JEE Main 2023 April 11 Shift-2 Chemistry Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**300	**Total Questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The Duration of test is 3 Hours.
2. This paper consists of 90 Questions.
3. There are three parts in the paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage..
4. Each part (subject) has two sections.
   (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each carries 4 marks for correct answer and –1 mark for wrong answer..
5. (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

Chemistry

Section A

1: The magnetic moment is measured in Bohr Magneton (BM). Spin only magnetic moment of Fe in $[Fe(H_2O)_6]^{3+}$ and $[Fe(CN)_6]^{3-}$ complexes respectively is:

(1) 3.87 B.M. and 1.732 B.M.

(2) 6.92 B.M. in both

(3) 5.92 B.M. and 1.732 B.M.

(4) 4.89 B.M. and 6.92 B.M.

Correct Answer: (3): 5.92 B.M. and 1.732 B.M.

Solution:

Step 1: Its Provided that electron configuration of Fe^{3+} in $[Fe(H_2O)_6]^{3+}$-

In $[Fe(H_2O)_6]^{3+}$, Fe is in the +3 oxidation state.

The electronic configuration of Fe is [Ar] $3d^6$ $4s^2$.

Fe^{3+} has the configuration [Ar] $3d^5$.

Water is a weak field ligand, so it does not cause pairing of electrons.

Number of unpaired electrons, $n = 5$.

Step 2: The spin-only magnetic moment for $[Fe(H_2O)_6]^{3+}$-

The spin-only magnetic moment μ is Provided that by

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

where n is the number of unpaired electrons. Substituting $n = 5$:

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92\ \text{BM}.$$

Step 3: Determine the electron configuration of Fe^{3+} in $[Fe(CN)_6]^{3-}$-

In $[Fe(CN)_6]^{3-}$, Fe is also in the +3 oxidation state, so its electronic configuration is [Ar] $3d^5$.

However, CN^- is a strong field ligand, causing pairing of electrons.

The five 3d electrons are arranged as follows:

(0,0) rectangle (5,0.5); in 0.5,1.5,2.5,3.5,4.5 (,0) – (,0.5); at (0.25,0.25) ↑↓; at (1.25,0.25) ↑↓; at (2.25,0.25) ↑;

Number of unpaired electrons, $n = 1$.

Step 4: The spin-only magnetic moment for $[Fe(CN)_6]^{3-}$-

Substituting $n = 1$ into the formula for magnetic moment:

$$\mu = \sqrt{1(1+2)} = \sqrt{3} \approx 1.732 \text{ BM}.$$

Conclusive Answer: The spin-only magnetic moments are 5.92 B.M. and 1.732 B.M. respectively.

Quick Tip

Strong field ligands cause pairing of electrons in the d-orbitals, while weak field ligands do not.

2: Which one of the following pairs is an example of polar molecular solids?

(1) $SO_2(s), CO_2(s)$

(2) $SO_2(s), NH_3(s)$

(3) $MgO(s), SO_2(s)$

(4) $HCl(s), AlN(s)$

Correct Answer: (2): $SO_2(s), NH_3(s)$

Solution:

Polar molecular solids consist of polar molecules held together by dipole-dipole interactions. Sulfur dioxide (SO) has a bent molecular structure and a net dipole moment, making it a polar molecule. Similarly, ammonia (NH) has a trigonal pyramidal shape with a net dipole moment, classifying it as polar. In contrast, carbon dioxide (CO) has a linear structure and is nonpolar. Magnesium oxide (MgO) is an ionic solid, while hydrogen chloride (HCl) is a polar molecule. Aluminum nitride (AlN) is also an ionic solid.

Conclusive Answer: The pair (SO_2(s), NH_3(s)) is an example of polar molecular solids.

Quick Tip

Polar molecules have a net dipole moment due to differences in electronegativity and asymmetrical molecular geometry.

3: Match List I with List II

	List I Complex		**List II Colour**
A.	$Mg(NH_4)PO_4$	I.	Brown
B.	$K_3[Co(NO_2)_6]$	II.	White
C.	$MnO(OH)_2$	III.	Yellow
D.	$Fe_4[Fe(CN)_6]_3$	IV.	blue

Choose the correct answer from the options Provided that below:

(1) A – II, B – III, C – IV, D – I

(2) A – II, B – IV, C – I, D – III

(3) A – III, B – IV, C – II, D – I

(4) A – II, B – III, C – I, D – IV

Correct Answer: (4): A - II, B - III, C - I, D - IV

Solution:

$Mg(NH_4)PO_4$ is white.

$K_3[Co(NO_2)_6]$ is yellow.

$MnO(OH)_2$ is brown.

$Fe_4[Fe(CN)_6]_3$ is blue (Prussian blue).

Conclusive Answer: A – II, B – III, C – I, D – IV

Quick Tip

The color of coordination complexes depends on the metal ion, its oxidation state, and the ligands attached to it.

4: A solution is prepared by adding 2 g of "X" to 1 mole of water. Mass percent of "X" in the solution is ____.

(1) 5%

(2) 20%

(3) 2%

(4) 10%

Correct Answer: (4): 10%

Solution:

Provided that: Mass of solute (X) = 2 g and moles of solvent (H_2O) = 1 mole.

Step 1: Evaluate the mass of the solvent-

The molar mass of water is 18 g/mol. Since we have 1 mole of water, the mass of the solvent is:

$$\text{Mass of solvent} = 1 \text{ mol} \times 18 \text{ g/mol} = 18 \text{ g}.$$

Step 2: Evaluate the total mass of the solution-

The total mass of the solution is the sum of the mass of solute and the mass of solvent:

$$\text{Total mass} = \text{Mass of solute} + \text{Mass of solvent} = 2 \text{ g} + 18 \text{ g} = 20 \text{ g}.$$

Step 3: Evaluate the mass percent of X-

The mass percent of X is Provided that by:

$$\% \text{ mass of X} = \frac{\text{Mass of X}}{\text{Total mass}} \times 100 = \frac{2 \text{ g}}{20 \text{ g}} \times 100 = 10\%.$$

Conclusive Answer: The mass percent of "X" in the solution is 10%.

Quick Tip

Mass percent is the mass of the solute divided by the total mass of the solution, multiplied by 100.

5: If Ni^{2+} is replaced by Pt^{2+} in the complex $[NiCl_2Br_2]^{2-}$, which of the following properties are expected to get changed?

