone pairs (Steric Number 6), the molecule adopts a square planar geometry to minimize repulsion between the lone pairs.

Final Answer: The number of lone pairs on Xe is 2.

Answer: (B)

Q40.

Solution

Concept:

Rosenmund reduction is a specific catalytic hydrogenation reaction used in organic chemistry. It involves the selective reduction of an acid chloride (acyl chloride) to an aldehyde.

Solution:

1. Reactant: Acid chloride ($R - COCl$).
2. Reagent: Hydrogen gas (H_2) in the presence of Palladium (Pd) catalyst supported on Barium sulphate ($BaSO_4$).
3. Catalyst Poisoning: The $BaSO_4$ acts as a catalyst poison (specifically for sulfur or quinoline additions) to prevent further reduction of the resulting aldehyde into a primary alcohol.
4. Reaction:

$$R - COCl + H_2 \xrightarrow{Pd/BaSO_4} R - CHO + HCl$$

5. This method is excellent for preparing both aliphatic and aromatic aldehydes, though it cannot be used to prepare formaldehyde because formyl chloride is unstable at room temperature.

Final Answer: Rosenmund reduction is used for the preparation of Aldehydes.

Answer: (B)

Q41.

Solution

Concept:

The reaction between alcohols and hydrogen halides (HX) is a nucleophilic substitution reaction where the hydroxyl group ($-OH$) is replaced by a halide ion. The reactivity depends on the bond strength of HX and the nucleophilicity of the halide ion.

Solution:

1. In the reaction $R - OH + HX \rightarrow R - X + H_2O$, the $H - X$ bond must break to release the halide ion and the proton.
2. The bond strength of hydrogen halides decreases as the size of the halogen atom increases: $HF > HCl > HBr > HI$.
3. Since the $H - I$ bond is the weakest and has the lowest bond dissociation enthalpy, it breaks most easily, making HI the most reactive.
4. Conversely, HCl has a much stronger bond and typically requires a catalyst (like anhydrous $ZnCl_2$ in Lucas reagent) to react with primary and secondary alcohols.
5. Therefore, the decreasing order of reactivity is $HI > HBr > HCl$.

Final Answer: The order of reactivity is $HI > HBr > HCl$.

Answer: (B)

Q42.

Solution

Concept:

For a first-order reaction, the time required for a specific percentage of completion can be related to the half-life ($t_{1/2}$). A key characteristic of first-order kinetics is that the time taken for the concentration to reduce by half is constant, regardless of the initial concentration.

Solution:

1. Given: 50% completion ($t_{50\%}$ or $t_{1/2}$) = 30 minutes.
2. For 75% completion, the reaction has gone through two half-lives: - After 1st half-life (30 min): 50% of the reactant remains. - After 2nd half-life (another 30 min): 50% of the remaining 50% reacts, leaving 25% of the original amount.
3. Calculation: If 25% remains, 75% has been completed.

$$t_{75\%} = 2 \times t_{1/2}$$

$$t_{75\%} = 2 \times 30 = 60 \text{ minutes}$$

4. Alternatively, using the integrated rate law: $k = \frac{0.693}{30}$. Then $t = \frac{2.303}{k} \log(\frac{100}{100-75})$. Both methods yield 60 minutes.

Final Answer: The time required is 60 min.

Answer: (B)

Q43.

Solution

Concept:

A coordinate covalent bond (dative bond) is a type of covalent bond where both electrons in the shared pair come from the same atom. This usually occurs when a species with a lone pair (Lewis base) donates electrons to an electron-deficient species (Lewis acid).

