WBJEE Chemistry Sample Paper-12

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Sections**.
- **Section 1 (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section 2 (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **−0.5** marks. Only **one** correct option.
- **Section 3 (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section–A — 30 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. The bond order of O_2^+ according to molecular orbital theory is:

(A) 1.5

(B) 2

(C) 2.5

(D) 3

Q2. For the cyclic process shown by an ideal gas, the net work done is equal to:

(A) Area under PV curve

(B) Area enclosed by cycle

(C) Change in internal energy

(D) Zero

Q3. The emf of a Daniell cell becomes zero when:

(A) Reaction quotient becomes zero

(B) Equilibrium constant becomes unity

(C) Gibbs free energy becomes maximum

(D) Reaction attains equilibrium

Q4. The major product formed on treating toluene with alkaline $KMnO_4$ followed by acidification is:

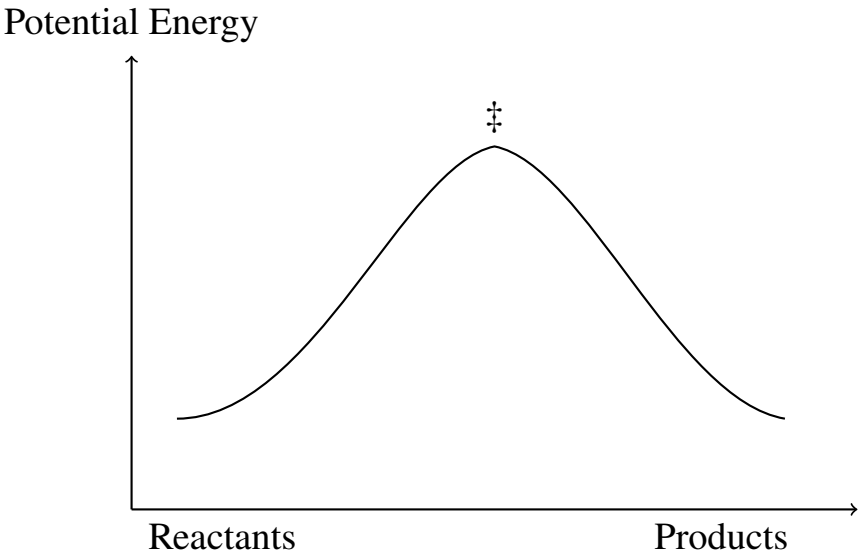
(A) Benzaldehyde

(B) Benzoic acid

(C) Benzyl alcohol

(D) Benzene

Q5. Refer to the following potential energy profile:



If the forward activation energy is 80 kJ mol^{-1} and $\Delta H = -20$ kJ mol^{-1}, then the backward activation energy is:

(A) 60 kJ mol^{-1}

(B) 80 kJ mol^{-1}

(C) 100 kJ mol^{-1}

(D) 120 kJ mol^{-1}

Q6. The magnetic moment of $[Fe(H_2O)_6]^{2+}$ is closest to:

(A) 0 BM

(B) 2.83 BM

(C) 4.90 BM

(D) 5.92 BM

Q7. For a first-order reaction, 75% completion takes 40 minutes. The half-life of the reaction is:

(A) 10 min

(B) 20 min

(C) 30 min

(D) 40 min

Q8. The van't Hoff factor for complete dissociation of $Al_2(SO_4)_3$ is:

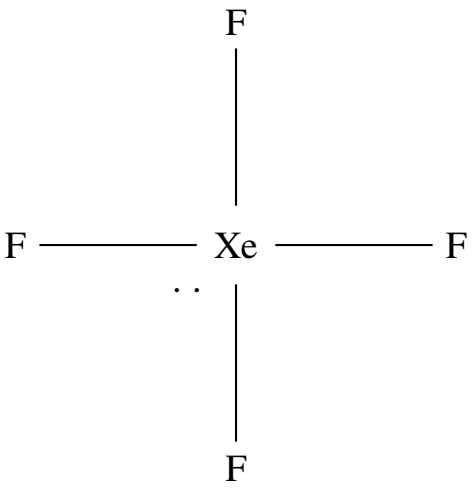
(A) 2

(B) 3

(C) 4

(D) 5

Q9. Refer to the following molecular geometry:



The shape of the molecule is:

(A) Tetrahedral

(B) Square planar

(C) Seesaw

(D) Square pyramidal

Q10. Which alkyl halide undergoes fastest $SN1$ reaction?

(A) CH_3Cl

(B) C_2H_5Cl

(C) tert-C_4H_9Cl

(D) Vinyl chloride

Q11. The maximum number of electrons having principal quantum number $n = 4$ is:

(A) 8

(B) 18

(C) 32

(D) 50

Q12. For an adiabatic free expansion of an ideal gas:

(A) $q = 0, w = 0$

(B) $q \neq 0, w = 0$

(C) $q = 0, w \neq 0$

(D) $\Delta U > 0$

Q13. The reagent used to convert benzene diazonium chloride into fluorobenzene is:

(A) CuCl/HCl

(B) KI

(C) HBF_4

(D) CuCN

Q14. Refer to the following galvanic cell:

$$Pt \mid Fe^{2+}, Fe^{3+} \parallel Sn^{2+}, Sn^{4+} \mid Pt$$

The species oxidised is:

(A) Fe^{2+}

(B) Fe^{3+}

(C) Sn^{2+}

(D) Sn^{4+}

Q15. The coordination number in a body-centred cubic crystal is:

(A) 4

(B) 6

(C) 8

(D) 12

Q16. Lucas reagent contains:

(A) Conc. HCl and $ZnCl_2$

(B) Conc. HNO_3

(C) NaOH and $CuSO_4$

(D) Dilute HCl and Zn

Q17. At equilibrium, the rate of forward reaction is:

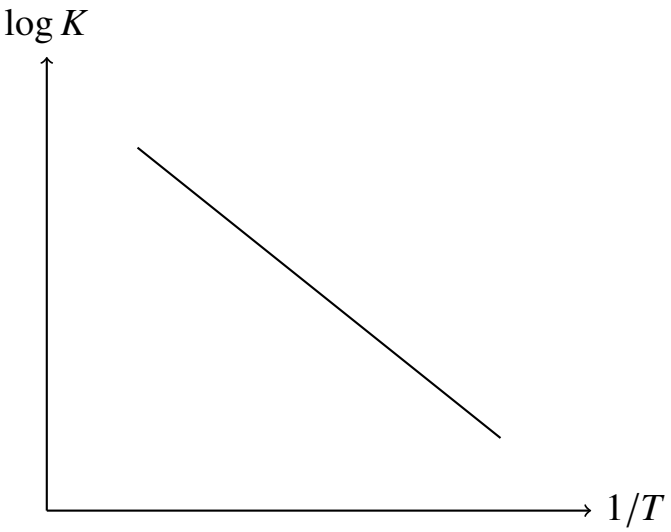
(A) Greater than backward rate

(B) Less than backward rate

(C) Equal to backward rate

(D) Zero

Q18. Refer to the following graph:



The graph represents:

(A) Arrhenius equation

(B) Van't Hoff equation

(C) Boyle's law

(D) Beer-Lambert law

Q19. Which species has the shortest bond length?

(A) O_2

(B) O_2^+

(C) O_2^-

(D) O_2^{2-}

Q20. Gold number is associated with:

(A) Stability of colloids

(B) Viscosity of liquids

(C) Surface tension

(D) Catalytic activity

Q21. Among the following oxides, the most acidic is:

(A) Na_2O

(B) MgO

(C) Al_2O_3

(D) Cl_2O_7

Q22. The number of structural isomers possible for C_5H_{12} is:

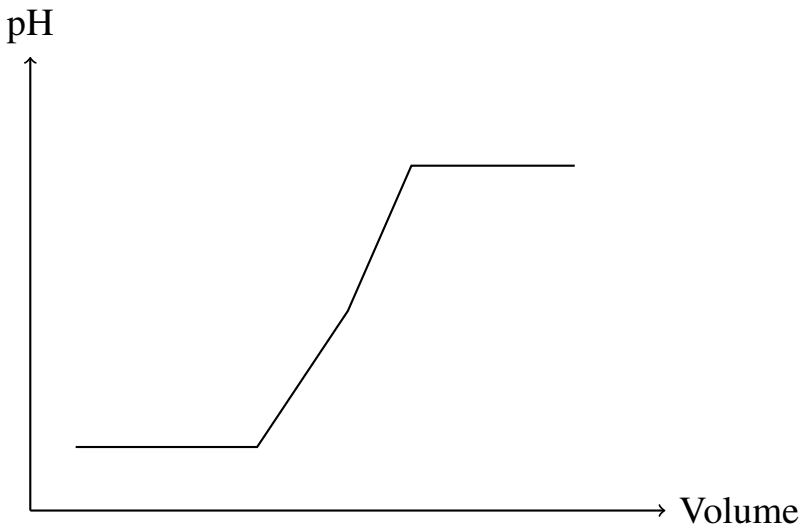
(A) 2

(B) 3

(C) 4

(D) 5

Q23. Refer to the following titration curve:



The titration corresponds to:

(A) Strong acid vs strong base

(B) Weak acid vs strong base

(C) Strong acid vs weak base

(D) Weak acid vs weak base

Q24. The linkage between amino acids in proteins is:

(A) Glycosidic linkage

(B) Peptide linkage

(C) Ester linkage

(D) Phosphodiester linkage

Q25. The equivalent conductance of a weak electrolyte increases on dilution due to:

(A) Increase in ionic mobility

(B) Increase in ionisation

(C) Decrease in viscosity

(D) Decrease in resistance

Q26. Which complex ion is expected to be colourless?

(A) $[Ti(H_2O)_6]^{3+}$

(B) $[Cu(H_2O)_6]^{2+}$

(C) $[Zn(NH_3)_4]^{2+}$

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

Q27. Which compound gives Cannizzaro reaction?