A. Geometry

B. Geometrical isomerism

C. Optical isomerism

D. Magnetic properties

(1) A, B and C

(2) A and D

(3) B and C

(4) A, B and D

Correct Answer: (4): A, B, and D

Solution:

$[NiCl_2Br_2]^{2-}$: This complex has Ni^{2+} with a d^8 configuration.
Since Cl^- and Br^- are weak field ligands, the complex is tetrahedral. Tetrahedral complexes with this formula do not show geometrical isomerism and are optically inactive.

$[PtCl_2Br_2]^{2-}$: This complex has Pt^{2+} with a d^8 configuration. Being a 5d series element, Pt^{2+} forms square planar complexes. Square planar complexes of the type MA_2B_2 can have cis and trans isomers (geometrical isomers), but for these particular ligands there would be no optical isomerism.
Also, the change in geometry from tetrahedral to square planar changes the crystal field splitting, which changes the magnetic properties.

Conclusive Answer: Geometry (A), Geometrical isomerism (B), and Magnetic properties

(D) are expected to change.

Quick Tip

The geometry and isomerism of coordination complexes are influenced by the metal ion's d-electron configuration and the nature of the ligands.

6: Provided that below are two statements :

Statement I: In the metallurgy process, sulphide ore is converted to oxide before reduction.
Statement II: Oxide ores in general are easier to reduce.

In the light of the above statements, choose the most appropriate answer from the options Provided that below:

(1) Both Statement I and Statement II are correct

(2) Statement I is correct but Statement II is incorrect

(3) Statement I is incorrect but Statement II is correct

(4) Both Statement I and Statement II are incorrect

Correct Answer: (1): Both Statement I and Statement II are correct

Solution:

Statement I: Sulphide ores are converted to oxides before reduction. This is true. The process of converting a sulphide ore to its oxide is called roasting. For example, zinc sulphide is roasted to zinc oxide:

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2.$$

Statement II: Oxide ores are generally easier to reduce. This statement is also true. Oxides are easier to reduce compared to sulphides. This can be explained by the following:

Carbon reduction of oxides produces CO_2, which is a gas and readily escapes, making the reaction proceed forward more easily. On the other hand, carbon reduction of sulphides would

form CS_2 which is less volatile than CO_2. The reaction is:

$$2MS + C \rightarrow 2M + CS_2$$

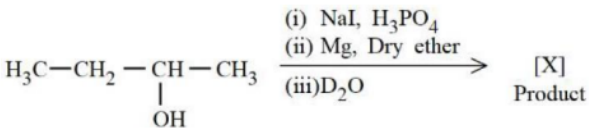
Where M is the metal CO_2 is more volatile compared to CS_2 because of its linear structure, while CS_2 also has a linear structure but has stronger intermolecular forces due to sulfur being larger than oxygen, making CS_2 less volatile, thereby hindering the reaction from being pushed forward.

Conclusive Answer: Both Statement I and Statement II are correct.

Quick Tip

Roasting is the process of converting sulfide ores to oxides by heating them in the presence of air. Oxides are easier to reduce than sulfides because the byproduct (CO_2) is more volatile.

7: Product [X] formed in the above reaction is:



(1) $CH_3 - CH_2 - CH(D) - CH_3$

(2) $CH_3 - CH_2 - CH = CH_2$

(3) $CH_3 - CH = CH - CH_3$

(4) $CH_3 - CH_2 - C(OH)(H) - CH_3$

Correct Answer: (1): $CH_3 - CH_2 - CH(D) - CH_3$

Solution: The reaction sequence proceeds as follows:

Step 1: Reaction with NaI and H_3PO_4-

The alcohol reacts with NaI and H_3PO_4 to form the corresponding iodoalkane via a nucleophilic substitution reaction. H_3PO_4 acts as an acid catalyst, and I^- from NaI acts as the

nucleophile. The hydroxyl group is replaced by an iodine atom:

$$CH_3 - CH_2 - CH(OH) - CH_3 \xrightarrow{NaI,\ H_3PO_4} CH_3 - CH_2 - CH(I) - CH_3$$

Step 2: Grignard reagent formation-

The iodoalkane reacts with magnesium in dry ether to form a Grignard reagent. Dry ether is used as a solvent because it stabilizes the Grignard reagent and prevents it from reacting with water.

$$CH_3 - CH_2 - CH(I) - CH_3 \xrightarrow{Mg,\ Dry\ ether} CH_3 - CH_2 - CH(MgI) - CH_3$$

Step 3: Reaction with D_2O-

The Grignard reagent reacts with D_2O (deuterated water) to form the deuterated alkane. The C-MgI bond is replaced by a C-D bond.

$$CH_3 - CH_2 - CH(MgI) - CH_3 \xrightarrow{D_2O} CH_3 - CH_2 - CH(D) - CH_3$$

Conclusive Answer: The product formed is $CH_3 - CH_2 - CH(D) - CH_3$.

Quick Tip

Grignard reagents are formed by the reaction of alkyl halides with magnesium in dry ether. They are strong nucleophiles and strong bases and readily react with compounds containing acidic hydrogen.

8: Provided that below are two statements :

Statement I : Ethene at 333 to 343 K and 6-7 atm pressure in the presence of $AlEt_3$ and $TiCl_4$ undergoes addition polymerization to give LDP.

Statement II : Caprolactam at 533-543 K in H_2O through step growth polymerizes to give Nylon 6.

In the light of the above statements, choose the correct answer from the options Provided that below:

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are true

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are false

Correct Answer: (3): Statement I is false but Statement II is true

Solution:

Statement I: Ethene at 333 to 343 K and 6-7 atm pressure in the presence of $AlEt_3$ and $TiCl_4$ undergoes addition polymerization to give *high-density polyethylene* (HDPE), not low-density polyethylene (LDPE). Ziegler-Natta catalysts (like $AlEt_3$ and $TiCl_4$) are used to produce HDPE. LDPE is produced via free radical polymerization at high temperatures (423-573 K) and very high pressures (1000-2000 atm). Thus, Statement I is false.

Statement II: Caprolactam undergoes ring-opening polymerization in the presence of water at high temperatures (533-543 K) to form Nylon 6. This is a step-growth polymerization. Thus, Statement II is true.

*6(—N(-[:30]O)–) [yshift=3pt]$\xrightarrow[H_2O]{533-543K}$ $[-C(=O)-(CH_2)_5-N(-[:30]H)-]_n$

Conclusive Answer: Statement I is false, but Statement II is true.

Quick Tip

Addition polymerization involves the addition of monomers without loss of atoms, while step-growth polymerization involves the loss of small molecules (like water) during the formation of polymer chains.

9: For a chemical reaction A + B $\rightarrow$ Product, the order is 1 with respect to A and B.

What is the value of x and y?