Solution:

1. $BaCl_2$: An ionic compound formed by the transfer of electrons from Barium to Chlorine.
2. HCl and H_2O: These contain standard polar covalent bonds where electrons are shared between the atoms.
3. NH_4^+ (Ammonium ion): Formed when ammonia (NH_3) reacts with a hydrogen ion (H^+). - Nitrogen in NH_3 has 5 valence electrons, 3 used in covalent bonds with Hydrogen and 1 lone pair. - The H^+ ion has an empty $1s$ orbital (no electrons). - Nitrogen donates its lone pair to the empty orbital of H^+ to form a coordinate bond.

$$NH_3 + H^+ \rightarrow [NH_3 \rightarrow H]^+$$

4. Once formed, all four $N - H$ bonds in NH_4^+ are identical due to resonance/hybridization.

Final Answer: NH_4^+ contains a coordinate covalent bond.

Answer: (A)

Q44.

Solution

Concept:

The geometry of Chlorine trifluoride (ClF_3) is predicted by VSEPR theory. The arrangement of electron pairs around the central Chlorine atom determines the overall shape of the molecule.

Solution:

1. Central Atom: Chlorine (Cl) has 7 valence electrons.
2. Bonding: It forms 3 single bonds with 3 Fluorine atoms.
3. Lone Pairs: Remaining electrons = 7 − 3 = 4 electrons, which form 2 lone pairs.
4. Steric Number: 3 (bond pairs) + 2 (lone pairs) = 5.
5. Electron Geometry: Trigonal bipyramidal.
6. Molecular Shape: To minimize $LP - LP$ and $LP - BP$ repulsions, the 2 lone pairs occupy the equatorial positions. The 3 Fluorine atoms occupy the remaining two axial and one equatorial positions.
7. This arrangement results in a "T-shaped" molecule where the axial $F - Cl - F$ angle is slightly less than 180° due to lone pair repulsion.

Final Answer: The geometry is T-shaped.

Answer: (C)

Q45.

Solution

Concept:

The basicity of amines in aqueous solution is determined by three factors: the inductive effect ($+I$) of alkyl groups, solvation (hydrogen bonding with water), and steric hindrance.

Solution:

1. $+I$ Effect: Alkyl groups are electron-donating. Increasing the number of alkyl groups increases the electron density on the Nitrogen, making it more basic. Order: $3° > 2° > 1° > NH_3$.
2. Solvation Effect: In water, the substituted ammonium cation is stabilized by hydrogen bonding. The more hydrogens on N, the better the solvation. Order: $NH_3 > 1° > 2° > 3°$.
3. Steric Hindrance: Bulky alkyl groups hinder the approach of a proton.
4. Combined Result (for Methyl amines in water): The interplay of these factors results in a specific order:

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

5. Reasoning: Secondary amines ($2°$) provide the best balance between electron donation and stabilization through solvation. Thus, dimethylamine is the most basic.

Final Answer: $(CH_3)_2NH$ is the most basic in aqueous solution.

Answer: (C)

Q46.

Solution

Concept:

The oxidation number of a central metal atom in a coordination complex is the charge it would carry if all the ligands were removed along with the electron pairs that are shared with it. The sum of the oxidation numbers of all atoms in the complex must equal the net charge of the complex.

Solution:

1. Formula: $[Co(NH_3)_4(H_2O)Cl]Cl_2$.
2. Ionization: In aqueous solution, the complex ionizes as: $[Co(NH_3)_4(H_2O)Cl]^{2+} + 2Cl^-$.
3. Net charge of the coordination sphere is +2.
4. Assign charges to ligands: - Ammonia (NH_3) is a neutral ligand (charge = 0). - Water (H_2O) is a neutral ligand (charge = 0). - Chloride (Cl^-) is an anionic ligand (charge = -1).
5. Calculation: Let x be the oxidation state of Cobalt (Co).

$$x + 4(0) + 1(0) + 1(-1) = +2$$

$$x - 1 = +2$$

$$x = +3$$

Final Answer: The oxidation number of Cobalt is +3.

Answer: (B)

Q47.

Solution

Concept:

Molarity (M) is defined as the number of moles of solute present in one liter (1000 mL) of solution. For a pure substance like water, the "solute" and the "solvent" are the same.