(A) Acetaldehyde

(B) Propanal

(C) Benzaldehyde

(D) Acetone

Q28. The depression in freezing point is directly proportional to:

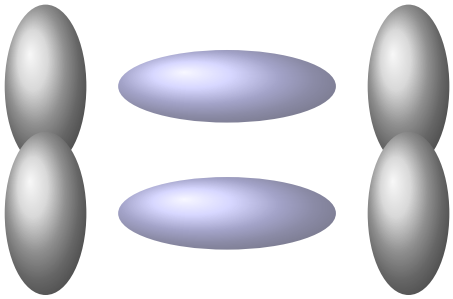
(A) Molarity

(B) Molality

(C) Mole fraction

(D) Density

Q29. Refer to the following orbital overlap:



Sideways overlap of p orbitals

The overlap results in formation of:

(A) Sigma bond

(B) Pi bond

(C) Ionic bond

(D) Coordinate bond

Q30. Which ion among the following is most stable in aqueous solution?

(A) Sc^{2+}

(B) Ti^{4+}

(C) V^{5+}

(D) Mn^{7+}

Section–B — 5 Questions × 1 Mark Each
(Negative Marking: −0.5) [Single Correct]

Q31. For a zero-order reaction, the plot of concentration versus time is:

(A) Linear with positive slope

(B) Linear with negative slope

(C) Exponential

(D) Hyperbolic

Q32. Chlorobenzene is less reactive towards nucleophilic substitution because:

(A) C–Cl bond has partial double bond character

(B) Chlorine is electron donating

(C) Benzene ring is saturated

(D) Chlorine atom is small

Q33. For a spontaneous exothermic process, the entropy change of surroundings is:

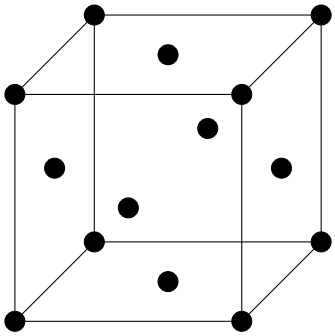
(A) Positive

(B) Negative

(C) Zero

(D) Infinity

Q34. Refer to the following crystal arrangement:



The number of atoms per unit cell is:

(A) 1

(B) 2

(C) 4

(D) 6

Q35. The reagent used to distinguish aldehydes from ketones is:

(A) Tollen's reagent

(B) Grignard reagent

(C) Conc. HCl

(D) PCC

Section C — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]

Q36. Which of the following molecules are polar?

(A) NH_3

(B) H_2O

(C) CO_2

(D) SO_2

Q37. Which of the following species are paramagnetic?

(A) O_2

(B) NO

(C) N_2

(D) O_2^-

Q38. Which of the following compounds give iodoform test?

(A) Ethanol

(B) Acetone

(C) Acetaldehyde

(D) Methanal

Q39. Which statements regarding adsorption are correct?

(A) Adsorption is exothermic

(B) Physical adsorption decreases with rise in temperature

(C) Chemisorption involves weak van der Waals forces

(D) Activated charcoal is a good adsorbent

Q40. Which of the following compounds exhibit geometrical isomerism?

(A) But-2-ene

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

(C) 1,1-dichloroethene

(D) Hex-3-ene

Detailed Solutions

Q1.

Solution

Concept: According to MO theory:

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

where N_b and N_a are the numbers of bonding and antibonding electrons respectively.
For O_2 and related molecules, the MO order is:

$$\sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_z} < \pi_{2p_x} = \pi_{2p_y} < \pi^*_{2p_x} = \pi^*_{2p_y} < \sigma^*_{2p_z}$$

Higher bond order means a stronger and shorter bond.

Solution: Oxygen atom has 8 electrons, so:

$$O_2^+ = 15 \text{ electrons}$$

For O_2 and its ions, the MO order is:

$$\sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_z} < \pi_{2p_x} = \pi_{2p_y} < \pi^*_{2p_x} = \pi^*_{2p_y} < \sigma^*_{2p_z}$$

Electronic configuration of O_2^+:

$$(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p_z})^2(\pi_{2p_x})^2(\pi_{2p_y})^2(\pi^*_{2p})^1$$

Bonding electrons:

$$N_b = 8$$

Antibonding electrons:

$$N_a = 3$$

Therefore,

$$\text{Bond Order} = \frac{N_b - N_a}{2} = \frac{8-3}{2} = 2.5$$

Thus, O_2^+ has bond order 2.5 and is paramagnetic due to one unpaired electron.

Final Answer: 2.5

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: In a Pressure-Volume (PV) diagram, work done by or on a system during a process is represented by the area under the curve on the PV diagram. For a cyclic process, the net work done by the system is equal to the area enclosed by the cycle. If the cycle is traversed in a clockwise direction, the net work done is positive (work done by the system). If traversed in a counter-clockwise direction, the net work done is negative (work done on the system).

Solution: The given process is a cyclic process for an ideal gas.

Step 1: Work done in a PV process Work done is:

$$w = -\int P\,dV$$

Graphically, this represents the area under the PV curve for a single process.

Step 2: Cyclic process In a cyclic process, the system returns to its initial state, so:

$$\Delta U = 0$$

However, work done is not necessarily zero. It depends on the path followed in the PV diagram. For a complete cycle:

- Work done during expansion is positive (volume increases)
- Work done during compression is negative (volume decreases)

So, the net work done is:

$$W_{\text{net}} = \oint P\,dV$$

This is equal to the area enclosed by the loop in the PV diagram.

Step 3: Interpretation

- Area under curve $\rightarrow$ single process
- Area enclosed by cycle $\rightarrow$ net work in cyclic process
- $\Delta U = 0$ but work is generally non-zero

Final Answer:

$$\boxed{\text{Area enclosed by cycle}}$$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: The emf of an electrochemical cell is related to Gibbs free energy:

$$\Delta G = -nFE_{cell}$$

and also:

$$\Delta G = -RT \ln K$$

where n is number of electrons transferred, F is Faraday constant, R is gas constant, T is temperature, and K is equilibrium constant.
At equilibrium:

$$\Delta G = 0$$

which means there is no net driving force for the reaction.

Solution: Step 1: Relation between emf and Gibbs free energy

$$\Delta G = -nFE_{cell}$$

Step 2: Condition at equilibrium At equilibrium:

$$\Delta G = 0$$

So,

$$-nFE_{cell} = 0$$

Since $n \neq 0$ and $F \neq 0$:

$$E_{cell} = 0$$

Step 3: Physical meaning When emf becomes zero, there is no net electron flow and the reaction has reached a state of dynamic balance.
Step 4: Conclusion This condition corresponds to chemical equilibrium.

Final Answer:

$$\boxed{\text{Reaction attains equilibrium}}$$

Answer: (D)

Go Back to Question 3

Q4.

Solution

Concept: Potassium permanganate ($KMnO_4$) is a strong oxidizing agent. In alkaline or neutral solutions, it oxidizes alkyl side chains on aromatic rings to carboxylic acid groups. The reaction proceeds through intermediate stages like benzyl alcohol and benzaldehyde, but under strongly alkaline conditions and with sufficient oxidizing power, the final product is the carboxylic acid. Acidification is then needed to protonate the carboxylate salt formed. The reaction for the side chain oxidation of toluene is: Toluene ($C_6H_5CH_3$) $\xrightarrow{Alkaline KMnO_4}$ intermediate salt $\xrightarrow{H^+}$ Benzoic acid (C_6H_5COOH)

Solution: The reactant is toluene ($C_6H_5CH_3$). The reagent is alkaline potassium permanganate ($KMnO_4$ in basic medium), followed by acidification.
Step 1: Oxidation by alkaline $KMnO_4$. Potassium permanganate is a strong oxidizing agent. When it reacts with the methyl group (CH_3) attached to the benzene ring in toluene, it oxidizes it. Under alkaline conditions, the methyl group is oxidized. The intermediate oxidation states would be benzyl alcohol ($C_6H_5CH_2OH$) and benzaldehyde (C_6H_5CHO), but with a strong oxidizing agent like $KMnO_4$ under alkaline conditions, the oxidation proceeds all the way to the carboxylate salt. The reaction is:

$$C_6H_5CH_3 + [O] \rightarrow C_6H_5COO^-K^+$$

(where [O] represents the oxidizing action of $KMnO_4$ and the basic medium).
Step 2: Acidification. The product of the reaction with alkaline $KMnO_4$ is the potassium salt of benzoic acid ($C_6H_5COO^-K^+$). This salt is then acidified (e.g., with dilute H_2SO_4 or HCl) to obtain the free carboxylic acid.

$$C_6H_5COO^-K^+ + H^+ \rightarrow C_6H_5COOH$$

Step 3: Identify the final product. The final product is benzoic acid (C_6H_5COOH).
Let's consider why other options are incorrect: - Benzaldehyde: This would be an intermediate product if a weaker oxidizing agent or milder conditions were used. - Benzyl alcohol: This would be an even earlier intermediate product. - Benzene: This is the parent aromatic ring and would not be formed from toluene by oxidation.

Final Answer: Benzoic acid

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: In a potential energy profile diagram:

- Reactants and products lie at different energy levels
- The peak represents the transition state
- Activation energy is the energy difference between reactants/products and the transition state
- Enthalpy change is given by:

$$\Delta H = E_{products} - E_{reactants}$$

Relationship between activation energies:

$$E_{a,b} = E_{a,f} - \Delta H$$

Solution: Given:

$$E_{a,f} = 80 \text{ kJ mol}^{-1}, \quad \Delta H = -20 \text{ kJ mol}^{-1}$$

Using:

$$E_{a,b} = E_{a,f} - \Delta H$$

Substitute values:

$$E_{a,b} = 80 - (-20)$$

$$E_{a,b} = 100 \text{ kJ mol}^{-1}$$

Final Answer:

$$\boxed{100 \text{ kJ mol}^{-1}}$$

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept: The magnetic moment (μ) of a coordination complex is related to the number of unpaired electrons (n) in the central metal ion by the spin-only formula:

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

where BM stands for Bohr magneton.
To determine the magnetic moment, we need to find the number of unpaired electrons in the central metal ion. This involves knowing the oxidation state of the metal and its electronic configuration in the complex, considering ligand field effects (Crystal Field Theory).

