NEET UG 2023 E1 Chemistry Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**720	**Total Questions :**200

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The Answer Sheet is this Test Booklet. When you are directed to open the Test Booklet, take the Answer Sheet and fill in the particulars in ORIGINAL Copy carefully with blue/black ball pen only.
2. The test is of 3 hours 20 minutes duration and the Test Booklet contains 200 multiple-choice questions (four options with a single correct answer) from Physics, Chemistry, and Biology (Botany and Zoology). 50 questions in each subject are divided into two Sections (A and B) as per details given below:
3. (a) Section A shall consist of 35 (Thirty-five) questions in each subject (Question Nos. 1 to 35, 51 to 85, 101 to 135 and 151 to 185).
4. (b) Section B shall consist of 15 (Fifteen) questions in each subject (Question Nos. 36 to 50, 86 to 100, 136 to 150 and 186 to 200). In Section B, a candidate needs to attempt any 10 (Ten) questions out of 15 (Fifteen) in each subject.
5. Candidates are advised to read all 15 questions in each subject of Section B before they start attempting the question paper. In the event of a candidate attempting more than ten questions, the first ten questions answered by the candidate shall be evaluated.
6. Each question carries 4 marks. For each correct response, the candidate will get 4 marks. For each incorrect response, one mark will be deducted from the total scores. The maximum marks are 720.
7. Rough work is to be done in the space provided for this purpose in the Test Booklet only.
8. On completion of the test, the candidate must hand over the Answer Sheet (ORIGINAL and OFFICE Copy) to the Invigilator before leaving the Room/Hall. The candidates are allowed to take away this Test Booklet with them.
9. Use of Electronic/Manual Calculator is prohibited.

Section - A

1. Which of the following reactions will NOT give primary amine as the product?

(A) $\mathbf{CH_3CONH_2} \xrightarrow{Br_2/KOH}$ **Product**

(B) $\mathbf{CH_3CN} \xrightarrow{(i)LiAlH_4(ii)H_3O^+}$ **Product**

(C) $\mathbf{CH_3NC} \xrightarrow{(i)LiAlH_4(ii)H_3O^+}$ **Product**

(D) $\mathbf{CH_3CONH_2} \xrightarrow{(i)LiAlH_4(ii)H_3O^+}$ **Product**

Correct Answer: (C) $\mathbf{CH_3NC} \xrightarrow{(i)LiAlH_4(ii)H_3O^+}$ **Product**

Solution:

Step 1: Understanding the Question:
The question asks to identify which of the given four reactions does not produce a primary amine (R-NH_2) as the final product.

Step 2: Detailed Explanation:
Let's analyze each reaction:

- **(A) Hofmann Bromamide Degradation:** This reaction converts a primary amide into a primary amine with one less carbon atom.

  $$\underset{\text{Acetamide}}{\mathrm{CH_3CONH_2}} \xrightarrow{\mathrm{Br_2/KOH}} \underset{\text{Methanamine (Primary amine)}}{\mathrm{CH_3NH_2}} + 2\mathrm{KBr} + \mathrm{K_2CO_3} + 2\mathrm{H_2O}$$

  This reaction gives a primary amine.

- **(B) Reduction of a Nitrile (Cyanide):** Complete reduction of a nitrile with a strong reducing agent like $LiAlH_4$ yields a primary amine.

  $$\underset{\text{Acetonitrile}}{\mathrm{CH_3C \equiv N}} \xrightarrow{\text{(i) LiAlH}_4\text{ (ii) H}_3\text{O}^+} \underset{\text{Ethanamine (Primary amine)}}{\mathrm{CH_3CH_2NH_2}}$$

  This reaction gives a primary amine.

- **(C) Reduction of an Isonitrile (Isocyanide):** Complete reduction of an isonitrile with a strong reducing agent like $LiAlH_4$ yields a secondary amine. The nitrogen atom is already bonded to two carbon atoms.

  $$\underset{\text{Methyl isocyanide}}{\mathrm{CH_3N \equiv C}} \xrightarrow{\text{(i) LiAlH}_4\text{ (ii) H}_3\text{O}^+} \underset{\text{N-methylmethanamine (Secondary amine)}}{\mathrm{CH_3NHCH_3}}$$

  This reaction gives a secondary amine, not a primary amine.

- **(D) Reduction of an Amide:** Complete reduction of a primary amide with $LiAlH_4$ reduces the carbonyl group (C=O) to a methylene group (CH_2), yielding a primary amine with the same number of carbon atoms.

  $$\underset{\text{Acetamide}}{\mathrm{CH_3CONH_2}} \xrightarrow{\text{(i) LiAlH}_4\text{ (ii) H}_3\text{O}^+} \underset{\text{Ethanamine (Primary amine)}}{\mathrm{CH_3CH_2NH_2}}$$

  This reaction gives a primary amine.

Step 3: Final Answer:
The reduction of methyl isocyanide (CH_3NC) is the only reaction that yields a secondary amine. Therefore, it does not give a primary amine as the product.

Quick Tip

Remember the key difference in the reduction of nitriles and isonitriles:

- Nitrile (R-C≡N) reduction gives a primary amine (R-CH_2-NH_2).
- Isonitrile (R-N≡C) reduction gives a secondary amine (R-NH-CH_3).

This is a common point of confusion and frequently tested.

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2. Match List - I with List - II:

List - I		**List - II**	
A.	Coke	I.	Carbon atoms are sp^3 hybridised.
B.	Diamond	II.	Used as a dry lubricant.
C.	Fullerene	III.	Used as a reducing agent.
D.	Graphite	IV.	Cage like molecules.