Solution:

1. Density of water: At room temperature, the density of pure water is approximately 1 g/mL.
2. Mass of 1 L of water: 1000 $mL \times 1\ g/mL = 1000\ g$.
3. Molar mass of water (H_2O): $(2 \times 1) + 16 = 18\ g/mol$.
4. Calculation of moles:

$$\text{Number of moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{1000\ g}{18\ g/mol} \approx 55.55\ mol$$

5. Molarity: Since these moles are present in 1 L, the molarity is 55.55 M.

Final Answer: The molarity of pure water is 55.5.

Answer: (B)

Q48.

Solution

Concept:

Paramagnetism is a property of substances that are attracted by a magnetic field, which occurs due to the presence of one or more unpaired electrons. To determine this for diatomic molecules, we use Molecular Orbital (MO) Theory.

Solution:

1. H_2 (2 electrons): Configuration is $(\sigma 1s)^2$. All electrons are paired. (Diamagnetic).
2. N_2 (14 electrons): Configuration is $(\sigma 1s)^2(\sigma^* 1s)^2(\sigma 2s)^2(\sigma^* 2s)^2(\pi 2p_x^2 = \pi 2p_y^2)(\sigma 2p_z^2)$. All electrons are paired. (Diamagnetic).
3. CO (14 electrons): It is isoelectronic with N_2. All electrons are paired. (Diamagnetic).
4. O_2 (16 electrons): According to MO theory, the configuration is:

$$\text{KK } (\sigma 2s)^2(\sigma^* 2s)^2(\sigma 2p_z)^2(\pi 2p_x^2 = \pi 2p_y^2)(\pi^* 2p_x^1 = \pi^* 2p_y^1)$$

5. Observation: There are two unpaired electrons in the degenerate antibonding pi (π^*) orbitals. Therefore, Oxygen is paramagnetic.

Final Answer: The paramagnetic species is O_2.

Answer: (A)

Q49.

Solution

Concept:

Bakelite is a thermosetting polymer known for its high resistance to electricity and heat. It is formed by a step-growth (condensation) polymerization reaction.

Solution:

1. Reactants: Bakelite is synthesized from Phenol (C_6H_5OH) and Formaldehyde ($HCHO$).
2. Process: The reaction occurs in the presence of either an acid or a base catalyst.
3. Initial Stages: The first step produces ortho- and para-hydroxymethylphenols.
4. Linear Polymer: Further condensation leads to a linear polymer called Novolac (used in paints).
5. Cross-linking: When Novolac is heated with more formaldehyde, it undergoes extensive cross-linking to form a rigid, three-dimensional network called Bakelite.
6. Melamine and formaldehyde react to form Melamine-formaldehyde resin (crockery). Ethylene glycol and phthalic acid form Glyptal.

Final Answer: Bakelite is formed from Phenol and Formaldehyde.

Answer: (A)

Q50.

Solution

Concept:

The electromotive force (emf) of a galvanic cell (E^o_{cell}) is the potential difference between the cathode and the anode under standard conditions. It is calculated using standard reduction potentials (E^o_{red}).

Solution:

1. Cell Notation: $Zn|Zn^{2+}(1M)||Fe^{2+}(1M)|Fe$. - Left side (Anode/Oxidation): $Zn \rightarrow Zn^{2+} + 2e^-$ - Right side (Cathode/Reduction): $Fe^{2+} + 2e^- \rightarrow Fe$
2. Standard Reduction Potentials: - $E^o_{Zn^{2+}/Zn} = -0.76\ V$ (Anode) - $E^o_{Fe^{2+}/Fe} = -0.44\ V$ (Cathode)
3. Formula:

$$E^o_{cell} = E^o_{cathode} - E^o_{anode}$$

4. Calculation:

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

$$E^o_{cell} = -0.44 + 0.76$$

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

5. Since E^o_{cell} is positive, the reaction is spontaneous as written.

Final Answer: The emf of the cell is +0.32 V.

Answer: (C)

Answer Key

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