Solution: The complex is $[Fe(H_2O)_6]^{2+}$.
Step 1: Determine the oxidation state of Iron (Fe). Let the oxidation state of Fe be x. The charge of the complex ion is +2. Water (H_2O) is a neutral ligand (charge = 0). So, $x + 6 \times (0) = +2$. $x = +2$. The iron ion is Fe^{2+}.
Step 2: Determine the electronic configuration of Fe^{2+}. Iron (Fe) has atomic number 26. Its electronic configuration is $[Ar]4s^2 3d^6$. When it forms Fe^{2+} ion, it loses the two $4s$ electrons. So, the electronic configuration of Fe^{2+} is $[Ar]3d^6$.
Step 3: Determine the number of unpaired electrons in Fe^{2+} in the given complex. The complex is $[Fe(H_2O)_6]^{2+}$. H_2O is a weak field ligand. In the presence of a weak field ligand, the electrons in the $3d$ orbitals will occupy the orbitals as spread out as possible to minimize repulsion, following Hund's rule. The $3d$ subshell has 5 orbitals: $d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}, d_{z^2}$. For Fe^{2+} ($3d^6$), the filling is: There are 6 electrons to be placed in the 5 $3d$ orbitals. - First 5 electrons go into separate orbitals (Hund's rule): 1 unpaired electron in each of the 5 orbitals. - The 6th electron pairs up with one of the electrons in any of the 5 orbitals. So, in the $3d$ subshell, there will be 4 unpaired electrons. $3d^6$: $d^2_{xy}, d^1_{yz}, d^1_{xz}, d^1_{x^2-y^2}, d^1_{z^2}$ (This is one possible distribution, the point is 4 unpaired electrons). Number of unpaired electrons, $n = 4$.
Step 4: Calculate the magnetic moment using the spin-only formula.

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

$$\mu = \sqrt{4(4+2)}\ \text{BM}$$

$$\mu = \sqrt{4 \times 6}\ \text{BM}$$

$$\mu = \sqrt{24}\ \text{BM}$$

$$\sqrt{24} \approx 4.899\ \text{BM}$$

Step 5: Compare with the given options. The calculated value is approximately 4.90 BM.

Final Answer: 4.90 BM

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: For a first-order reaction:

$$t_{1/2} = \frac{\ln 2}{k}$$

and

$$\ln\left(\frac{[A]_0}{[A]_t}\right) = kt$$

If the reaction is 75% complete, then 25% reactant remains:

$$[A]_t = 0.25[A]_0$$

Thus,

$$\frac{[A]_0}{[A]_t} = 4$$

Solution: We are given that 75% completion takes 40 minutes.
This means that after 40 minutes, only 25% of the reactant remains.

Step 1: Relate the remaining amount to half-life.
For a first-order reaction: - After 1 half-life $\rightarrow$ 50% remains.
- After 2 half-lives $\rightarrow$ 25% remains.

Thus, 75% completion corresponds to 2 half-lives.

Step 2: Calculate the half-life.
Given:

$$2t_{1/2} = 40 \text{ min}$$

Therefore,

$$t_{1/2} = \frac{40}{2}$$

$$t_{1/2} = 20 \text{ min}$$

Final Answer: 20 min

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: The van't Hoff factor (i) is a measure of the extent to which a solute dissociates or associates in a solution. It is defined as the ratio of the observed colligative property to the value of the colligative property calculated assuming no dissociation or association. It can also be expressed as the ratio of the actual number of particles in solution after dissociation/association to the number of formula units initially dissolved.
For complete dissociation of an electrolyte A_mB_n into m cations and n anions, the van't Hoff factor is $i = m + n$.

Solution: The compound is $Al_2(SO_4)_3$ (Aluminium sulfate).
We need to determine the van't Hoff factor for complete dissociation.

Step 1: Write the dissociation equation for $Al_2(SO_4)_3$ in water.
Aluminium sulfate is an ionic compound that dissociates into aluminium ions (Al^{3+}) and sulfate ions (SO_4^{2-}).

$$Al_2(SO_4)_3 \rightarrow \text{ions}$$

The formula indicates 2 aluminium atoms and 3 sulfate groups.
So, when it dissociates, it will produce 2 aluminium ions and 3 sulfate ions.

$$Al_2(SO_4)_3(s) \xrightarrow{H_2O} 2Al^{3+}(aq) + 3SO_4^{2-}(aq)$$

Step 2: Count the total number of ions produced per formula unit.
From the dissociation equation, one formula unit of $Al_2(SO_4)_3$ produces:
- 2 ions of Al^{3+}
- 3 ions of SO_4^{2-}

Total number of ions = 2 + 3 = 5.

Step 3: Determine the van't Hoff factor (i).
Assuming complete dissociation, the van't Hoff factor is equal to the total number of ions produced per formula unit. $i = 5$.

Final Answer: $\boxed{5}$

Answer: (E)

Go Back to Question 8

Q9.

Solution

Concept: The shape of a molecule is determined by the arrangement of its atoms in space, which is based on the arrangement of electron pairs (bonding pairs and lone pairs) around the central atom. This is predicted by VSEPR theory. The steric number (number of sigma bonds + number of lone pairs) determines the electron geometry. The molecular geometry is then determined by the arrangement of atoms only, considering the lone pairs.

- XeF_4 (Xenon tetrafluoride):
- Xenon (Xe) is the central atom. It has 8 valence electrons.
- Fluorine (F) is bonded to Xe. There are 4 Xe-F bonds, so 4 bonding pairs.
- Xenon uses its remaining $8 - 4 \times 1 = 4$ valence electrons to form lone pairs. These 4 electrons form 2 lone pairs.
- Steric Number = (Number of sigma bonds) + (Number of lone pairs) = 4 (sigma bonds) + 2 (lone pairs) = 6.
- Electron geometry for steric number 6 is Octahedral.
- With 4 bonding pairs and 2 lone pairs in an octahedral electron geometry, the lone pairs occupy opposite positions to minimize repulsion. This results in a square planar arrangement of the 4 fluorine atoms around the xenon atom.

Solution: The given molecular geometry diagram shows a central atom 'Xe' bonded to four 'F' atoms. There are two lone pairs shown on the central Xenon atom (represented by dots).

Step 1: Determine the number of sigma bonds and lone pairs on the central atom.
- The central atom is Xe.
- There are 4 Xe-F bonds, which are sigma bonds.
- There are 2 lone pairs on Xe.

Step 2: Calculate the steric number.
Steric Number = (Number of sigma bonds) + (Number of lone pairs) = 4 + 2 = 6.

Step 3: Determine the electron geometry.
A steric number of 6 corresponds to an octahedral electron geometry.

Step 4: Determine the molecular geometry.
In an octahedral arrangement, when there are 4 bonding pairs and 2 lone pairs, the lone pairs occupy positions opposite to each other (axial positions) to minimize repulsion. This leaves the 4 fluorine atoms arranged in a plane around the central xenon atom, forming a square. Therefore, the molecular shape is square planar.

Final Answer: Square planar

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: $SN1$ reactions (unimolecular nucleophilic substitution) proceed via a carbocation intermediate. The rate of the reaction is determined by the stability of this carbocation. More stable carbocations lead to faster $SN1$ reactions. The stability order of carbocations is: Tertiary (3°) > Secondary (2°) > Primary (1°) > Methyl. This stability is due to inductive effects and hyperconjugation.

Solution: We need to identify the alkyl halide that forms the most stable carbocation, as this will undergo $SN1$ reaction the fastest.

(A) CH_3Cl (Methyl chloride): Forms a methyl carbocation (CH_3^+). This is the least stable carbocation.
(B) C_2H_5Cl (Ethyl chloride): Forms an ethyl carbocation ($CH_3CH_2^+$). This is a primary carbocation, slightly more stable than methyl due to hyperconjugation.
(C) tert-C_4H_9Cl (tert-Butyl chloride): Forms a tert-butyl carbocation ($(CH_3)_3C^+$). This is a tertiary carbocation, stabilized by the inductive effect and hyperconjugation from three methyl groups. It is significantly more stable than primary or secondary carbocations.
(D) Vinyl chloride ($CH_2 = CHCl$): Forms a vinyl carbocation ($CH_2 = CH^+$). This carbocation is highly unstable because the positive charge is on an sp^2 hybridized carbon, which is more electronegative than an sp^3 hybridized carbon, and the charge is adjacent to a pi system, leading to repulsion.

Comparing the stability:
Methyl carbocation < Ethyl carbocation < Vinyl carbocation (unstable) < tert-Butyl carbocation.

The tert-butyl carbocation is the most stable among these. Therefore, tert-butyl chloride will undergo $SN1$ reaction fastest.

Final Answer: $\boxed{tert\text{-}C_4H_9Cl}$

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: The maximum number of electrons that can occupy a principal energy level (n) is given by the formula $2n^2$. This formula arises from the fact that for a given n, the possible values of the azimuthal quantum number (l) range from 0 to $n-1$. For each value of l, there are $2l+1$ orbitals, and each orbital can hold a maximum of 2 electrons.

Solution: We are asked to find the maximum number of electrons having the principal quantum number $n = 4$.

Step 1: Identify the principal quantum number. $n = 4$.

Step 2: Determine the possible values of the azimuthal quantum number (l). For $n = 4$, the possible values of l are 0, 1, 2, 3. These correspond to the subshells s, p, d, f.