(1) 80 and 2

(2) 40 and 4

(3) 80 and 4

Rate $molL^{-1}S^{-1}$	[A] $molL^{-1}$	[B] $molL^{-1}$
0.10	20	0.5
0.40	x	0.5
0.80	40	Y

(4) 160 and 4

Correct Answer: (1): 80 and 2

Solution:

Provided that: The reaction A + B $\rightarrow$ Product is first order with respect to both A and B.

Step 1: Recall the rate law-

Since the reaction is first order with respect to both A and B, the rate law is Provided that by:

$$r = k[A][B],$$

where r is the rate, k is the rate constant, and [A] and [B] are the concentrations of A and B, respectively.

Step 2: Set up equations using the provided that data-

We can set up three equations using the provided that data:

$$0.10 = k(20)(0.5) \tag{1}$$

$$0.40 = k(x)(0.5) \tag{2}$$

$$0.80 = k(40)(Y) \tag{3}$$

Step 3: Solve for x-

Dividing the second equation by the first equation:

$$\frac{0.40}{0.10} = \frac{k(x)(0.5)}{k(20)(0.5)}.$$

$$4 = \frac{x}{20} \implies x = 4 \times 20 = 80.$$

Step 4: Solve for Y-

Dividing the third equation by the first equation:

$$\frac{0.80}{0.10} = \frac{k(40)(Y)}{k(20)(0.5)}.$$

$$8 = \frac{40Y}{10} \implies 80 = 40Y \implies Y = \frac{80}{40} = 2.$$

Conclusive Answer: The values of x and Y are 80 and 2, respectively.

Quick Tip

The rate law expresses the relationship between the rate of a reaction and the concentrations of the reactants. The order of a reaction with respect to a particular reactant is the power to which its concentration is raised in the rate law.

10: Which of the following compounds is an example of Freon?

(1) C_2F_4

(2) C_2HF_3

(3) $C_2Cl_2F_2$

(4) $C_2H_2F_2$

Correct Answer: (3): $C_2Cl_2F_2$

Solution:

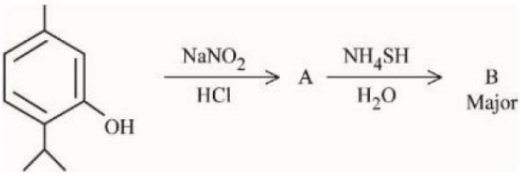
Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), collectively known as Freons, are hydrocarbons in which some or all hydrogen atoms are replaced by chlorine and fluorine atoms. Among the given options, only $C_2Cl_2F_2$ (dichlorodifluoroethylene) contains both chlorine and fluorine along with carbon, making it a Freon.

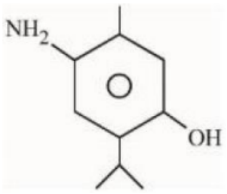
Conclusive Answer: $C_2Cl_2F_2$ is an example of a Freon.

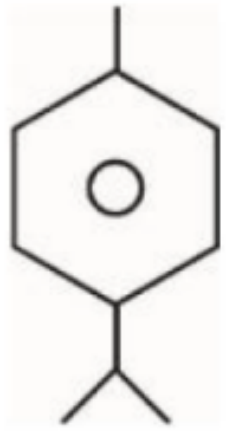
Quick Tip

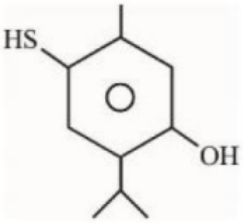
Freons are chlorofluorocarbons (CFCs) which contain chlorine, fluorine, and carbon. They were commonly used as refrigerants but are now being phased out due to their ozone-depleting properties.

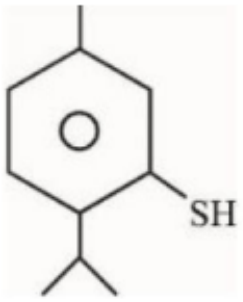
11: Compound 'B' is _____.

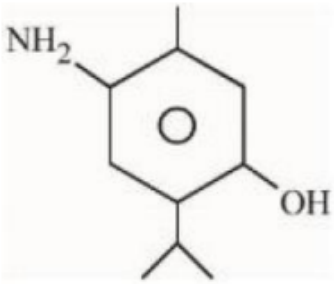


(1) 

(2) 

(3) 

(4) 



Correct Answer: (1)

Solution: The Provided that reaction sequence is:

**6(——) C(=[2]O)(-)(-[::-60]OH) **6(——) $\xrightarrow[HCl]{NaNO2} A \xrightarrow[H2O]{NH4SH} B$

Step 1: Diazotization-

The first step involves the reaction of the Provided that compound (2-hydroxycyclohexanone) with sodium nitrite ($NaNO_2$) and hydrochloric acid (HCl). This is a diazotization reaction, which converts the amino group (-NH_2) of an aromatic amine to a diazonium salt (-$N_2^+Cl^-$). This reaction doesn't happen with the carbonyl group. Since the starting compound shown is not an amino compound, it needs to have NH2 for diazotization reaction to happen. Hence it would be more logical if the used a starting compound of 2-aminocyclohexanol rather than 2-hydroxycyclohexanone.

Step 2: Reduction of Diazonium salt-

The second step involves the reaction of the diazonium salt (A) with ammonium hydrosulfide (NH_4SH) in water. This reduces the diazonium salt to the corresponding amine, with nitrogen gas as a byproduct.

So the final product B is 2-aminocyclohexanol.

Conclusive Answer: The major product (B) is 2-aminocyclohexanol.

Quick Tip

Diazotization reactions are important for converting aromatic amines into various other functional groups. NH_4SH is a reducing agent that converts diazonium salts to amines.

12: Provided that below are two statements, one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: C(=[2]O)-C(-[6]Cl) can be subjected to Wolff-Kishner reduction to give $CH_2 - C(-[6]Cl)(-H)(-H)$

Reason R: Wolff-Kishner reduction is used to convert C(=[2]O) into CH_2

In the light of the above statements, choose the correct answer from the options Provided that below:

(1) Both A and R are true and R is the correct explanation of A

(2) A is true but R is false

(3) Both A and R are true but R is NOT the correct explanation of A

(4) A is false but R is true

Correct Answer: (4): A is false but R is true

Solution:

Assertion (A): The Wolff-Kishner reduction converts a carbonyl group (C=O) to a methylene group (CH_2). The Provided that assertion states that 2-chloropropanal (C(=[2]O)-C(-[6]Cl)) can undergo Wolff-Kishner reduction to form 2-chloropropane ($CH_2-C(-[6]Cl)(-H)(-H)$). $ThisassertionisFalse.Thereactionproceedsasfollows:$

C(=[2]O)-C(-[6]Cl) $\xrightarrow[^{-}OH]{NH2-NH2} CH_2 - C(-[6]Cl)(-H)(-H)$

Reason (R): The Provided that reason states that the Wolff-Kishner reduction is used to convert C(=[2]O) into CH_2.$Thisreasonistrueandistheprinciplebehindthe Wolff-Kishnerreduction.$

Conclusive Answer: A is false but R is true.