Choose the correct answer from the options given below :

(A) A-II, B-IV, C-I, D-III
(B) A-IV, B-I, C-II, D-III
(C) A-III, B-I, C-IV, D-II
(D) A-III, B-IV, C-I, D-II

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

Solution:

Step 1: Understanding the Question:
The question requires matching different forms (allotropes and amorphous) of carbon with their characteristic properties or uses.

Step 2: Detailed Explanation:
Let's analyze each item in List-I and find its correct match in List-II.

- **A. Coke:** Coke is an amorphous, impure form of carbon produced by heating coal in the absence of air. It is a key material in metallurgy, where it acts as a fuel and a powerful **reducing agent** to reduce metal oxides to metals (e.g., in a blast furnace). Therefore, **A matches III**.

- **B. Diamond:** Diamond is a crystalline allotrope of carbon where each carbon atom is tetrahedrally bonded to four other carbon atoms. This tetrahedral arrangement corresponds to **sp^3 hybridisation**. Therefore, **B matches I**.

- **C. Fullerene:** Fullerenes (like C_{60}) are allotropes of carbon where the atoms are bonded in a mixed pattern of pentagons and hexagons to form a closed sphere or ellipsoid. This structure is often described as a **cage-like molecule** (or buckyball). Therefore, **C matches IV**.

- **D. Graphite:** Graphite is a crystalline allotrope of carbon with a layered structure. Within each layer, carbon atoms are sp^2 hybridized. The layers are held by weak van der Waals forces and can easily slide over one another, which makes graphite an excellent **dry lubricant**. Therefore, **D matches II**.

Step 3: Final Answer:
The correct set of matches is A-III, B-I, C-IV, D-II. This corresponds to option (C).

Quick Tip

Remember the hybridization of carbon in its main allotropes:

- Diamond: sp^3 (tetrahedral, 3D network) → Hardest substance.
- Graphite: sp^2 (trigonal planar, 2D layers) → Soft, lubricant, conductor.
- Fullerene: sp^2 (pentagons/hexagons, cage-like).

These core properties explain their uses.

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3. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R :
Assertion A: Metallic sodium dissolves in liquid ammonia giving a deep blue solution, which is paramagnetic.
Reason R : The deep blue solution is due to the formation of amide.
In the light of the above statements, choose the correct answer from the options given below :

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Correct Answer: (C) A is true but R is false.

Solution:

Step 1: Understanding the Question:
The question presents an assertion and a reason regarding the solution of alkali metals, specifically sodium, in liquid ammonia. We need to evaluate the correctness of both statements and their relationship.

Step 2: Detailed Explanation:
Analysis of Assertion A:
When an alkali metal like sodium is dissolved in liquid ammonia, it ionizes to give the metal cation and an electron.

$$\mathrm{Na(s)} + (x+y)\mathrm{NH_3(l)} \rightarrow \underbrace{[\mathrm{Na(NH_3)}_x]^+}_{\text{Ammoniated cation}} + \underbrace{[\mathrm{e(NH_3)}_y]^-}_{\text{Ammoniated electron}}$$

The ammoniated electrons are responsible for the characteristic **deep blue color** of the solution. These electrons are unpaired, which makes the solution **paramagnetic**. Therefore, Assertion A is a correct statement.

Analysis of Reason R:
Reason R claims that the blue color is due to the formation of an amide. This is incorrect. The blue color is due to the ammoniated electrons. Sodium amide ($NaNH_2$) is formed when the solution is allowed to stand for a long time, or in the presence of a catalyst like Fe^{3+}. The formation of the amide is actually a decomposition reaction of the blue solution, causing the color to fade.

$$2\mathrm{Na} + 2\mathrm{NH_3} \rightarrow 2\mathrm{NaNH_2} + \mathrm{H_2(g)}$$

Thus, amide formation is a subsequent reaction, not the cause of the blue color. Therefore, Reason R is a false statement.

Step 3: Final Answer:
Assertion A is true, but Reason R is false.

Quick Tip

For alkali metal-ammonia solutions, remember:

- **Blue color and paramagnetism** are due to **ammoniated electrons**.
- **High electrical conductivity** is also due to both ammoniated cations and electrons.
- **Amide formation** is a slow decomposition reaction that leads to the fading of the blue color.

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4. In Lassaigne's extract of an organic compound, both nitrogen and sulphur are present, which gives blood red colour with Fe^{3+} due to the formation of -

(A) $Fe_4[Fe(CN)_6]_3.xH_2O$
(B) NaSCN
(C) $[Fe(CN)_5NOS]^{4-}$
(D) $[Fe(SCN)]^{2+}$

Correct Answer: (D) $[Fe(SCN)]^{2+}$

Solution:

Step 1: Understanding the Question:
The question asks to identify the chemical species responsible for the blood-red coloration observed in Lassaigne's test when both nitrogen and sulfur are present in the original organic compound.

Step 2: Detailed Explanation:
Lassaigne's test, or the sodium fusion test, is used for the qualitative detection of elements like nitrogen, sulfur, and halogens in organic compounds.

1. **Fusion:** The organic compound is fused with metallic sodium. If both nitrogen and sulfur are present, they react with sodium and carbon to form sodium thiocyanate.

$$\mathrm{Na} + \mathrm{C} + \mathrm{N} + \mathrm{S} \xrightarrow{\Delta} \mathrm{NaSCN}$$

2. **Extraction:** The fused mass is extracted with distilled water to get the "Lassaigne's extract," which contains NaSCN (dissociated as Na^+ and SCN^-).

3. **Test:** A few drops of a neutral ferric chloride ($FeCl_3$) solution are added to the extract. The ferric ions (Fe^{3+}) react with the thiocyanate ions (SCN^-) to form a complex ion, iron(III) thiocyanate. This complex has a characteristic **blood-red color**.

$$\mathrm{Fe}^{3+} + \mathrm{SCN}^- \rightleftharpoons \underset{\text{(Blood-red complex)}}{[\mathrm{Fe(SCN)}]^{2+}}$$

(A more complete representation of the complex is $[Fe(SCN)(H_2O)_5]^{2+}$).