Step 3: Determine the number of orbitals for each subshell.
- For $l = 0$ (s subshell): Number of orbitals = $2l + 1 = 2(0) + 1 = 1$.
- For $l = 1$ (p subshell): Number of orbitals = $2l + 1 = 2(1) + 1 = 3$.
- For $l = 2$ (d subshell): Number of orbitals = $2l + 1 = 2(2) + 1 = 5$.
- For $l = 3$ (f subshell): Number of orbitals = $2l + 1 = 2(3) + 1 = 7$.

Step 4: Calculate the total number of orbitals in the $n = 4$ shell.
Total orbitals = $1 + 3 + 5 + 7 = 16$.

Step 5: Calculate the maximum number of electrons.
Since each orbital can hold a maximum of 2 electrons, the maximum number of electrons is:
Maximum electrons = (Total number of orbitals) $\times$ 2
Maximum electrons = $16 \times 2 = 32$.

Alternatively, using the formula $2n^2$:
Maximum electrons = $2 \times (4)^2 = 2 \times 16 = 32$.

Final Answer: $\boxed{32}$

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: An adiabatic process is a thermodynamic process in which there is no heat exchange between the system and its surroundings. Mathematically, this means the heat transfer (q) is zero ($q = 0$). Free expansion is a process where a gas expands into a vacuum. In such a process, the external pressure is zero, so no work is done by the gas ($w = 0$). The first law of thermodynamics states:

$$\Delta U = q + w$$

where ΔU is the change in internal energy, q is the heat transfer, and w is the work done.

Solution: We are considering the adiabatic free expansion of an ideal gas.

Step 1: Analyze the adiabatic condition.
Adiabatic means no heat exchange with the surroundings. So, $q = 0$.

Step 2: Analyze the free expansion condition.
Free expansion means expansion into a vacuum. The external pressure is essentially zero. Therefore, the work done by the gas is zero. So, $w = 0$.

Step 3: Apply the first law of thermodynamics.

$$\Delta U = q + w$$

Substitute the values from steps 1 and 2:

$$\Delta U = 0 + 0$$

$$\Delta U = 0$$

This means the internal energy of the gas does not change during an adiabatic free expansion.

Step 4: Evaluate the options.
(A) $q = 0, w = 0$: This correctly describes the adiabatic free expansion.
(B) $q \neq 0, w = 0$: This is incorrect because the process is adiabatic ($q = 0$).
(C) $q = 0, w \neq 0$: This is incorrect because for free expansion, $w = 0$.
(D) $\Delta U > 0$: This is incorrect because we found $\Delta U = 0$.

Final Answer: q=0, w=0

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: The Schiemann reaction is a method for synthesizing aryl fluorides from aromatic amines. The reaction involves the diazotization of the amine, followed by the formation of a diazonium tetrafluoroborate salt, and finally, thermal decomposition of this salt to yield the aryl fluoride. The steps are: 1. Diazotization: Primary aromatic amine + $NaNO_2$ + strong acid (like HCl) $\rightarrow$ Diazonium salt. 2. Formation of Diazonium Tetrafluoroborate: Diazonium salt + HBF_4 $\rightarrow$ Diazonium tetrafluoroborate salt. 3. Thermal Decomposition: Diazonium tetrafluoroborate salt $\xrightarrow{\Delta}$ Aryl fluoride + N_2 + BF_3.

Solution: The question asks for the reagent used to convert benzene diazonium chloride into fluorobenzene. This corresponds to the Schiemann reaction.

Step 1: Recall the Schiemann reaction.
The Schiemann reaction involves the formation of an aryl fluoride from an arylamine via a diazonium tetrafluoroborate intermediate.

Step 2: Identify the role of each reagent in the options:
- CuCl/HCl: Used in the Sandmeyer reaction to introduce chlorine into an aromatic ring, converting a diazonium salt to an aryl chloride.
- KI: Used to introduce iodine into an aromatic ring, converting a diazonium salt to an aryl iodide (along with N_2).
- HBF_4 (Tetrafluoroboric acid): This reagent is used in the Schiemann reaction to form the diazonium tetrafluoroborate salt. The subsequent heating of this salt leads to the formation of fluorobenzene.
- CuCN: Used in the Sandmeyer reaction to introduce a cyanide group into an aromatic ring, converting a diazonium salt to an aryl nitrile.

Step 3: Match the reagent to the desired product.
To obtain fluorobenzene from benzene diazonium chloride, the intermediate diazonium tetrafluoroborate must be formed, which is achieved by treating the diazonium salt with HBF_4.

Final Answer:

$$\boxed{HBF_4}$$

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: In an electrochemical cell notation, the standard convention is to write the anode (where oxidation occurs) on the left and the cathode (where reduction occurs) on the right, separated by a salt bridge (||). The half-cells are represented by indicating the electrode and the ions involved.
The general notation is:
Anode half-cell || Cathode half-cell
where the line segment '|' indicates a phase boundary (e.g., electrode | ion solution).
Oxidation is the loss of electrons (increase in oxidation state).
Reduction is the gain of electrons (decrease in oxidation state).

Solution: The given galvanic cell notation is:

$$\text{Pt} \mid \text{Fe}^{2+}, \text{Fe}^{3+} \parallel \text{Sn}^{2+}, \text{Sn}^{4+} \mid \text{Pt}$$

Step 1: Identify the anode and cathode half-cells.
The left side of the salt bridge (||) represents the anode half-cell: Pt | Fe^{2+}, Fe^{3+} The right side of the salt bridge (||) represents the cathode half-cell: Sn^{2+}, Sn^{4+} | Pt

Step 2: Determine the process occurring in each half-cell.
In the anode half-cell (Pt | Fe^{2+}, Fe^{3+}): We have Fe^{2+} and Fe^{3+} ions. The conversion between them involves a change in oxidation state:
$Fe^{2+} \rightarrow Fe^{3+} + e^-$ (Oxidation, oxidation state of Fe increases from +2 to +3). Since oxidation occurs at the anode, Fe^{2+} is oxidized to Fe^{3+}.

In the cathode half-cell (Sn^{2+}, Sn^{4+} | Pt):
We have Sn^{2+} and Sn^{4+} ions. The conversion between them involves a change in oxidation state:
$Sn^{4+} + 2e^- \rightarrow Sn^{2+}$ (Reduction, oxidation state of Sn decreases from +4 to +2). Since reduction occurs at the cathode, Sn^{4+} is reduced to Sn^{2+}.

Step 3: Identify the species being oxidized.
Oxidation involves an increase in oxidation state. In the anode half-cell, Fe^{2+} loses an electron to become Fe^{3+}. Therefore, Fe^{2+} is the species being oxidized.

Final Answer:

$$\boxed{Fe^{2+}}$$

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: In a crystal lattice, the coordination number of an atom or ion is the number of nearest neighbors it has. Different crystal structures have different coordination numbers.
- Simple cubic (SC): Each atom touches 6 other atoms (one above, one below, one front, one back, one left, one right). Coordination number = 6.
- Body-centred cubic (BCC): The central atom touches 8 corner atoms. Each corner atom touches the central atom and 6 other corner atoms (in different unit cells). Coordination number = 8.
- Face-centred cubic (FCC): Each atom touches 12 other atoms. Coordination number = 12.
- Hexagonal close packed (HCP): Coordination number = 12.

Solution: We are asked for the coordination number in a body-centred cubic (BCC) crystal.

Step 1: Visualize the BCC structure.
In a BCC unit cell, there is an atom at each of the 8 corners of the cube and one atom at the very center of the cube.

Step 2: Determine the nearest neighbors for the central atom.
The atom at the center of the cube is equidistant from all 8 corner atoms. Each corner atom is a nearest neighbor to the central atom.
Thus, the central atom has 8 nearest neighbors.

Step 3: Determine the coordination number.
The coordination number is the number of nearest neighbors. For the central atom in a BCC structure, the coordination number is 8. (Note: If considering a corner atom, its coordination number is also 8 when considering its nearest neighbors across unit cell boundaries).

Final Answer: 8

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: Lucas reagent is a solution used to distinguish between primary, secondary, and tertiary alcohols based on their reaction rates with the reagent, which leads to the formation of insoluble alkyl chlorides (turbidity). The reagent consists of anhydrous zinc chloride ($ZnCl_2$) dissolved in concentrated hydrochloric acid (HCl).

Solution: The composition of Lucas reagent is key here.
- Anhydrous $ZnCl_2$: Acts as a Lewis acid, activating the alcohol by coordinating with the oxygen atom of the hydroxyl group, making it a better leaving group.
- Concentrated HCl: Provides the chloride ions (Cl^-) which act as the nucleophile to attack the carbocation formed.

The reaction proceeds via an $SN1$ mechanism, where the rate of reaction depends on the stability of the carbocation formed. Tertiary alcohols react fastest, followed by secondary, and then primary alcohols.

The options are:
(A) Conc. HCl and $ZnCl_2$: This matches the composition of Lucas reagent.
(B) Conc. HNO_3: Nitric acid is a strong oxidizing acid, not used in Lucas reagent.
(C) NaOH and $CuSO_4$: This combination is not a standard reagent for alcohol classification. NaOH is a strong base, and $CuSO_4$ is a salt.
(D) Dilute HCl and Zn: Dilute HCl is not concentrated enough, and Zn is a reducing metal, not part of Lucas reagent.

Therefore, Lucas reagent contains concentrated HCl and $ZnCl_2$.

Final Answer:

$$\boxed{\text{Conc. HCl and } ZnCl_2}$$

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept: In a reversible reaction, the reaction proceeds in both the forward and backward directions.

- Forward reaction: Reactants → Products.
- Backward reaction: Products → Reactants.

Equilibrium is reached when the rate of the forward reaction becomes exactly equal to the rate of the backward reaction. At this point, the net concentrations of reactants and products do not change, although the reactions continue to occur at the molecular level.

Solution: We need to describe the relationship between the forward and backward reaction rates at equilibrium.

Step 1: Define Equilibrium.