Quick Tip

The Wolff-Kishner reduction is a useful reaction for converting carbonyl groups to methylene groups. Remember that this reaction requires basic conditions.

13: Provided that below are two statements, one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : $[CoCl(NH_3)_5]^{2+}$ absorbs at lower wavelength of light wrt- $[CoCl(NH_3)_5(H_2O)]^{3+}$

Reason R : It is because the wavelength of the light absorbed depends on the oxidation state of the metal ion.

In the light of the above statements, choose the correct answer from the options Provided that below:

(1) Both A and R are true but R is NOT the correct explanation of A

(2) A is true but R is false

(3) Both A and R are true and R is the correct explanation of A

(4) A is false but R is true

Correct Answer: (4): A is false but R is true

Solution:

Assertion A: The assertion states that $[CoCl(NH_3)_5]^{2+}$ absorbs at a lower wavelength compared to $[CoCl(NH_3)_5(H_2O)]^{3+}$. This assertion is false. The complex with Co^{3+} will have a larger crystal field splitting energy (CFSE) compared to the complex with Co^{2+}, since H_2O is a stronger field ligand than Cl^-, and a higher oxidation state leads to a larger CFSE. A larger CFSE means that higher energy (shorter wavelength) light is absorbed. Thus $[CoCl(NH_3)_5(H_2O)]^{3+}$, should absorb at a lower wavelength (higher energy) than $[CoCl(NH_3)_5]^{2+}$.

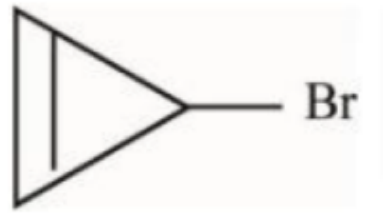
Reason R: The reason states that the wavelength of light absorbed depends on the oxidation state of the metal ion. This reason is true. The oxidation state of the central metal ion affects the crystal field splitting energy (CFSE). A higher oxidation state generally leads to a larger CFSE, resulting in the absorption of light at a lower wavelength (higher energy).

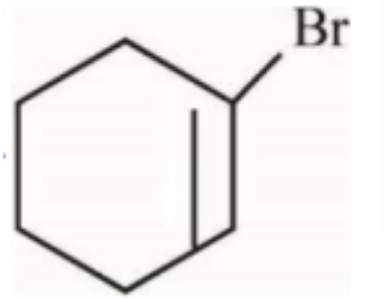
Conclusive Answer: Assertion A is false, but Reason R is true.

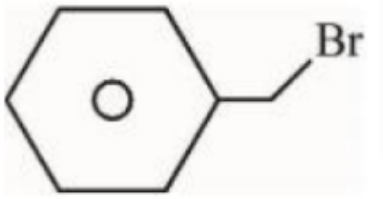
Quick Tip

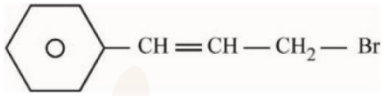
The crystal field splitting energy (CFSE) is the energy difference between the d-orbitals in a coordination complex. It is affected by the metal ion, its oxidation state, and the ligands. A larger CFSE leads to absorption at a lower wavelength (higher energy).

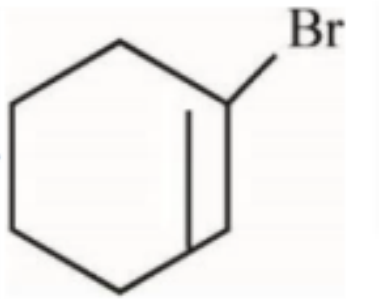
14: Compound from the following that will not produce precipitate on reaction with $AgNO_3$ is:

(1) 

(2) 

(3) 

(4) 



Correct Answer: (2)

Solution:

The reaction with $AgNO_3$ is used to test for halide ions. A precipitate of AgBr (pale yellow) will form if a bromide ion is available to react with Ag^+.

Compound 1: This is a cyclopropyl bromide. The C-Br bond is not easily broken, so it does not readily form a precipitate with $AgNO_3$. The cation formed is **6(——) C^+(−[:
$30, , , , draw = none]1)(-[:: 60, , , , draw = none]2)(-[:: -60, , , , draw = none]3) and is stabilized by aromatic$

Compound 2: This is bromobenzene. The C-Br bond in aryl halides is strong due to res-

onance and sp^2 hybridization of carbon, thus it does not react with $AgNO_3$ to form a precipitate. The cation **6(——) C^+(−[:: −60, , , , $draw = none$]1)(−[: 30, , , , $draw = none$]2)(−[:: 60, , , , $draw = none$]3)$isnotformedbecauseitishighlyunstable.$

Compound 3: This is a benzylic bromide. The benzylic carbocation formed after removal of bromide ion is stabilized by resonance with the benzene ring. Hence, it reacts with $AgNO_3$ to form a precipitate. The cation formed is
**6(——) C(=[2]O)(-)(-[::-60]CH_2^+)$**6(−−−−−−)andisstabilizedbybenzylicnature.$

Compound 4: This is an allylic bromide. The allylic carbocation formed is stabilized by resonance. Hence, it reacts with $AgNO_3$ to form a precipitate. The cation formed is **6(——) C(=[2]O)(-)(-[::-60]CH=CH-CH_2^+)$**6(−−−−−−)andisstabilizedbyallylicnature.$

Conclusive Answer: Bromobenzene will not produce a precipitate with $AgNO_3$.

Quick Tip

Aryl and vinyl halides do not readily react with $AgNO_3$ to form a precipitate due to the stronger C-X bond. Benzylic and allylic halides do form precipitates because they form resonance stabilized carbocations.

15: Provided that below are two statements, one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : A solution of the product obtained by heating a mole of glycine with a mole of chlorine in presence of red phosphorous generates chiral carbon atom.

Reason R : A molecule with 2 chiral carbons is always optically active.