Let's analyze the other options:

- (A) $Fe_4[Fe(CN)_6]_3.xH_2O$ is Prussian blue, formed when only nitrogen is present.
- (B) NaSCN is the substance formed during fusion, but it is colorless. The color appears only after reacting with Fe^{3+}.
- (C) $[Fe(CN)_5NOS]^{4-}$ is the violet complex formed in the sodium nitroprusside test for sulfur (when S^{2-} is present), not for SCN^-.

Step 3: Final Answer:
The blood-red color is due to the formation of the $[Fe(SCN)]^{2+}$ complex.

Quick Tip

Remember the colors of Lassaigne's test:

- Nitrogen only: **Prussian blue** ($[Fe_4[Fe(CN)_6]_3]$).
- Sulphur only: **Violet** ($[Fe(CN)_5NOS]^{4-}$) with sodium nitroprusside.
- Nitrogen and Sulphur together: **Blood red** ($[Fe(SCN)]^{2+}$) with $FeCl_3$.

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5. The conductivity of centimolar solution of KCl at 25°C is 0.0210 ohm^{-1} cm^{-1} and the resistance of the cell containing the solution at 25°C is 60 ohm. The value of cell constant is -

(A) 1.34 cm^{-1}
(B) 3.28 cm^{-1}
(C) 1.26 cm^{-1}
(D) 3.34 cm^{-1}

Correct Answer: (C) 1.26 cm^{-1}

Solution:

Step 1: Understanding the Question:
The question provides the conductivity (κ) and resistance (R) of a KCl solution in a conductivity cell and asks to calculate the cell constant (G*).

Step 2: Key Formula or Approach:
The relationship between conductivity (κ), resistance (R), and the cell constant (G*) is given by the formula:

$$\kappa = \frac{1}{R} \times G^*$$

We can rearrange this formula to solve for the cell constant:

$$G^* = \kappa \times R$$

Step 3: Detailed Explanation:
We are given the following values:

- Conductivity, κ = 0.0210 ohm^{-1} cm^{-1}
- Resistance, R = 60 ohm

Now, we substitute these values into the rearranged formula:

$$G^* = (0.0210 \text{ ohm}^{-1} \text{ cm}^{-1}) \times (60 \text{ ohm})$$

$$G^* = 0.0210 \times 60 \text{ cm}^{-1}$$
$$G^* = 1.26 \text{ cm}^{-1}$$

Step 4: Final Answer:
The value of the cell constant is 1.26 cm^{-1}.

Quick Tip

Remember the fundamental relationships in conductivity:

- Conductance (G) = 1 / Resistance (R).
- Conductivity (κ) = Conductance (G) × Cell Constant (G*).
- Combining these gives $\kappa = (1/R) \times G^*$.

The cell constant (G*) itself is the ratio of the distance between the electrodes (l) to their area of cross-section (A), so G* = l/A, and its unit is cm^{-1}.

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6. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R :
Assertion A: A reaction can have zero activation energy.
Reason R: The minimum extra amount of energy absorbed by reactant molecules so that their energy becomes equal to threshold value, is called activation energy.
In the light of the above statements, choose the correct answer from the options given below :

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Correct Answer: (D) A is false but R is true.

Solution:

Step 1: Understanding the Question:
The question presents an assertion and a reason related to the concept of activation energy in chemical kinetics. We need to evaluate both statements.

Step 2: Detailed Explanation:
Analysis of Assertion A:
The assertion claims that a reaction can have zero activation energy ($E_a = 0$). Activation energy is the minimum energy barrier that must be overcome for a reaction to occur. For most chemical reactions, which involve the breaking and forming of bonds, this energy barrier is positive and non-zero. The reactants must absorb energy to reach the transition state. Reactions

with zero activation energy are extremely rare and are typically barrierless processes, such as the recombination of free radicals, where almost every collision is effective. However, from the perspective of general chemical kinetics taught in introductory courses, it is considered that a reaction must overcome an energy barrier. Therefore, within this common framework, the assertion is considered **false**. A reaction must have some activation energy, however small.

Analysis of Reason R:
The reason provides the standard definition of activation energy. It is the excess energy that reactant molecules must acquire to reach the threshold energy level (the energy of the activated complex) and proceed to form products. Mathematically, $E_a = E_{\text{threshold}} - E_{\text{reactants}}$. This definition is perfectly **true**.

Step 3: Final Answer:
Based on the standard curriculum, Assertion A is considered false, while Reason R is a true statement. This aligns with the provided answer key.

Quick Tip

Activation energy is visualized as the 'hill' on a reaction coordinate diagram that reactants must climb to become products. While some highly specialized reactions might be 'downhill all the way' (zero E_a), for general exam purposes, assume a reaction always has a hill to climb, meaning E_a is positive.

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7. Which one is an example of heterogenous catalysis?

(A) Oxidation of sulphur dioxide into sulphur trioxide in the presence of oxides of nitrogen.
(B) Hydrolysis of sugar catalysed by H^+ ions.
(C) Decomposition of ozone in presence of nitrogen monoxide.
(D) Combination between dinitrogen and dihydrogen to form ammonia in the presence of finely divided iron.

Correct Answer: (D) Combination between dinitrogen and dihydrogen to form ammonia in the presence of finely divided iron.

Solution:

Step 1: Understanding the Question:
The question asks to identify an example of heterogeneous catalysis from the given options. Heterogeneous catalysis is a type of catalysis where the phase of the catalyst is different from the phase of the reactants. In contrast, homogeneous catalysis is where the catalyst and reactants are in the same phase.