Chemical equilibrium is a state in a reversible reaction where the rate of the forward reaction is equal to the rate of the reverse reaction. This is also known as a dynamic equilibrium because both reactions are still occurring, but at equal rates, resulting in no net change in macroscopic properties.

Step 2: Compare the rates.

- If the forward rate were greater than the backward rate, the concentration of products would increase, and the concentration of reactants would decrease, moving towards equilibrium.
- If the forward rate were less than the backward rate, the concentration of products would decrease, and the concentration of reactants would increase, moving towards equilibrium.
- At equilibrium, the rates must be equal to maintain constant concentrations.

Step 3: Evaluate the options.

(A) Greater than backward rate: This describes a state before equilibrium is reached in a reversible reaction moving towards products.

(B) Less than backward rate: This describes a state before equilibrium is reached in a reversible reaction moving towards reactants.

(C) Equal to backward rate: This is the definition of equilibrium for a reversible reaction.

(D) Zero: The rates are generally not zero at equilibrium (unless the reaction has gone to completion, which is a special case, or the activation energy is infinite).

Final Answer: Equal to backward rate

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: The Van't Hoff equation relates the change in the equilibrium constant (K) of a chemical reaction to the change in temperature (T). It describes how the equilibrium constant varies with temperature and is derived from the Gibbs free energy equation and the relationship between enthalpy change and temperature. The equation is typically written as:

$$\frac{d(\ln K)}{dT} = \frac{\Delta H^0}{RT^2}$$

Or in integrated form (assuming ΔH^0 is constant):

$$\ln \frac{K_2}{K_1} = -\frac{\Delta H^0}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Rearranging this equation, we can see a linear relationship between $\ln K$ and $1/T$:

$$\ln K = -\frac{\Delta H^0}{R}\left(\frac{1}{T}\right) + \text{constant}$$

This equation has the form $y = mx + c$, where $y = \ln K$, $x = 1/T$, $m = -\Delta H^0/R$, and c is a constant. Thus, a plot of $\log K$ versus $1/T$ should be a straight line with a negative slope if ΔH^0 is negative (exothermic reaction) or a positive slope if ΔH^0 is positive (endothermic reaction). The graph shows $\log K$ on the y-axis and $1/T$ on the x-axis, which is a plot consistent with the Van't Hoff equation. The line is shown decreasing, implying a negative slope.

Solution: The graph plots $\log K$ on the y-axis and $1/T$ on the x-axis. This relationship is characteristic of the Van't Hoff equation, which describes how the equilibrium constant (K) changes with temperature (T).

Let's examine the options:
(A) Arrhenius equation: This equation relates the rate constant (k) of a reaction to temperature: $k = Ae^{-E_a/RT}$. A plot of $\ln k$ vs $1/T$ is linear. This graph plots $\log K$ vs $1/T$, not $\ln k$ vs $1/T$.
(B) Van't Hoff equation: As discussed in the concept, the Van't Hoff equation predicts a linear relationship between $\ln K$ (or $\log K$) and $1/T$. The given graph perfectly matches this form.
(C) Boyle's law: Relates pressure and volume of an ideal gas at constant temperature (PV = constant). Not relevant here.
(D) Beer-Lambert law: Relates the absorbance of a solution to the concentration of the absorbing species and the path length. Not relevant here.

Therefore, the graph represents the Van't Hoff equation.

Final Answer: Van't Hoff equation

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Bond length is inversely proportional to bond order.

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

For oxygen species:

$$O_2^+ > O_2 > O_2^- > O_2^{2-}$$

in terms of bond order.

Hence, O_2^+ has the highest bond order and therefore the shortest bond length.

Solution: Bond order is given by:

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

1. O_2 (16 electrons):

Bond order:

$$\frac{8-4}{2} = 2$$

2. O_2^+ (15 electrons):

One electron is removed from antibonding orbital.

Bond order:

$$\frac{8-3}{2} = 2.5$$

3. O_2^- (17 electrons):

One electron is added to antibonding orbital.

Bond order:

$$\frac{8-5}{2} = 1.5$$

4. O_2^{2-} (18 electrons):

Two electrons are added to antibonding orbitals.

Bond order:

$$\frac{8-6}{2} = 1$$

Cmparison:

$$O_2^+ > O_2 > O_2^- > O_2^{2-}$$

Since bond length is inversely proportional to bond order, the species with the highest bond order has the shortest bond length.

Final Answer:

$$\boxed{O_2^+}$$

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: The gold number is a measure of the protective power of a lyophilic colloid. It is defined as the minimum weight (in milligrams) of a protective colloid required to prevent the coagulation of 10 mL of a standard gold sol when 1 mL of a 10% sodium chloride ($NaCl$) solution is added to it. A lower gold number indicates a higher protective power, meaning less of the colloid is needed to protect the gold sol from precipitation. Protective colloids adsorb onto the surface of the particles of the lyophobic sol, forming a protective layer that prevents aggregation.

Solution: The gold number is a quantitative measure of the ability of a lyophilic colloid to protect a lyophobic sol (like gold sol) from precipitation by an electrolyte.
- It quantifies the effectiveness of a substance as a stabilizer for colloids.
- A smaller gold number implies greater protective power.

Therefore, the gold number is associated with the stability of colloids.

Let's consider why other options are incorrect:
- Viscosity of liquids: This is a bulk property and not directly related to the protective action of colloids.
- Surface tension: This is related to the cohesive forces at the surface of a liquid, not the stabilization of colloidal dispersions.
- Catalytic activity: This refers to the ability of a substance to increase the rate of a chemical reaction, which is unrelated to colloid stabilization.

Final Answer: Stability of colloids

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: The acidity of oxides generally increases from left to right across a period and decreases from top to bottom down a group in the periodic table.
- Oxides of metals are generally basic.
- Oxides of non-metals are generally acidic.
- Oxides of elements in the middle (like Al, Ga, Ge, As) can be amphoteric.

The acidity of metal oxides is related to the charge density of the metal cation. A higher positive charge and smaller ionic radius lead to a stronger attraction for the oxygen atom's electrons, polarizing the O-H bond in the hydroxide and making it more acidic. For non-metal oxides, the acidity is related to the electronegativity of the central atom and the number of oxygen atoms attached. A higher electronegativity and more oxygen atoms attached to the central non-metal atom lead to a more acidic oxide.

Solution: Let's examine the nature of the oxides of the given elements:

(A) Na_2O (Sodium oxide): Sodium (Na) is an alkali metal (Group 1). Its oxide is strongly basic.
(B) MgO (Magnesium oxide): Magnesium (Mg) is an alkaline earth metal (Group 2). Its oxide is basic.
(C) Al_2O_3 (Aluminium oxide): Aluminium (Al) is in Group 13. Its oxide is amphoteric, meaning it can react with both acids and bases.
(D) Cl_2O_7 (Dichlorine heptoxide): Chlorine (Cl) is a halogen (Group 17), a non-metal. Its oxide is highly acidic. The central atom (Cl) has a high oxidation state (+7) and is highly electronegative. The presence of many oxygen atoms bonded to the central atom increases the acidity by polarizing the O-H bond in its hydrated form ($2HClO_4$).

Comparing the acidity:
Basic oxides (Na_2O, MgO) < Amphoteric oxide (Al_2O_3) < Acidic oxides.

Among the acidic oxides, the acidity increases with the electronegativity of the non-metal and the number of oxygen atoms. Cl_2O_7 is the oxide of a highly electronegative element in a very high oxidation state, making it the most acidic among the given options.

Final Answer:

$$\boxed{Cl_2O_7}$$

Answer: (D)

Go Back to Question 21

Q22.

Solution

Concept: Structural isomers are compounds with the same molecular formula but different structural formulas (different connectivity of atoms). For alkanes, we are looking for different arrangements of the carbon chain and branches. We need to find the number of structural isomers for C_5H_{12}, which is an alkane. Alkanes have the general formula C_nH_{2n+2}.

Solution: Let's systematically draw the possible structures for C_5H_{12}:
1. Straight chain: A continuous chain of 5 carbon atoms. $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
This is n-pentane.

2. Branched chains: We can form branched structures by changing the carbon skeleton. - Main chain of 4 carbons:

$$CH_3 - CH_2 - CH_2 - CH_3$$

Adding one methyl group to the second carbon gives:

$$CH_3 - CH(CH_3) - CH_2 - CH_3$$

This is **2-methylbutane**. - Main chain of 3 carbons:

$$CH_3 - CH_2 - CH_3$$

Adding two methyl groups to the central carbon gives:

$$CH_3 - C(CH_3)_2 - CH_3$$

This is **2,2-dimethylpropane**. Thus, the three structural isomers are:

1. n-pentane
2. 2-methylbutane
3. 2,2-dimethylpropane

Let's check if there are any other possibilities. We cannot have a main chain of 2 carbons, as adding 3 carbons would extend the chain.

So, there are 3 structural isomers for C_5H_{12}.

Final Answer: $\boxed{3}$

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: A titration curve shows the variation of pH with the volume of titrant added. The nature of the curve depends on the strength of the acid and base involved. - Strong acid + Strong base: Equivalence point at pH = 7.
- Weak acid + Strong base: Equivalence point at pH > 7 due to hydrolysis of the conjugate base.
- Strong acid + Weak base: Equivalence point at pH < 7 due to hydrolysis of the conjugate acid.
- Weak acid + Weak base: No sharp pH change near equivalence point.
The shape and equivalence point of the curve help identify the type of titration.

Solution: From the titration curve:
- The initial pH is very low, indicating the presence of a strong acid.
- As titrant is added, the pH increases gradually.
- The equivalence point occurs at pH < 7, which is characteristic of a strong acid–weak base titration.
- After the equivalence point, the pH rises slowly and remains moderately acidic/basic due to the weak base.

Comparison with standard titration curves:
1. Strong acid + Strong base → Equivalence point at pH = 7
2. Weak acid + Strong base → Equivalence point at pH > 7
3. Strong acid + Weak base → Equivalence point at pH < 7

Since the curve shows an equivalence point below 7, the titration is:

Final Answer: Strong acid vs. weak base

Answer: (C)

Go Back to Question 23

Q24.