In the light of the above statements, choose the correct answer from the options Provided that below:

(1) A is false but R is true

(2) Both A and R are true but R is NOT the correct explanation of A

(3) A is true but R is false

(4) Both A and R are true and R is the correct explanation of A

Correct Answer: (3): A is true but R is false

Solution:

Assertion A: Glycine (NH_2CH_2COOH) reacts with chlorine (Cl_2) in the presence of red phosphorus to undergo alpha-halogenation. The product formed is 2-chloroacetic acid:

$$NH_2CH_2COOH \xrightarrow[\text{Red P}]{Cl_2} NH_2CHClCOOH$$

The product, 2-chloroacetic acid or α-chloroacetic acid, which has a chiral carbon (marked with an asterisk):

$H_2N - C^*(-[:-30]Cl)(-[6]COOH)$

This assertion is true.

Reason R: The reason states that a molecule with two chiral carbons is always optically active. This reason is false. A molecule with two chiral centers can be optically inactive if it has an internal plane of symmetry. Such molecules are called meso compounds.

Conclusive Answer: Assertion A is true, but Reason R is false.

Quick Tip

A chiral carbon is a carbon atom bonded to four different groups. A molecule is optically active if it does not have a plane of symmetry, even with chiral carbons. Meso compounds are optically inactive molecules with chiral centers.

16: Alkali metal from the following with least melting point is:

(1) K

(2) Cs

(3) Rb

(4) Na

Correct Answer: (2): Cs

Solution:

Alkali metal's melting points decrease as we move down the group. This trend occurs because metallic bonding, which arises from the electrostatic attraction between positive metal ions and a sea of delocalized electrons, becomes weaker with increasing atomic size. As the atomic radius grows down the group, the outermost electron experiences weaker attraction, resulting in weaker metallic bonding and consequently lower melting points.

Among the Provided that options, Cs is the largest alkali metal and therefore has the weakest metallic bonding. Consequently, Cs has the lowest melting point. The melting points of the Provided that alkali metals are:

Na: 98°C
K: 64°C
Rb: 39°C
Cs: 29°C

Conclusive Answer: Cs has the least melting point.

Quick Tip

Melting points of alkali metals decrease down the group due to weakening metallic bonds caused by increasing atomic size.

17: Which hydride among the following is less stable?

(1) HF
(2) NH_3
(3) BeH_2
(4) LiH

Correct Answer: (3): BeH_2

Solution:

Stability of hydrides is connected with the bond strength between the element and hydrogen. BeH_2 is less stable because it is electron deficient or hypovalent. Be has 2 valence

electrons, each forming a covalent bond with hydrogen to give BeH_2. Beryllium needs 4 electrons in its valence shell according to the octet rule to gain stability but only has two electrons bonded to hydrogen, making it electron deficient. This electron deficiency makes BeH_2 less stable and prone to polymerization, forming polymeric $(BeH_2)_n$.

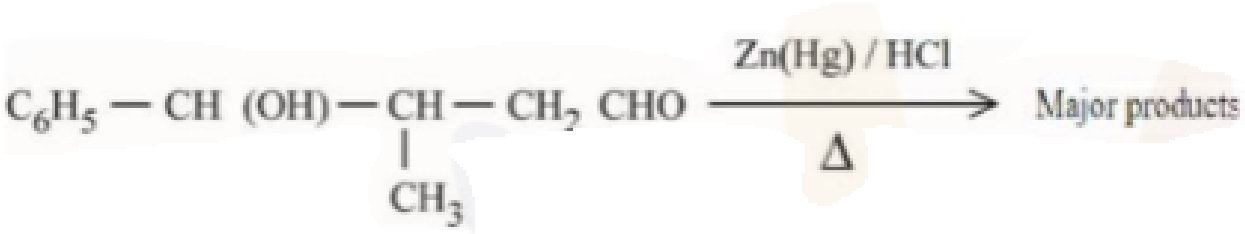
HF, NH_3, and LiH are all stable compounds. HF has a strong polar covalent bond, NH_3 satisfies the octet rule and forms stable covalent bonds, and LiH is an ionic hydride formed between Li^+ and H^-.

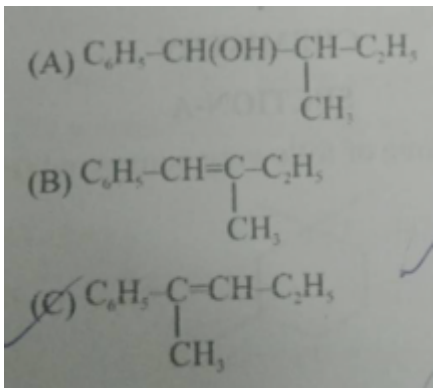
Conclusive Answer: BeH_2 is less stable among the Provided that hydrides.

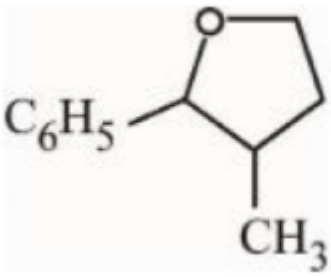
Quick Tip

Electron-deficient or hypovalent compounds are less stable due to their incomplete valence shells. They tend to react with other molecules or polymerize to achieve a more stable configuration.

18: The major product formed in the following reaction is _____.





D. 

Choose the correct answer from the options Provided that below:

(1) C only

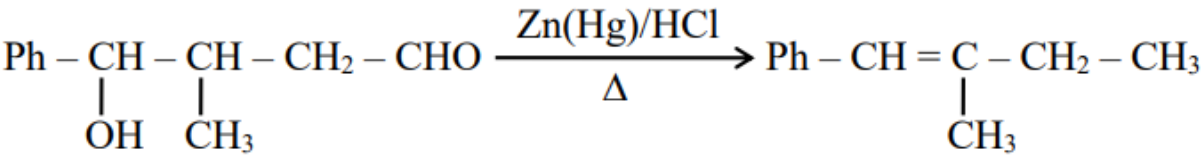
(2) A only

(3) B only

(4) D only

Correct Answer: (3): B only

Solution:



Quick Tip

The Clemmensen reduction is a useful reaction for reducing aldehydes and ketones to alkanes. It is typically carried out under acidic conditions using zinc amalgam and hydrochloric acid.

19: One mole of P_4 reacts with 8 moles $SOCl_2$ to give 4 moles of A, x mole of SO_2 and 2 moles of B. A, B and x respectively are _____.

(1) $POCl_3$, S_2Cl_2 and 4

(2) $POCl_3$, S_2Cl_2 and 2

(3) PCl_3, S_2Cl_2 and 4

(4) PCl_3, S_2Cl_2 and 2

Correct Answer: (1): $POCl_3$, S_2Cl_2, and 4

Solution:

Provided that: 1 mole of P_4 reacts with 8 moles of $SOCl_2$ to give 4 moles of A, x moles of SO_2, and 2 moles of B.