Step 2: Detailed Explanation:
Let's analyze the phases of reactants and catalysts in each option:

- **(A) Oxidation of sulphur dioxide into sulphur trioxide in the presence of oxides of nitrogen.** This is the lead chamber process.

  $$2\mathrm{SO_2(g)} + \mathrm{O_2(g)} \xrightarrow{\mathrm{NO(g)}} 2\mathrm{SO_3(g)}$$

  Reactants (SO_2, O_2) are gases, and the catalyst (NO) is also a gas. Since they are all in the same phase, this is **homogeneous catalysis**.

- **(B) Hydrolysis of sugar catalysed by H^+ ions.**

  $$\underset{\text{Sucrose (aq)}}{\mathrm{C_{12}H_{22}O_{11}}} + \mathrm{H_2O(l)} \xrightarrow{\mathrm{H^+(aq)}} \underset{\text{Glucose (aq)}}{\mathrm{C_6H_{12}O_6}} + \underset{\text{Fructose (aq)}}{\mathrm{C_6H_{12}O_6}}$$

  The reactant (sucrose) is in the aqueous phase, and the catalyst (H^+ ions from an acid) is also in the aqueous phase. This is **homogeneous catalysis**.

- **(C) Decomposition of ozone in presence of nitrogen monoxide.**

  $$2\mathrm{O_3(g)} \xrightarrow{\mathrm{NO(g)}} 3\mathrm{O_2(g)}$$

  The reactant (O_3) is a gas, and the catalyst (NO) is also a gas. This is **homogeneous catalysis**.

- **(D) Combination between dinitrogen and dihydrogen to form ammonia in the presence of finely divided iron.** This is the Haber-Bosch process.

  $$\mathrm{N_2(g)} + 3\mathrm{H_2(g)} \rightleftharpoons \underset{\text{Iron (s)}}{2\mathrm{NH_3(g)}}$$

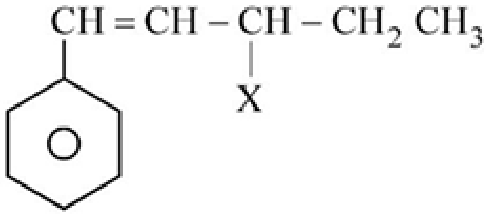
  The reactants (N_2, H_2) are gases, but the catalyst (iron) is a solid. Since the phases are different, this is an example of **heterogeneous catalysis**.

Step 3: Final Answer:
The Haber-Bosch process for ammonia synthesis is the correct example of heterogeneous catalysis among the given options.

Quick Tip

To quickly identify heterogeneous catalysis, look for a solid catalyst acting on gaseous or liquid reactants. Common examples include the Haber process (Fe catalyst), the Contact process for sulfuric acid (V_2O_5 catalyst), and catalytic converters in cars (Pt, Pd, Rh catalysts).

8. The given compound



is an example of ____________.

(A) benzylic halide
(B) aryl halide
(C) allylic halide
(D) vinylic halide

Correct Answer: (C) allylic halide

Solution:

Step 1: Understanding the Question:
The question asks to classify the given organic halide based on the position of the halogen atom (X) relative to the C=C double bond. The structure is 3-halopent-1-ene.

Step 2: Detailed Explanation:
Let's define the different types of halides:

- **Benzylic halide:** The halogen atom is bonded to an sp^3-hybridized carbon atom which is directly attached to an aromatic ring. (e.g., $C_6H_5CH_2$-X). The given compound does not have an aromatic ring.

- **Aryl halide:** The halogen atom is directly bonded to an sp^2-hybridized carbon atom of an aromatic ring. (e.g., C_6H_5-X). The given compound is not aromatic.

- **Allylic halide:** The halogen atom is bonded to an sp^3-hybridized carbon atom that is adjacent to a carbon-carbon double bond (C=C). The general structure is C=C-C-X. In the given compound, CH_2=CH-CH(X)-CH_2CH_3, the halogen X is on a carbon atom next to the C=C double bond. This fits the definition of an allylic halide.

- **Vinylic halide:** The halogen atom is directly bonded to an sp^2-hybridized carbon atom of a carbon-carbon double bond. The general structure is C=C-X. This is not the case in the given compound.

Step 3: Final Answer:
The given compound is an example of an allylic halide.

Quick Tip

To easily differentiate, look at the carbon atom attached to the halogen:

- **Allylic:** X is on a carbon **next to** a C=C bond.
- **Vinylic:** X is **directly on** a C=C bond.
- **Benzylic:** X is on a carbon **next to** a benzene ring.
- **Arylic:** X is **directly on** a benzene ring.

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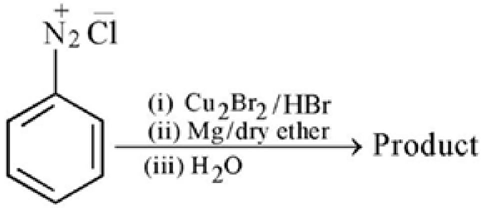
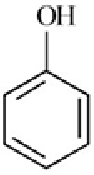
9. Identify the product in the following reaction:



(1)



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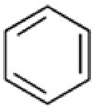

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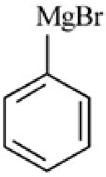

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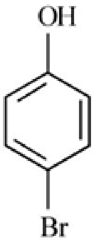
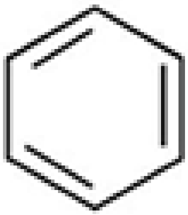


Correct Answer: (B)



Solution:

Step 1: Understanding the Question:
The question asks for the final product of a three-step reaction sequence starting from benzenediazonium chloride.