Solution

Concept: Proteins are macromolecules composed of amino acids linked together by peptide bonds. A peptide bond is formed by the reaction between the carboxyl group (-COOH) of one amino acid and the amino group (-NH_2) of another amino acid, with the elimination of a water molecule. This is a type of condensation reaction.

Solution: Let's define the different types of linkages mentioned:
- Glycosidic linkage: Found in carbohydrates (sugars), linking monosaccharides together to form disaccharides and polysaccharides. It is formed between a hemiacetal or hemiketal group of a carbohydrate and a hydroxyl group of another molecule.
- Peptide linkage: Formed between amino acids in proteins. It is an amide linkage formed between the carboxyl group of one amino acid and the amino group of another. The structure is -CO-NH-.
- Ester linkage: Formed between a carboxylic acid and an alcohol, with the elimination of water. The structure is -COO-. Found in fats (triglycerides) and polyesters.
- Phosphodiester linkage: Found in nucleic acids (DNA and RNA), linking nucleotides together. It connects the phosphate group of one nucleotide to the sugar of another.

The question asks for the linkage between amino acids in proteins. Based on the definitions, this linkage is the peptide linkage.

Final Answer: Peptide linkage

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: Equivalent conductance (Λ_{eq}) of a weak electrolyte increases on dilution because: 1. Increased ionization: Dilution shifts the equilibrium towards greater dissociation, producing more ions.
2. Increased ionic mobility: Interionic attractions decrease on dilution, so ions move more freely.
Equivalent conductance is:

$$\Lambda_{eq} = \frac{\kappa}{C_{eq}}$$

Although conductivity decreases on dilution, the increase in ionization and ionic mobility causes Λ_{eq} to increase overall.

Solution: The question asks for the reason why the equivalent conductance of a weak electrolyte increases on dilution. Let's analyze the options based on the factors affecting conductivity:

(A) Increase in ionic mobility: As dilution occurs, interionic attractions decrease, leading to greater freedom of movement for ions. This increases the mobility of ions, contributing to higher conductance. This is a valid reason.

(B) Increase in ionization: For weak electrolytes, dilution shifts the equilibrium towards further dissociation, increasing the number of ions in the solution. An increase in the number of charge carriers directly leads to increased conductivity. This is a primary reason for the increase in equivalent conductance of weak electrolytes.

(C) Decrease in viscosity: Dilution generally causes a slight decrease in the viscosity of the solvent. Lower viscosity would lead to higher ionic mobility, which indirectly contributes to increased conductance. However, it is not usually cited as the primary direct reason for the increase in equivalent conductance.

(D) Decrease in resistance: Resistance is the inverse of conductance. As conductance increases, resistance decreases. However, this is a consequence, not the cause of increased conductance.

Both increased ionization and increased ionic mobility are responsible for the increase in equivalent conductance of a weak electrolyte upon dilution. However, the increase in the number of ions due to enhanced ionization is often considered the more significant factor, especially for very weak electrolytes. The question asks for *the* reason. In the context of typical chemistry questions concerning weak electrolytes, "increase in ionization" is often the emphasized explanation.

Final Answer: Increase in ionisation

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: The colour of coordination compounds arises from d-d electronic transitions, where an electron is promoted from a lower energy d-orbital to a higher energy d-orbital within the same metal atom. This transition occurs when the energy of visible light corresponds to the energy difference between these d-orbitals. This energy difference is influenced by the ligand field strength and the oxidation state of the metal. For a complex to be coloured, the central metal ion must have partially filled d-orbitals, and there must be a ligand field that causes splitting of these d-orbitals. Ions with empty d-orbitals (d^0) or completely filled d-orbitals (d^{10}) do not undergo d-d transitions and are typically colourless.

Solution: We need to determine which of the given complex ions has a central metal ion with either d^0 or d^{10} electronic configuration, or a ligand field that prevents d-d transitions.

(A) $[Ti(H_2O)_6]^{3+}$: Titanium (Ti) has atomic number 22. Electronic configuration: $[Ar]4s^2 3d^2$. In the +3 oxidation state, Ti^{3+} has the configuration $[Ar]3d^1$. Since it has a partially filled d-orbital, it can undergo d-d transitions and is expected to be coloured (typically violet).

(B) $[Cu(H_2O)_6]^{2+}$: Copper (Cu) has atomic number 29. Electronic configuration: $[Ar]4s^1 3d^{10}$. In the +2 oxidation state, Cu^{2+} has the configuration $[Ar]3d^9$. It has a partially filled d-orbital, so it can undergo d-d transitions and is expected to be coloured (typically blue).

(C) $[Zn(NH_3)_4]^{2+}$: Zinc (Zn) has atomic number 30. Electronic configuration: $[Ar]4s^2 3d^{10}$. In the +2 oxidation state, Zn^{2+} has the configuration $[Ar]3d^{10}$. All d-orbitals are completely filled. Therefore, d-d transitions are not possible. This complex is expected to be colourless.

(D) $[Fe(CN)_6]^{3-}$: Iron (Fe) has atomic number 26. Electronic configuration: $[Ar]4s^2 3d^6$. In the +3 oxidation state, Fe^{3+} has the configuration $[Ar]3d^5$. Since it has a partially filled d-orbital, it can undergo d-d transitions and is expected to be coloured (typically yellow or brown). Note that cyanide (CN-) is a strong field ligand, which can also lead to charge transfer transitions, making it coloured.

Based on the electronic configurations, $[Zn(NH_3)_4]^{2+}$ has Zn^{2+} with a d^{10} configuration, so it is expected to be colourless.

Final Answer:

$$\boxed{[Zn(NH_3)_4]^{2+}}$$

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: The Cannizzaro reaction is a disproportionation reaction exhibited by aldehydes that lack an α-hydrogen atom. In the presence of a strong base, these aldehydes undergo both oxidation (to a carboxylic acid) and reduction (to a primary alcohol) in a 1:1 ratio.

Solution: We need to identify which of the given compounds has no α-hydrogen atoms. An α-hydrogen is a hydrogen atom attached to the carbon atom adjacent to the carbonyl group ($C = O$).

(A) Acetaldehyde (CH_3CHO): Structure: $CH_3 - CH = O$. The carbon atom adjacent to the carbonyl group is the CH_3 carbon. It has 3 α-hydrogens. Therefore, acetaldehyde does not undergo the Cannizzaro reaction (it undergoes aldol condensation).

(B) Propanal (CH_3CH_2CHO): Structure: $CH_3 - CH_2 - CH = O$. The carbon atom adjacent to the carbonyl group is the CH_2 carbon. It has 2 α-hydrogens. Therefore, propanal does not undergo the Cannizzaro reaction.

(C) Benzaldehyde (C_6H_5CHO): Structure: A benzene ring attached to a $-CHO$ group. The carbon atom of the aldehyde group (the carbonyl carbon) is directly attached to the phenyl ring. There are no hydrogen atoms directly attached to the carbon atom adjacent to the carbonyl group (there are no α-carbons with hydrogens). The carbons of the phenyl ring are not considered α-carbons in this context for typical aldol-type reactions. Benzaldehyde lacks α-hydrogens. Therefore, benzaldehyde undergoes the Cannizzaro reaction.

(D) Acetone (CH_3COCH_3): Structure: $CH_3 - C(= O) - CH_3$. The carbon atoms adjacent to the carbonyl group are the two CH_3 groups. Each has 3 α-hydrogens. Therefore, acetone does not undergo the Cannizzaro reaction (it undergoes aldol condensation).

Final Answer: Benzaldehyde

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: The depression in freezing point (ΔT_f) is a colligative property, meaning it depends on the number of solute particles in the solution, not their identity. The relationship is given by the cryoscopic equation:

$$\Delta T_f = K_f \cdot m \cdot i$$

where: - K_f is the cryoscopic constant of the solvent. - m is the molality of the solution. - i is the van't Hoff factor. Molality (m) is defined as the number of moles of solute per kilogram of solvent.

$$m = \frac{\text{moles of solute}}{\text{kilograms of solvent}}$$

Solution: We need to determine what the depression in freezing point is directly proportional to. From the cryoscopic equation, $\Delta T_f = K_f \cdot m \cdot i$. Here, K_f is a constant for a given solvent. i is a factor related to the solute's dissociation/association. The term $m \cdot i$ represents the effective molality, or effectively the total concentration of solute particles in terms of molality.
The depression in freezing point is directly proportional to the product of the molality and the van't Hoff factor ($m \cdot i$). This product represents the molality of the solute particles.
Let's examine the options: (A) Molarity: Molarity is moles of solute per liter of solution. Molality is moles of solute per kilogram of solvent. Colligative properties are generally expressed in terms of molality because the mass of the solvent does not change with temperature, whereas the volume of the solution can change.
(B) Molality: The equation shows ΔT_f is directly proportional to molality (m), assuming i is constant for a given solute.
(C) Mole fraction: While mole fraction is related to concentration, the standard formulation for colligative properties uses molality. If the solvent is water and the solute is dilute, molality is approximately proportional to mole fraction. However, molality is the definition used.
(D) Density: Density is mass per unit volume and is not directly used in the basic colligative property equations.

The freezing point depression is directly proportional to the molality of the solute particles ($m \cdot i$). Therefore, it is directly proportional to molality if i is constant (e.g., for a non-electrolyte, $i = 1$, so $\Delta T_f \propto m$). If considering different solutes or varying degrees of dissociation, it's proportional to the effective molality ($m \cdot i$). However, among the options given, molality is the fundamental concentration unit used.

Final Answer: Molality

Answer: (B)

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Q29.