Step 1: The balanced chemical equation-

The balanced chemical equation for the reaction of P_4 with $SOCl_2$ is:

$$P_4 + 8SOCl_2 \rightarrow 4PCl_3 + 2S_2Cl_2 + 4SO_2.$$

In this reaction phosphorus is being oxidised from 0 to +3 state and sulfur is being reduced from +4 to +2 as well as +4 to +1 oxidation state.

Step 2: Identify A, B, and x-

Comparing the balanced equation with the Provided that information, we have:

- A = PCl_3
- B = S_2Cl_2
- x = 4

The correct balanced reaction is $P_4 + 8SOCl_2 \rightarrow 4POCl_3 + 2S_2Cl_2 + 4SO_2$

Conclusive Answer: A = $POCl_3$, B = S_2Cl_2, and x = 4.

Quick Tip

Balancing chemical equations is crucial for stoichiometric calculations. Make sure the number of atoms of each element is equal on both sides of the equation.

20: What weight of glucose must be dissolved in 100 g of water to lower the vapour pressure by 0.20 mmHg? (Assume dilute solution is being formed)

Provided that : Vapour pressure of pure water is 54.2 mmHg at room temperature. Molar mass of glucose is 180g mol^{-1}

(1) 2.59 g

(2) 3.59 g

(3) 3.69 g

(4) 4.69 g

Correct Answer: (3): 3.69 g

Solution:

Step 1: Apply the formula for relative lowering of vapor pressure-

For a dilute solution, the relative lowering of vapor pressure is Provided that by:

$$\frac{P^0 - P_s}{P^0} = \frac{n}{N},$$

where:

- P^0 is the vapor pressure of the pure solvent,
- P_s is the vapor pressure of the solution,
- n is the number of moles of solute,
- N is the number of moles of solvent.

Step 2: Substitute the provided values-

Provided that:

$$\frac{P^0 - P_s}{P^0} = \frac{0.2}{54.2}, \quad N = \frac{100}{18} \text{ moles.}$$

Substitute these values into the equation:

$$\frac{0.2}{54.2} = \frac{n \cdot 18}{100}.$$

Step 3: Solve for n-

Rearranging:

$$n = \frac{100 \cdot 0.2}{54.2 \cdot 18}.$$

Simplify:

$$n = \frac{100}{271 \cdot 18}.$$

Step 4: Evaluate the mass of solute (w)-

The mass of the solute is Provided that by:

$$w = n \cdot M,$$

where $M = 180\,\text{g/mol}$ is the molar mass of the solute. Substituting:

$$w = \frac{100 \cdot 180}{271 \cdot 18}.$$

Simplify:

$$w = 3.69\,\text{g}.$$

Conclusive Answer:

The mass of the solute is:

$$w = 3.69\,\text{g}.$$

Quick Tip

Raoult's law states that the vapor pressure of a solution is directly proportional to the mole fraction of the solvent. For dilute solutions, the relative lowering of vapor pressure is approximately equal to the mole fraction of the solute.

Section B

21: The total number of intensive properties from the following is _____.

Mole, Volume, Molar heat capacity, Molarity, E° cell, Gibbs free energy change, Molar mass, Mole

Correct Answer: 4

Solution:

Intensive properties are properties that do not depend on the amount of substance. Extensive properties are properties that do depend on the amount of substance.

From the Provided that list:

Extensive: Mole, Volume, Gibbs free energy change

Intensive: Molar mass, Molar heat capacity, Molarity, E° cell

There are four intensive properties in the list.

Conclusive Answer: The total number of intensive properties is 4.

Quick Tip

Intensive properties are independent of the amount of substance, while extensive properties depend on the amount of substance.

22: The volume of hydrogen liberated at STP by treating 2.4 g of magnesium with excess of hydrochloric acid is _____ $\times 10^{-2}$ L.

Provided that: Molar volume of gas is 22.4 L at STP. Molar mass of magnesium is 24 g mol^{-1}

Correct Answer: 224

Solution:

Provided that: Mass of magnesium $w = 2.4$ g, molar mass of magnesium $M = 24$ g/mol, and molar volume of gas at STP = 22.4 L.

Step 1: Write the balanced chemical equation-

The balanced chemical equation for the reaction of magnesium with hydrochloric acid is:

$$Mg + 2HCl \rightarrow MgCl_2 + H_2.$$

Step 2: Evaluate the moles of magnesium-

The number of moles n is Provided that by:

$$n = \frac{w}{M} = \frac{2.4 \text{ g}}{24 \text{ g/mol}} = 0.1 \text{ mol}.$$

Step 3: Evaluate the moles of hydrogen gas produced-

From the balanced equation, 1 mole of Mg reacts to produce 1 mole of H_2. Thus, 0.1 mole of Mg will produce 0.1 mole of H_2.

Step 4: Evaluate the volume of hydrogen gas at STP-

The volume of 1 mole of any gas at STP is 22.4 L. Therefore, the volume of 0.1 mole of hydrogen gas at STP is

$$V = n \times 22.4 \text{ L/mol} = 0.1 \text{ mol} \times 22.4 \text{ L/mol} = 2.24 \text{ L} = 224 \times 10^{-2} \text{ L}.$$

Conclusive Answer: The volume of hydrogen liberated at STP is 224×10^{-2} L.

Quick Tip

At STP (Standard Temperature and Pressure), one mole of any ideal gas occupies a volume of 22.4 liters.

23: The number of correct statements about modern adsorption theory of heterogeneous catalysis from the following is ____.

A. The catalyst is diffused over the surface of reactants.

B. Reactants are adsorbed on the surface of the catalyst.

C. Occurrence of chemical reaction on the catalyst's surface through formation of an intermediate.

D. It is a combination of intermediate compound formation theory and the old adsorption theory.

E. It explains the action of the catalyst as well as those of catalytic promoters and poisons.

Correct Answer: 3

Solution:

Let's have an emphasis o each statement:

A. The catalyst is diffused over the surface of reactants. This statement is incorrect. In heterogeneous catalysis, the catalyst is in a different phase than the reactants. The reactants are adsorbed onto the surface of the catalyst, not the other way around.

B. Reactants are adsorbed on the surface of the catalyst. This statement is correct. Adsorption of reactants on the catalyst surface is a crucial step in heterogeneous catalysis.

C. Occurrence of chemical reaction on the catalyst's surface through formation of an intermediate. This statement is correct. The adsorbed reactants form an intermediate compound with the catalyst, which then decomposes to form the products.

D. It is a combination of intermediate compound formation theory and the old adsorption theory. This statement is correct. The modern adsorption theory incorporates the concept of intermediate formation, which was not present in the older adsorption theory.