Step 2: Detailed Explanation:
Let's analyze the reaction step-by-step:

- **Step (i): Benzenediazonium chloride $\xrightarrow{Cu_2Br_2/HBr}$:** This is the Sandmeyer reaction. The diazonium group (-$N_2^+Cl^-$) is replaced by a bromine atom, forming bromobenzene.

- **Step (ii): Bromobenzene $\xrightarrow{Mg/dry\ ether}$:** This is the preparation of a Grignard reagent. Bromobenzene reacts with magnesium in dry ether to form phenylmagnesium bromide.

- **Step (iii): Phenylmagnesium bromide $\xrightarrow{H_2O}$:** This is the hydrolysis of a Grignard reagent. Grignard reagents are strong bases and react with any source of acidic protons, such as water. The phenyl anion ($C_6H_5^-$) abstracts a proton from water to form benzene. The other product is magnesium hydroxybromide.

$$C_6H_5MgBr \xrightarrow{1/2O_2} C_6H_5OMgBr \xrightarrow{H_2O/H^+} C_6H_5OH$$

Step 3: Final Answer:
The final product is phenol. This likely implies an unstated oxidation step of the Grignard reagent before hydrolysis.

Quick Tip

Be aware of standard reaction pathways. While the direct hydrolysis of phenylmagnesium bromide gives benzene, the formation of phenol from a Grignard reagent is a known reaction involving oxygen. In an exam, if a direct interpretation contradicts the options/answer key, consider alternative possibilities like side reactions or reactions with air.

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10. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R :
Assertion A: Helium is used to dilute oxygen in diving apparatus.
Reason R : Helium has high solubility in O_2.
In the light of the above statements, choose the correct answer from the options given below :

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true and R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Correct Answer: (C) A is true but R is false.

Solution:

Step 1: Understanding the Question:
The question presents an Assertion and a Reason about the use of helium in diving gas mixtures. We must evaluate the correctness of both statements and their logical connection.

Step 2: Detailed Explanation:
Analysis of Assertion A:
Deep-sea divers use a mixture of oxygen and an inert gas for breathing. Using compressed air ($O_2 + N_2$) at high pressures can lead to nitrogen narcosis (intoxication-like effects) and decompression sickness ("the bends") caused by nitrogen bubbles forming in the blood upon ascent. To avoid this, nitrogen is replaced with helium. A mixture of helium and oxygen (heliox) is used. The helium acts as a diluent for the oxygen. Therefore, Assertion A is a **true** statement.

Analysis of Reason R:
The reason claims that helium has high solubility in O_2. This is incorrect and irrelevant. The crucial property of helium is its **very low solubility in blood** compared to nitrogen. According to Henry's Law, the solubility of a gas in a liquid is proportional to its partial pressure. Because helium is much less soluble in blood, fewer gas bubbles form during decompression, reducing the risk of the bends. The solubility of helium in oxygen is not the relevant factor. Therefore, Reason R is a **false** statement.

Step 3: Final Answer:
Assertion A is true, but Reason R is false.

Quick Tip

Remember the key reason for using helium in diving gas: **low solubility in blood**. This prevents the dangerous condition known as "the bends" when divers resurface. The high solubility of nitrogen in blood under pressure is the problem that helium solves.

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11. A compound is formed by two elements A and B. The element B forms cubic close packed structure and atoms of A occupy 1/3 of tetrahedral voids. If the formula of the compound is A_xB_y, then the value of x + y is in option

(A) 5
(B) 4
(C) 3
(D) 2

Correct Answer: (A) 5

Solution:

Step 1: Understanding the Question:
The question describes the crystal structure of a compound formed by elements A and B. We need to determine the empirical formula of the compound (A_xB_y) and then find the sum x + y.

Step 2: Key Formula or Approach:
In a close-packed structure (CCP or FCC):

- If the number of atoms forming the lattice is N,
- Then the number of octahedral voids is N.
- And the number of tetrahedral voids is 2N.

We will use this relationship to find the ratio of atoms A and B in the unit cell.

Step 3: Detailed Explanation:
1. **Determine the number of B atoms:** Element B forms a cubic close-packed (CCP) structure. Let's assume the number of B atoms per unit cell is N. For a CCP (or FCC) lattice, N = 4. So, there are 4 B atoms per unit cell.

2. **Determine the number of tetrahedral voids:** The number of tetrahedral voids is 2N. Since N = 4, the number of tetrahedral voids is 2 × 4 = 8.

3. **Determine the number of A atoms:** Atoms of element A occupy 1/3 of the tetrahedral voids.
Number of A atoms = (1/3) × (Total tetrahedral voids)
Number of A atoms = (1/3) × 8 = 8/3.

4. **Determine the formula:** The ratio of atoms A to B in the unit cell is A : B = 8/3 : 4.
To get a simple whole number ratio, we can divide by 4:
A : B = (8/3)/4 : 4/4
A : B = 2/3 : 1
To eliminate the fraction, we multiply by 3:
A : B = 2 : 3
So, the empirical formula of the compound is A_2B_3.

5. **Calculate x + y:** From the formula $A_xB_y = A_2B_3$, we have x = 2 and y = 3.
The value of x + y = 2 + 3 = 5.

Step 4: Final Answer:
The value of x + y is 5.

Quick Tip

For problems involving voids in close-packed structures, always start by defining the number of lattice atoms as 'N'. Then, remember the crucial relationship: Octahedral voids = N, Tetrahedral voids = 2N. This simplifies finding the ratio of atoms.

12. Given below are two statements :
Statement I: A unit formed by the attachment of a base to 1' position of sugar is known as nucleoside
Statement II: When nucleoside is linked to phosphorous acid at 5'-position of sugar moiety, we get nucleotide.
In the light of the above statements, choose the correct answer from the options given below:

(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

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

Solution:

Step 1: Understanding the Question:
The question presents two statements about the structure of nucleosides and nucleotides. We need to evaluate their correctness.