Solution

Concept:

The diagram shows a unit cell with atoms located at the corners and at the center of each face. This arrangement is characteristic of specific cubic crystal structures. - Simple cubic (SC): Atoms only at the 8 corners. - Body-centred cubic (BCC): Atoms at the 8 corners and 1 atom at the body center. - Face-centred cubic (FCC): Atoms at the 8 corners and 1 atom at the center of each of the 6 faces.

Solution:

The diagram shows:

1. Atoms at all 8 corners of the cube.
2. Atoms at the center of each of the 6 faces of the cube.

This specific arrangement of atoms is the defining characteristic of a face-centred cubic (FCC) crystal structure.

Final Answer: Face-centred cubic

Answer: (C)

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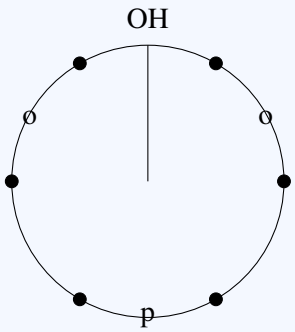
Q30.

Solution

Concept: Phenol (C_6H_5OH) is an aromatic alcohol. The hydroxyl group (-OH) is strongly activating and an ortho-, para- director for electrophilic aromatic substitution reactions due to resonance and inductive effects. Bromine water (Br_2 dissolved in water) is a potent electrophilic brominating agent. Due to the strong activation by the -OH group, phenol reacts readily with bromine water to substitute all available ortho and para positions, even without a catalyst.

Solution: Phenol has the structure:



The ortho positions are at C-2 and C-6, and the para position is at C-4. When phenol reacts with bromine water (Br_2/H_2O), the electrophilic bromine attacks these activated positions. The reaction leads to the substitution of hydrogen atoms at all three ortho and para positions.
The reaction is:

$$C_6H_5OH + 3Br_2 \xrightarrow{H_2O} C_6H_2(Br_3)OH + 3HBr$$

The product formed is 2,4,6-tribromophenol.

Let's consider the options:
(A) Bromobenzene: This would involve substitution of H on the benzene ring, but not necessarily all ortho/para positions, and lacks the OH group.
(B) 2-bromophenol: This would be a product of monobromination, which can occur under different conditions (e.g., with Br_2 in CS_2), but not with bromine water.
(C) 2,4,6-tribromophenol: This is the product formed due to substitution at all ortho and para positions.
(D) Bromocyclohexane: This would involve reduction of the aromatic ring, which does not happen in this reaction.

Final Answer: 2,4,6-tribromophenol

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept: The number of atoms in a given mass of an element is calculated using the molar mass and Avogadro's number. - Molar mass (M) of an element is numerically equal to its atomic mass in grams per mole. - Avogadro's number (N_A) is approximately 6.022×10^{23} atoms/mol. Number of atoms = (Given mass / Molar mass) $\times N_A$.

Solution: We need to find the number of atoms in 4 g of Helium (He).

Step 1: Determine the molar mass of Helium.
The atomic mass of Helium is approximately 4.00 g/mol. So, the molar mass of He is 4.00 g/mol.

Step 2: Calculate the number of moles of Helium.
Number of moles = $\frac{\text{Mass of He}}{\text{Molar mass of He}} = \frac{4\text{ g}}{4.00\text{ g/mol}} = 1$ mole.

Step 3: Calculate the number of atoms.
Since 1 mole of any element contains Avogadro's number of atoms:
Number of atoms = 1 mole $\times 6.022 \times 10^{23}$ atoms/mol
Number of atoms = 6.022×10^{23} atoms.

Final Answer:

$$\boxed{6.022 \times 10^{23}}$$

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: Dipole moment is a measure of the polarity of a molecule. It arises from the difference in electronegativity between bonded atoms and the molecular geometry. - A molecule has a net dipole moment if it has polar bonds and an asymmetrical shape such that the individual bond dipoles do not cancel each other out. - Symmetrical molecules, even with polar bonds, often have zero net dipole moment because the bond dipoles cancel each other vectorially.

Solution: Let's analyze the molecules:

(A) CO_2: Linear molecule ($O = C = O$). The C=O bonds are polar, but due to the linear symmetry, the bond dipoles cancel out. Net dipole moment = 0.
(B) BF_3: Trigonal planar molecule. The B-F bonds are polar, but due to the symmetrical trigonal planar geometry, the bond dipoles cancel out. Net dipole moment = 0.
(C) NH_3: Trigonal pyramidal molecule. The N-H bonds are polar. Additionally, there is a lone pair of electrons on the nitrogen atom. The combination of polar bonds and the lone pair results in an asymmetrical distribution of electron density, leading to a significant net dipole moment.
(D) CCl_4: Tetrahedral molecule. The C-Cl bonds are polar, but due to the symmetrical tetrahedral geometry, the bond dipoles cancel out. Net dipole moment = 0.

Among the given options, NH_3 is the only molecule with a non-zero net dipole moment due to its asymmetrical trigonal pyramidal shape and the presence of a lone pair on the central atom.

Final Answer: $NH_3NH_3NH_{3NH_3}$

Answer: (C)

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Q33.

Solution

Concept: Reducing agents donate electrons or hydrogen atoms, causing the reduction of other species. - Aldehydes have the general structure R-CHO. They can be reduced to primary alcohols (R-CH_2OH). - Ketones have the general structure R-CO-R'. They can be reduced to secondary alcohols (R-CH(OH)-R'). - PCC (Pyridinium Chlorochromate): A mild oxidizing agent. It oxidizes primary alcohols to aldehydes and secondary alcohols to ketones. It does not reduce aldehydes or ketones.
- $LiAlH_4$ (Lithium Aluminium Hydride): A strong reducing agent. It effectively reduces aldehydes to primary alcohols and ketones to secondary alcohols. It can also reduce carboxylic acids, esters, and amides.
- Tollens' reagent: An oxidizing agent used to test for aldehydes. It oxidizes aldehydes to carboxylic acids.
- Fehling solution: An oxidizing agent used to test for aldehydes. It oxidizes aldehydes to carboxylic acids.

Solution: We are looking for a reagent that converts aldehydes into primary alcohols.

Let's analyze the options:
(A) PCC: This is an oxidizing agent, not a reducing agent for aldehydes.
(B) $LiAlH_4$: This is a strong reducing agent that reduces aldehydes to primary alcohols. For example, $RCHO \xrightarrow{LiAlH_4} RCH_2OH$.
(C) Tollen's reagent: This is an oxidizing agent for aldehydes.
(D) Fehling solution: This is an oxidizing agent for aldehydes.

Therefore, $LiAlH_4$ is the correct reagent.

Final Answer: $\boxed{LiAlH_4 LiAlH_4 LiAlH_{4\,LiAlH_4}}$

Answer: (B)

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Q34.

Solution

Concept: A π (pi) bond is formed by the sideways or lateral overlap of atomic orbitals, typically p orbitals. This overlap occurs above and below the internuclear axis, creating two regions of electron density. π bonds are generally weaker than σ bonds, which are formed by axial or head-on overlap.

Solution: The diagram shows two p orbitals from different atoms overlapping side-by-side. This type of overlap occurs in a plane perpendicular to the internuclear axis.
- Sigma (σ) bond: Formed by head-on overlap of atomic orbitals (e.g., s-s, s-p, p-p axial overlap). The electron density is concentrated along the internuclear axis.
- Pi (π) bond: Formed by sideways overlap of atomic orbitals (e.g., p-p lateral overlap). The electron density is located above and below the internuclear axis.
- Ionic bond: Formed by the electrostatic attraction between oppositely charged ions.
- Coordinate bond: A type of covalent bond where both electrons in the shared pair come from one atom.

The diagram explicitly states "Sideways overlap of p orbitals," which is the definition of how a π bond is formed.

Final Answer: Pi bond

Answer: (B)

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Q35.

Solution

Concept: The Haber process is the industrial synthesis of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2). It is a reversible reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A catalyst is used to increase the rate of this reaction.

Solution: The Haber process for the synthesis of ammonia utilizes a specific catalyst to accelerate the reaction.
- Ni (Nickel): Commonly used as a catalyst in hydrogenation reactions.
- Pt (Platinum): Used in various catalytic applications, including hydrogenation and catalytic converters.
- Fe (Iron): Iron (often promoted with oxides like K_2O and Al_2O_3) is the standard catalyst used in the industrial Haber process.
- V_2O_5 (Vanadium pentoxide): Used as a catalyst in the Contact process for the manufacture of sulfuric acid.

Therefore, the catalyst used in the Haber process is iron.

Final Answer: Fe

Answer: (C)

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Q36.

Solution

Concept: A molecule is polar if it has a net dipole moment. This occurs when the molecule contains polar bonds and has an asymmetrical shape such that the individual bond dipoles do not cancel each other out. The polarity of a molecule depends on both the polarity of its bonds and its geometry.

Solution: We need to identify the molecules that have a net dipole moment.

(A) NH_3 (Ammonia): - Geometry: Trigonal pyramidal. - Bond polarity: N-H bonds are polar (N is more electronegative than H). - Symmetry: The molecule is asymmetrical due to the lone pair on nitrogen and the trigonal pyramidal shape. - Net dipole moment: The bond dipoles and the lone pair's contribution do not cancel out. Thus, NH_3 is polar.

(B) H_2O (Water): - Geometry: Bent (V-shaped). - Bond polarity: O-H bonds are polar (O is more electronegative than H). - Symmetry: The molecule is asymmetrical due to the two lone pairs on oxygen and the bent shape. - Net dipole moment: The bond dipoles do not cancel out. Thus, H_2O is polar.

(C) CO_2 (Carbon dioxide): - Geometry: Linear ($O = C = O$). - Bond polarity: C=O bonds are polar (O is more electronegative than C). - Symmetry: The molecule is symmetrical. The two polar C=O bond dipoles are equal in magnitude and opposite in direction. - Net dipole moment: The bond dipoles cancel each other out. Thus, CO_2 is nonpolar.