E. It explains the action of the catalyst as well as those of catalytic promoters and poisons. This statement is incorrect. The modern adsorption theory can explain the role of promoters, which enhance the activity of the catalyst, and poisons, which decrease or inhibit catalytic activity, by influencing adsorption on the catalyst surface.

Conclusive Answer: The number of correct statements is 4 (B, C, D Only).

Quick Tip

In heterogeneous catalysis, the catalyst and reactants are in different phases. The modern adsorption theory explains the process by adsorption of reactants, formation of intermediates on the catalyst surface, and the influence of promoters and poisons.

24: The number of correct statements from the following is _____.

A. For 1 s orbital, the probability density is maximum at the nucleus

B. For 2 s orbital, the probability density first increases to maximum and then decreases sharply to zero.

C. Boundary surface diagrams of the orbitals encloses a region of 100% probability of finding the electron.

D. p and d-orbitals have 1 and 2 angular nodes respectively

E. probability density of p-orbital is zero at the nucleus

Correct Answer: 3

Solution:

A. For 1 s orbital, the probability density is maximum at the nucleus. This statement is **correct**. The 1s orbital has a spherically symmetrical distribution, and the probability density is highest at the nucleus, decreasing as the distance from the nucleus increases.

B. For 2 s orbital, the probability density first increases to maximum and then decreases sharply to zero. This statement is **incorrect**. The probability density for a 2s orbital is maximum at the nucleus, then decreases to zero at the radial node, then increases again to a smaller maximum, and finally decreases asymptotically to zero. It does not increase to a maximum before decreasing. The probability density versus radius plot for the 2s orbital is shown below.

[scale=1] [-¿] (0,0) – (3,0) node[below] r; [-¿] (0,0) – (0,3) node[left] ψ^2; [thick] (0.2,2.8) to[out=-80, in=120] (1,0) to[out=0,in=180] (2,1) to[out=0,in=150] (2.8,0.2);

C. Boundary surface diagrams of the orbitals encloses a region of 100% probability of finding the electron. This statement is **incorrect**. Boundary surface diagrams enclose a region where there is a high (typically 90%) probability of finding the electron, but not 100%. There is always a small, but non-zero probability to find the electron outside that region as well.

D. p and d-orbitals have 1 and 2 angular nodes respectively. This statement is **correct**. The number of angular nodes is equal to the azimuthal quantum number (ℓ). For p orbitals, $\ell = 1$, and for d orbitals, $\ell = 2$.

E. probability density of p-orbital is zero at the nucleus. This statement is **correct**. p-orbitals have a nodal plane passing through the nucleus, so the probability density at the

nucleus is zero.

Conclusive Answer: The number of correct statements is 3 (A, D, and E).

Quick Tip

Probability density (ψ^2) represents the probability of finding an electron at a Provided that point in space. Nodes are regions where the probability density is zero.

25: The number of correct statements from the following is _____.

A. E_{cell} is an intensive parameter

B. A negative E° means that the redox couple is a stronger reducing agent than the H^+/H_2 couple.

C. The amount of electricity required for oxidation or reduction depends on the stoichiometry of the electrode reaction.

D. The amount of chemical reaction which occurs at any electrode during electrolysis by a current is proportional to the quantity of electricity passed through the electrolyte.

Correct Answer: 4

Solution:

Let's examine each statement:

A. E_{cell} is an intensive parameter. This statement is **correct**. Intensive properties are independent of the amount of substance present. The cell potential depends on the nature of the redox reaction, concentrations, and temperature, not on the size of the electrochemical cell.

B. A negative E° means that the redox couple is a stronger reducing agent than the H^+/H_2 couple. This statement is **correct**. A negative standard electrode potential (E°) indicates that the redox couple has a greater tendency to lose electrons (be oxidized) compared to the standard hydrogen electrode (SHE), which has E° = 0 V. Thus, the redox couple with negative E° is a stronger reducing agent.

C. The amount of electricity required for oxidation or reduction depends on the stoichiometry of the electrode reaction. This statement is **correct**. The amount of electricity required for a redox reaction is directly proportional to the number of electrons transferred in the balanced half-reaction. This is described by Faraday's laws of electrolysis.

D. The amount of chemical reaction which occurs at any electrode during electrolysis by a current is proportional to the quantity of electricity passed through the electrolyte. This statement is **correct**. This is a direct statement of Faraday's first law of electrolysis.

Conclusive Answer: All four statements (A, B, C, and D) are correct.

Quick Tip

Electrode potential (E°) is an intensive property. A more negative E° indicates a stronger reducing agent. Faraday's laws relate the amount of substance produced or consumed during electrolysis to the quantity of electric charge passed.

26: $Mg(NO_3)_2 \cdot XH_2O$ and $Ba(NO_3)_2 \cdot YH_2O$, represent formula of the crystalline forms of nitrate salts. Sum of X and Y is _____.

Correct Answer: 6

Solution:

The Provided that formulas represent hydrated magnesium nitrate and hydrated barium nitrate. The formulas for these hydrated salts are:

Magnesium nitrate hexahydrate: $Mg(NO_3)_2 \cdot 6H_2O$

Barium nitrate: $Ba(NO_3)_2$ (anhydrous)

Therefore, $X = 6$ and $Y = 0$. The sum of X and Y is:

$$X + Y = 6 + 0 = 6.$$

Conclusive Answer: The sum of X and Y is 6.

Quick Tip

Hydrated salts contain water molecules within their crystal structure, represented by the formula $\cdot n\mathrm{H_2O}$, where n is the number of water molecules per formula unit. Anhydrous salts do not contain water molecules in their crystal structure.

27: The number of possible isomeric products formed when 3-chloro-1-butene reacts with HCl through carbocation formation is _____.

Correct Answer: 4

Solution:

Provided that: 3-chloro-1-butene reacts with HCl.

Step 1: Protonation of the alkene-

The reaction starts with the protonation of the double bond in 3-chloro-1-butene by HCl. The proton adds to the carbon with more hydrogen atoms (Markovnikov's rule), leading to the formation of a secondary carbocation.

Step 2: Carbocation rearrangement (hydride shift)-

The initially formed secondary carbocation can undergo a 1,2-hydride shift to form a more stable tertiary carbocation.

Step 3: Nucleophilic attack by chloride ion-

The chloride ion (Cl^-) from HCl can now attack either the secondary or the tertiary carbocation, leading to the formation of different isomeric products.

This forms 1,3-dichlorobutane.