Step 2: Detailed Explanation:
Analysis of Statement I:
A nucleoside is a structural subunit of nucleic acids (DNA and RNA). It is composed of a nitrogenous base (a purine like Adenine or Guanine, or a pyrimidine like Cytosine, Thymine, or Uracil) attached to a pentose sugar (ribose in RNA, deoxyribose in DNA). The linkage is a β-N-glycosidic bond between the C-1' of the sugar and a nitrogen atom of the base (N-9 for purines, N-1 for pyrimidines). This statement correctly defines a nucleoside. Therefore, **Statement I is true**.

Analysis of Statement II:
A nucleotide is formed when a phosphate group is attached to a nucleoside. The phosphate group is esterified to the hydroxyl group on the C-5' of the sugar moiety. The statement says the nucleoside is linked to "phosphorous acid" (H_3PO_3). This is incorrect. The linkage is with **phosphoric acid** (H_3PO_4). This distinction is chemically significant. Therefore, because it specifies the wrong acid, **Statement II is false**.

Step 3: Final Answer:
Statement I is true, but Statement II is false.

Quick Tip

Remember the basic building blocks of nucleic acids:

- Base + Sugar = **Nucleoside**
- Nucleoside + Phosphate = **Nucleotide**
- (Base + Sugar + Phosphate = **Nucleotide**)

Pay close attention to chemical names. The phosphate group in nucleotides comes from phosphoric acid, not phosphorous acid.

---

13. The relation between n_m, (n_m = the number of permissible values of magnetic quantum number (m)) for a given value of azimuthal quantum number (l), is

(A) $l = \frac{n_m - 1}{2}$
(B) $l = 2n_m + 1$
(C) $n_m = 2l^2 + 1$
(D) $n_m = l + 2$

Correct Answer: (A) $l = \frac{n_m - 1}{2}$

Solution:

Step 1: Understanding the Question:
The question asks for the mathematical relationship between the azimuthal quantum number (l) and the total number of possible values of the magnetic quantum number (m), which is denoted by n_m.

Step 2: Key Formula or Approach:
The rules for quantum numbers state that for a given value of the azimuthal quantum number, l, the magnetic quantum number, m (or m_l), can take on any integer value from -l to +l, including 0.
The possible values are: -l, -(l-1), ..., 0, ..., (l-1), l.

Step 3: Detailed Explanation:
To find the total number of permissible values (n_m), we can count the number of terms in the sequence -l, ..., +l.
The number of negative values is l.
The number of positive values is l.
There is one value for zero.
So, the total number of values is $n_m = l + l + 1 = 2l + 1$.
The relationship is:

$$n_m = 2l + 1$$

Now, we need to rearrange this formula to express l in terms of n_m, to match the options.

$$n_m - 1 = 2l$$
$$l = \frac{n_m - 1}{2}$$

This matches option (A). Let's check the other options:
(B) $l = 2n_m + 1$ is incorrect.
(C) $n_m = 2l^2 + 1$ is incorrect.
(D) $n_m = l + 2$ is incorrect.

Step 4: Final Answer:
The correct relationship is $l = \frac{n_m - 1}{2}$.

Quick Tip

The most direct relationship to memorize is $\mathbf{n_m = 2l + 1}$. This tells you the number of orbitals in any subshell. For example, for a p-subshell, l=1, so there are 2(1)+1 = 3 p-orbitals. For a d-subshell, l=2, so there are 2(2)+1 = 5 d-orbitals. You can then derive the relationship in the question from this fundamental formula.

---

14. Amongst the following, the total number of species NOT having eight electrons around central atom in its outer most shell, is
NH_3, $AlCl_3$, $BeCl_2$, CCl_4, PCl_5:

(A) 3
(B) 2
(C) 4
(D) 1

Correct Answer: (A) 3

Solution:

Step 1: Understanding the Question:
The question asks to count how many of the given species are exceptions to the octet rule. The octet rule states that atoms tend to bond in such a way that they each have eight electrons in their valence shell. We need to find the species where the central atom has either fewer than eight (incomplete octet) or more than eight (expanded octet) valence electrons.

Step 2: Detailed Explanation:
Let's analyze the Lewis structure and electron count for the central atom in each species:

- **NH_3 (Ammonia):** Nitrogen (Group 15) has 5 valence electrons. It forms 3 single bonds with 3 hydrogen atoms and has 1 lone pair. Total electrons around N = 3 × 2 (from bonds) = 6 + 2 (lone pair) = **8 electrons**. Obeys the octet rule.

- **$AlCl_3$ (Aluminum Chloride):** Aluminum (Group 13) has 3 valence electrons. It forms 3 single bonds with 3 chlorine atoms. Total electrons around Al = 3 × 2 = **6 electrons**. This is an electron-deficient molecule with an incomplete octet. **(Exception)**

- **$BeCl_2$ (Beryllium Chloride):** Beryllium (Group 2) has 2 valence electrons. It forms 2 single bonds with 2 chlorine atoms. Total electrons around Be = 2 × 2 = **4 electrons**. This is an electron-deficient molecule with an incomplete octet. **(Exception)**

- **CCl_4 (Carbon Tetrachloride):** Carbon (Group 14) has 4 valence electrons. It forms 4 single bonds with 4 chlorine atoms. Total electrons around C = 4 × 2 = **8 electrons**. Obeys the octet rule.

- **PCl_5 (Phosphorus Pentachloride):** Phosphorus (Group 15) has 5 valence electrons. It forms 5 single bonds with 5 chlorine atoms. Total electrons around P = 5 × 2 = **10 electrons**. This is a hypervalent molecule with an expanded octet. **(Exception)**

Step 3: Final Answer:
The species that do not have eight electrons around the central atom are $AlCl_3$ ($6e^-$), $BeCl_2$ ($4e^-$), and PCl_5 ($10e^-$). There are a total of 3 such species.