(D) SO_2 (Sulfur dioxide): - Geometry: Bent (V-shaped). - Bond polarity: S-O bonds are polar (O is more electronegative than S). - Symmetry: The molecule is asymmetrical due to the lone pair on sulfur and the bent shape. - Net dipole moment: The bond dipoles do not cancel out. Thus, SO_2 is polar.

Therefore, NH_3, H_2O, and SO_2 are polar molecules.

Final Answer:

$$\boxed{NH_3,\ H_2O,\ SO_2}$$

Answer: (A,B,D)

Go Back to Question 36

Q37.

Solution

Concept: Paramagnetism is a property of atoms, molecules, or ions that have one or more unpaired electrons. These unpaired electrons interact with an external magnetic field, causing the substance to be attracted to the field. Diamagnetism is the property of substances where all electrons are paired. These substances are weakly repelled by a magnetic field. To determine paramagnetism, we need to examine the molecular orbital (MO) configurations and identify the presence of unpaired electrons.

Solution: We will determine the MO configuration and number of unpaired electrons for each species. The MO energy order for O_2, F_2 and Ne_2 is: $\sigma_{2s} < \sigma^*_{2s} < \pi_{2p_x} = \pi_{2p_y} < \sigma_{2p_z} < \pi^*_{2p_x} = \pi^*_{2p_y} < \sigma^*_{2p_z}$

(A) O_2 (16 electrons): MO configuration: $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p_z})^2(\pi_{2p_x})^2(\pi_{2p_y})^2(\pi^*_{2p_x})^1(\pi^*_{2p_y})^1$ There are two unpaired electrons in the π^*_{2p} orbitals. Thus, O_2 is paramagnetic.

(B) NO (Nitric oxide) (11 electrons for NO, total electrons = 7 (N) + 8 (O) = 15 electrons): Let's recheck NO. Nitrogen (N) has 7 electrons. Oxygen (O) has 8 electrons. Total electrons = 7 + 8 = 15. MO configuration (using the order for O_2 as it's similar): $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p_z})^2(\pi_{2p_x})^2(\pi_{2p_y})^2(\pi^*_{2p_x})^1$ There is one unpaired electron in the $\pi^*_{2p_x}$ orbital. Thus, NO is paramagnetic.

(C) N_2 (Nitrogen) (14 electrons): MO configuration: $(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p_x})^2(\pi_{2p_y})^2(\sigma_{2p_z})^2(\pi^*_{2p_x})^0(\pi^*_{2p_y})^0$ All electrons are paired. Thus, N_2 is diamagnetic.

(D) O_2^- (Superoxide ion) (17 electrons): MO configuration: $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p_z})^2(\pi_{2p_x})^2(\pi_{2p_y})^2(\pi^*_{2p_x})^2(\pi^*_{2p_y})^1$ There is one unpaired electron in the $\pi^*_{2p_y}$ orbital. Thus, O_2^- is paramagnetic.

Therefore, O_2, NO, and O_2^- are paramagnetic.

Final Answer:

$$\boxed{O_2,\ NO,\ O_2^-}$$

Answer: (A,B,D)

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Q38.

Solution

Concept: The iodoform test is a qualitative test used to detect the presence of a methyl ketone (a ketone with a methyl group attached to the carbonyl carbon) or a secondary alcohol with the structure R-CH(OH)-CH_3 (where R is hydrogen, alkyl, or aryl). The test involves reacting the compound with iodine (I_2) in the presence of a base (like $NaOH$ or Na_2CO_3). If the compound gives a positive test, a yellow precipitate of iodoform (CHI_3) is formed.

Solution: We need to identify which of the given compounds can give a positive iodoform test. This means the compound must have either a methyl ketone structure or a secondary alcohol of the form R-CH(OH)-CH_3.

(A) Ethanol (CH_3CH_2OH): This is a primary alcohol. However, it has the structure $CH_3 - CH_2OH$. The carbon bearing the hydroxyl group is attached to a methyl group (CH_3) and a hydrogen atom. This fits the pattern of a secondary alcohol where R=H, specifically R-CH(OH)-CH_3 would be $H - CH(OH) - CH_3$, which is isopropanol. Ethanol does not fit the required structure. However, ethanol can be oxidized to acetaldehyde, which does give the iodoform test. Let's check the direct test. Ethanol itself (CH_3CH_2OH) upon reaction with $I_2/NaOH$ is oxidized to acetaldehyde (CH_3CHO), which then undergoes the iodoform reaction. So, ethanol gives a positive iodoform test.

(B) Acetone (CH_3COCH_3): This is a methyl ketone because it has a methyl group (CH_3) attached to the carbonyl group ($C = O$) on both sides. It fits the structure $R - CO - CH_3$ where R is CH_3. Thus, acetone gives a positive iodoform test.

(C) Acetaldehyde (CH_3CHO): This is a methyl aldehyde. It has a methyl group (CH_3) attached to the aldehyde group ($CH = O$). It fits the structure $R - CHO$ where R is CH_3. Thus, acetaldehyde gives a positive iodoform test.

(D) Methanal ($HCHO$): This is formaldehyde. It does not have a methyl group attached to the carbonyl group ($H - CH = O$). It has two hydrogen atoms attached to the carbonyl carbon. Methanal does not give the iodoform test.

Therefore, Ethanol, Acetone, and Acetaldehyde give a positive iodoform test.

Final Answer: Ethanol, Acetone, Acetaldehyde

Answer: (A,B,C)

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Q39.

Solution

Concept: Adsorption is the process where molecules of a substance (adsorbate) accumulate on the surface of another substance (adsorbent). - Physical adsorption (Physisorption): Involves weak van der Waals forces between adsorbate and adsorbent. It is generally reversible and exothermic. It decreases with increasing temperature. - Chemical adsorption (Chemisorption): Involves the formation of chemical bonds between adsorbate and adsorbent. It is generally irreversible or less reversible, exothermic, and has a higher activation energy. It typically increases initially with temperature and then decreases at higher temperatures.

Solution: Let's evaluate each statement:

(A) Adsorption is exothermic: This is generally true for both physisorption and chemisorption. When molecules adsorb onto a surface, they lose some of their kinetic energy, which is released as heat. Thus, adsorption is an exothermic process ($\Delta H < 0$). Correct.

(B) Physical adsorption decreases with rise in temperature: This is true. Physisorption is driven by weak van der Waals forces and is an equilibrium process. According to Le Chatelier's principle, increasing the temperature favors the endothermic process (desorption), thus decreasing the extent of physical adsorption. Correct.

(C) Chemisorption involves weak van der Waals forces: This is incorrect. Chemisorption involves the formation of chemical bonds (covalent, ionic, etc.) between the adsorbate and adsorbent, which are much stronger than van der Waals forces. Physisorption involves weak van der Waals forces.

(D) Activated charcoal is a good adsorbent: This is true. Activated charcoal has a very large surface area due to its porous structure, making it an excellent adsorbent for various gases and solutes. Correct.

Therefore, the correct statements are A, B, and D.

Final Answer:

Adsorption is exothermic,
Physical adsorption decreases with rise in temperature,
Activated charcoal is a good adsorbent

Answer: (A,B,D)

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Q40.

Solution

Concept: Geometrical isomerism (cis-trans isomerism) in organic compounds occurs when there is restricted rotation around a bond and different groups are attached to the atoms involved in the restricted rotation. Common examples include:
1. Alkenes: Restricted rotation around the C=C double bond. If the two groups attached to each carbon of the double bond are different, geometrical isomers (cis and trans) can exist.
2. Cyclic compounds: Restricted rotation due to the ring structure.
3. Coordination compounds: Restricted rotation around coordinate bonds, leading to cis and trans isomers.

Solution: We need to identify which of the given compounds exhibit geometrical isomerism.

(A) But-2-ene: Structure: $CH_3 - CH = CH - CH_3$. The double bond is between the second and third carbon atoms. On the first carbon of the double bond, there is a CH_3 group and a hydrogen atom. On the second carbon of the double bond, there is a CH_3 group and a hydrogen atom. Since the groups attached to each carbon of the double bond are different, but-2-ene exhibits geometrical isomerism (cis-but-2-ene and trans-but-2-ene).

(B) $[Pt(NH_3)_2Cl_2]$: This is a coordination complex with a square planar geometry. It has two ammonia ligands and two chloride ligands. This is of the type MA_2B_2, which exhibits geometrical isomerism (cis and trans isomers).

(C) 1,1-dichloroethene: Structure: $CH_2 = CCl_2$. On the first carbon of the double bond, there are two identical hydrogen atoms (H and H). On the second carbon of the double bond, there are two identical chlorine atoms (Cl and Cl). Since there are identical groups on each carbon of the double bond, geometrical isomerism is not possible.

(D) Hex-3-ene: Structure: $CH_3 - CH_2 - CH = CH - CH_2 - CH_3$. The double bond is between the third and fourth carbon atoms. On the third carbon of the double bond, there is a CH_2CH_3 (ethyl) group and a hydrogen atom. On the fourth carbon of the double bond, there is a CH_2CH_3 (ethyl) group and a hydrogen atom. Since the groups attached to each carbon of the double bond are different (ethyl group and hydrogen atom), hex-3-ene exhibits geometrical isomerism (cis-hex-3-ene and trans-hex-3-ene).

Therefore, But-2-ene, $[Pt(NH_3)_2Cl_2]$, and Hex-3-ene exhibit geometrical isomerism.

Final Answer:

$$\boxed{\text{But-2-ene, } [Pt(NH_3)_2Cl_2], \text{ Hex-3-ene}}$$

Answer: (A,B,D)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	D	4	B	5	C
6	C	7	B	8	E	9	B	10	C
11	C	12	A	13	C	14	A	15	C
16	A	17	C	18	B	19	B	20	A
21	D	22	B	23	C	24	B	25	B
26	C	27	C	28	B	29	C	30	C
36	A,B,D	37	A,B,D	38	A,B,C	39	A,B,D	40	A,B,D