Attack on the tertiary carbocation:

C(-[:60]Cl)(-[:120]C^+)$(-[:180]CH_3)(-[0]CH_3)\xrightarrow{Cl^-}C(-[:60]Cl)(-[:120]C(-[:90]Cl))(-[:180]CH_3)$
This forms 2,3-dichlorobutane which has a chiral carbon hence has two stereoisomers. So in total three isomers are possible including one structural isomer and 2 stereoisomers. Attack of Cl^- on secondary carbocation:
$CH_3-CHCl-CH_2-CH_2Cl(1product)AttackofCl^-$ on tertiary carbocation: $CH_3-CHCl-CHCl-CH_3(3isomers-apairofenantiomersandamesocompound)Totalpossibleproducts$: $1+3=4$

Conclusive Answer: The total number of possible isomeric products is 4.

Quick Tip

Carbocation rearrangements can occur through hydride or methyl shifts to form more stable carbocations. Markovnikov's rule states that in the addition of HX to an alkene, the hydrogen atom adds to the carbon atom that already has the most hydrogen atoms.

28: 4.5 moles each of hydrogen and iodine is heated in a sealed ten litre vessel. At equilibrium, 3 moles of HI were found. The equilibrium constant for $H_2(g)+I_2(g)\rightleftharpoons 2HI(g)$ is _____.

Correct Answer: 1

Solution:

Provided that: Initial moles of H_2 = 4.5, initial moles of I_2 = 4.5, moles of HI at equilibrium = 3, and volume of the vessel = 10 L.

Step 1: Write the balanced chemical equation and the ICE table. The balanced chemical equation is:

$$H_2(g)+I_2(g)\rightleftharpoons 2HI(g).$$

The ICE (Initial, Change, Equilibrium) table is:

	H_2	I_2	2HI
Initial (t=0)	4.5	4.5	0
Change	-x	-x	+2x
Equilibrium (t_{eq})	4.5 - x	4.5 - x	2x

We are Provided that that at equilibrium, there are 3 moles of HI. Therefore,

$$2x = 3 \implies x = \frac{3}{2} = 1.5.$$

At equilibrium:

- Moles of H_2 = 4.5 - 1.5 = 3
- Moles of I_2 = 4.5 - 1.5 = 3
- Moles of HI = 3

Step 2: Evaluate the equilibrium concentrations. The equilibrium concentrations are obtained by dividing the moles by the volume (10 L):

- $[H_2] = \frac{3}{10} = 0.3$ M
- $[I_2] = \frac{3}{10} = 0.3$ M
- $[HI] = \frac{3}{10} = 0.3$ M

Step 3: Evaluate the equilibrium constant. The equilibrium constant K_c is Provided that by

$$K_c = \frac{[HI]^2}{[H_2][I_2]}.$$

Substituting the equilibrium concentrations:

$$K_c = \frac{(0.3)^2}{(0.3)(0.3)} = \frac{0.09}{0.09} = 1.$$

Conclusive Answer: The equilibrium constant is 1.

Quick Tip

The equilibrium constant (K_c) is the ratio of the product of the concentrations of the products raised to their stoichiometric coefficients to the product of the concentrations of the reactants raised to their stoichiometric coefficients at equilibrium.

29: Number of compounds from the following which will not produce orange red precipitate with Benedict solution is _____.

Glucose, maltose, sucrose, ribose, 2-deoxyribose, amylose, lactose

Correct Answer: 2

Solution:

Benedict's solution is used to test for the presence of reducing sugars. Reducing sugars are carbohydrates that have a free aldehyde or ketone group that can reduce Cu^{2+} ions in Benedict's solution to Cu^{+} ions, resulting in the formation of an orange-red precipitate of copper(I) oxide (Cu_2O).

The Provided that compounds and their behavior with Benedict's test are:

- Glucose: Reducing sugar (✓)
- Maltose: Reducing sugar (✓)
- Sucrose: Non-reducing sugar (×)
- Ribose: Reducing sugar (✓)
- 2-deoxyribose: Reducing sugar (✓)
- Amylose: Non-reducing sugar (×)
- Lactose: Reducing sugar (✓)

Sucrose and amylose are the two compounds that do not give a positive Benedict's test and will not produce an orange-red precipitate. Sucrose consists of glucose and fructose linked by their anomeric carbons, resulting in no free aldehyde or ketone group. Amylose also does not have a free aldehyde group to react with Benedict's reagent, which is why a precipitate is not formed.

Conclusive Answer: Two compounds (sucrose and amylose) will not produce an orange-red precipitate with Benedict's solution.

Quick Tip

Benedict's test is used to detect reducing sugars, which have a free aldehyde or ketone group. Non-reducing sugars, like sucrose, do not react with Benedict's solution.

30: The maximum number of lone pairs of electrons on the central atom from the following species is _____.

ClO_3^-, XeF_4, SF_4, and I_3^-

Correct Answer: 3

Solution:

To determine the number of lone pairs on the central atom, we need to draw the Lewis structures of each species:

1. ClO_3^- (Chlorate ion): Chlorine (Cl) is the central atom. It has 7 valence electrons. Each oxygen (O) atom contributes 6 valence electrons, and the negative charge adds 1 more electron. Total valence electrons = 7 + (3 × 6) + 1 = 26. The Lewis structure is:

Cl(=[:0]O)(=[:120]O)(-[::-60]O^-) The central Cl atom has 1 lone pair.

2. XeF_4 (Xenon tetrafluoride): Xenon (Xe) is the central atom. It has 8 valence electrons. Each fluorine (F) atom contributes 7 valence electrons. Total valence electrons = 8 + (4 × 7) = 36. The Lewis structure is:

Xe(-[:90]F)(-[:180]F)(-[:0]F)(-[:270]F)

The central Xe atom has 2 lone pairs.

3. SF_4 (Sulfur tetrafluoride): Sulfur (S) is the central atom. It has 6 valence electrons. Each fluorine (F) atom contributes 7 valence electrons. Total valence electrons = 6 + (4 × 7) = 34. The Lewis structure is:

S(-[:45]F)(-[:135]F)(-[:225]F)(-[:315]F)

The central S atom has 1 lone pair.

4. I_3^- (Triiodide ion): Iodine (I) is the central atom. It has 7 valence electrons. Each other iodine atom contributes 7 valence electrons, and the negative charge adds 1 more electron. Total valence electrons = 7 + 7 + 7 + 1 = 22. The Lewis structure is:

$I^-(-[::+40]I)(-[::-40]I)$ The central I atom has 3 lone pairs.

Conclusive Answer: The maximum number of lone pairs on the central atom is 3 (in I_3^-).

Quick Tip

Lone pairs are electron pairs that are not involved in bonding. To determine the number of lone pairs on the central atom, draw the Lewis structure of the molecule or ion.