Quick Tip

Look for central atoms from specific groups to quickly spot octet rule exceptions:

- **Incomplete Octet:** Often seen with elements from Group 2 (Be), Group 13 (B, Al).
- **Expanded Octet:** Possible for non-metal central atoms from Period 3 and below (like P, S, Cl, Br, I) because they have vacant d-orbitals.

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15. The correct order of energies of molecular orbitals of N_2 molecule, is :

(A) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$
(B) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$
(C) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < \sigma^* 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y)$
(D) $\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma 2p_z < \sigma^* 2p_z$

Correct Answer: (A) $\sigma 1s < \sigma^*1s < \sigma 2s < \sigma^*2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^*2p_x = \pi^*2p_y) < \sigma^*2p_z$

Solution:

Step 1: Understanding the Question:
The question asks for the correct energy order of molecular orbitals (MOs) for the nitrogen molecule (N_2). This relates to the Molecular Orbital Theory.

Step 2: Key Formula or Approach:
For diatomic molecules of the second period, there are two different energy level sequences depending on s-p mixing.

- **For B_2, C_2, and N_2 (up to 14 electrons):** Due to significant s-p mixing, the $\sigma 2p_z$ orbital is pushed to a higher energy level than the $\pi 2p$ orbitals. The order is: $\sigma 1s$, σ^*1s, $\sigma 2s$, σ^*2s, $(\pi 2p_x = \pi 2p_y)$, $\sigma 2p_z$, $(\pi^*2p_x = \pi^*2p_y)$, σ^*2p_z
- **For O_2, F_2, and Ne_2 (more than 14 electrons):** The s-p mixing is less significant, and the "normal" order is followed, where the $\sigma 2p_z$ orbital has lower energy than the $\pi 2p$ orbitals. The order is: $\sigma 1s$, σ^*1s, $\sigma 2s$, σ^*2s, $\sigma 2p_z$, $(\pi 2p_x = \pi 2p_y)$, $(\pi^*2p_x = \pi^*2p_y)$, σ^*2p_z

Step 3: Detailed Explanation:
The nitrogen molecule, N_2, has a total of $7 + 7 = 14$ electrons. Therefore, it follows the energy order for molecules with up to 14 electrons. The correct increasing order of energy is:
$\sigma 1s < \sigma^*1s < \sigma 2s < \sigma^*2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^*2p_x = \pi^*2p_y) < \sigma^*2p_z$
This sequence matches option (A). Option (B) represents the order for O_2 and F_2. Options (C) and (D) have incorrect ordering of the antibonding and bonding orbitals.

Step 4: Final Answer:
The correct energy order for N_2 molecular orbitals is given in option (A).

Quick Tip

Remember the "14 electron rule" for MO diagrams. For diatomic molecules ≤ 14 electrons (like N_2), the $\pi 2p$ orbitals are lower in energy than the $\sigma 2p_z$. For molecules > 14 electrons (like O_2), the $\sigma 2p_z$ is lower than the $\pi 2p$. Think of the numbers "2121" for the p-orbitals in N_2 (π, σ, π^*, σ^*) and "1221" for O_2 (σ, π, π^*, σ^*).

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16. The number of σ bonds, π bonds and lone pair of electrons in pyridine, respectively are:

(A) 11, 2, 0
(B) 12, 3, 0
(C) 11, 3, 1
(D) 12, 2, 1

Correct Answer: (C) 11, 3, 1

Solution:

Step 1: Understanding the Question:
The question asks to determine the number of sigma (σ) bonds, pi (π) bonds, and lone pairs of electrons in the pyridine molecule.

Step 2: Key Formula or Approach:
We need to draw the structure of pyridine and then count each type of bond and the non-bonding electron pairs. The chemical formula for pyridine is C_5H_5N. It is a six-membered aromatic heterocyclic compound.

Step 3: Detailed Explanation:
1. **Draw the structure of Pyridine:** Pyridine has a hexagonal ring structure similar to benzene, but with one CH group replaced by a nitrogen atom.

2. **Count the σ bonds:**

- There are C-H bonds: 5 (one on each carbon except the one adjacent to N).
- There are bonds within the ring: There are 5 C-C/C-N single bonds forming the ring framework. Let's count them directly from the structure. There are 6 single bonds forming the hexagon skeleton. So, 6 ring σ bonds.
- Total σ bonds = (C-H bonds) + (Ring σ bonds) = 5 + 6 = **11 σ bonds**.

3. **Count the π bonds:** The aromatic ring has alternating double bonds. There are three double bonds in the ring, similar to benzene. Each double bond consists of one σ bond and one π bond. Therefore, there are **3 π bonds**.

4. **Count the lone pairs:**

- Each carbon atom in the ring forms 3 bonds (two with adjacent ring atoms and one with hydrogen), so it has 4 valence electrons involved in bonding and no lone pairs.
- The nitrogen atom (Group 15) has 5 valence electrons. In pyridine, it forms two single bonds with adjacent carbon atoms and participates in one double bond, for a total of 3 bonds. This uses 3 of its valence electrons.
- The remaining 5 - 3 = 2 electrons exist as a **one lone pair** on the nitrogen atom. This lone pair resides in an sp^2 orbital and is not part of the aromatic π system.

5. **Summarize the count:**

- σ bonds: 11
- π bonds: 3
- Lone pairs: 1

This corresponds to the option (11, 3, 1).

Step 4: Final Answer:
Pyridine has 11 σ bonds, 3 π bonds, and 1 lone pair of electrons.

Quick Tip

For cyclic compounds, a quick way to count σ bonds is to count all the atoms and subtract 1 (for a simple ring) and then add the number of substituent atoms (like H). For pyridine: (6 ring atoms + 5 H atoms) - 1 = 10. This is not quite right. A better way: Count all single bonds as one σ and all double bonds as one σ and one π. In pyridine ring: 3 single bonds + 3 double bonds = 6 σ bonds in the ring. Add the 5 C-H σ bonds. Total = 11 σ.

---

17. Intermolecular forces are forces of attraction and repulsion between interacting particles that will include :
A. dipole - dipole forces.
B. dipole - induced dipole forces.
C. hydrogen bonding.
D. covalent bonding.
E. dispersion forces.
Choose the most appropriate answer from the options given below :

(A) B, C, D, E are correct.
(B) A, B, C, D are correct.
(C) A, B, C, E are correct.
(D) A, C, D, E are correct.

Correct Answer: (C) A, B, C, E are correct.

Solution:

Step 1: Understanding the Question:
The question asks to identify which of the listed forces are classified as intermolecular forces. Intermolecular forces are forces that exist between molecules, as opposed to intramolecular forces, which exist within a molecule.

Step 2: Detailed Explanation:
Let's analyze each force listed:

- **A. Dipole-dipole forces:** These are attractive forces between the positive end of one polar molecule and the negative end of another polar molecule. This is a classic example of an intermolecular force.

- **B. Dipole-induced dipole forces:** These occur when a polar molecule induces a temporary dipole in a nonpolar molecule, leading to a weak attraction. This is an intermolecular force.

- **C. Hydrogen bonding:** This is a special, strong type of dipole-dipole interaction that occurs between a hydrogen atom bonded to a highly electronegative atom (N, O, or F) and another nearby electronegative atom. It is an intermolecular force.

- **D. Covalent bonding:** This is the force that holds atoms together *within* a molecule by the sharing of electrons. It is a strong **intramolecular force**, not an intermolecular one.

- **E. Dispersion forces (London forces):** These are weak intermolecular forces caused by temporary fluctuations in electron distribution, creating instantaneous dipoles. They exist between all types of molecules.

The forces classified as intermolecular are A, B, C, and E. Covalent bonding (D) is an intramolecular force. Therefore, the correct combination is A, B, C, and E.

Step 3: Final Answer:
The correct set of intermolecular forces is dipole-dipole forces, dipole-induced dipole forces, hydrogen bonding, and dispersion forces. This corresponds to option (C).

Quick Tip

Remember the distinction:

- **Intramolecular forces** are the "strong" bonds that make up a molecule (covalent, ionic, metallic).
- **Intermolecular forces (van der Waals forces + Hydrogen bonds)** are the "weaker" forces that exist between separate molecules and determine physical properties like boiling point and solubility.

Covalent bonds are always intramolecular.

---

18. Which of the following statements are NOT correct?
A. Hydrogen is used to reduce heavy metal oxides to metals.
B. Heavy water is used to study reaction mechanism.
C. Hydrogen is used to make saturated fats from oils.
D. The H-H bond dissociation enthalpy is lowest as compared to a single bond between two atoms of any element.
E. Hydrogen reduces oxides of metals that are more active than iron.

Choose the most appropriate answer from the options given below :

(A) B, C, D, E only
(B) B, D only
(C) D, E only
(D) A, B, C only

Correct Answer: (C) D, E only

Solution:

Step 1: Understanding the Question:
The question asks to identify the incorrect statements about hydrogen and its properties or uses from a list of five statements.

Step 2: Detailed Explanation:
Let's evaluate each statement:

- **A. Hydrogen is used to reduce heavy metal oxides to metals.** This is **correct**. Hydrogen is a good reducing agent and is used in metallurgy to reduce oxides of metals that are less reactive than iron, such as copper and lead. (e.g., $CuO + H_2 \rightarrow Cu + H_2O$).

- **B. Heavy water is used to study reaction mechanism.** This is **correct**. Heavy water (D_2O) is used as a tracer compound in studying reaction mechanisms because the heavier deuterium isotope can be tracked, and its slower reaction rate (kinetic isotope effect) can provide insights into the mechanism.

- **C. Hydrogen is used to make saturated fats from oils.** This is **correct**. This process is called hydrogenation of oils. Unsaturated fats (oils) contain C=C double bonds, which react with hydrogen in the presence of a catalyst (like Ni, Pt, or Pd) to form saturated fats (single C-C bonds), which are solid at room temperature (e.g., vanaspati ghee).

- **D. The H-H bond dissociation enthalpy is lowest as compared to a single bond between two atoms of any element.** This is **incorrect**. The H-H single bond has a very **high** bond dissociation enthalpy (435.88 kJ/mol). This is one of the strongest single bonds known, which is why dihydrogen is relatively inert at room temperature.

- **E. Hydrogen reduces oxides of metals that are more active than iron.** This is **incorrect**. Hydrogen can reduce oxides of metals that are **less** active (less electropositive) than iron, such as copper, lead, tin, zinc, etc. It cannot reduce the oxides of highly active metals like sodium, potassium, or aluminum because these metals have a stronger affinity for oxygen than hydrogen does.

Step 3: Final Answer:
The incorrect statements are D and E. Therefore, the correct option is (C).

Quick Tip

Remember the reactivity series (electrochemical series). A reducing agent can only reduce the oxides of metals that are below it in the series (less reactive). Hydrogen is placed in the series and can reduce the oxides of metals like Cu, Pb, Sn, and Fe, but not the oxides of highly reactive metals like Na, K, Ca, Al. Also, the strength of the H-H bond is a key characteristic of dihydrogen.

---

19. Which amongst the following molecules on polymerization produces neoprene?

(A) $H_2C{=}CH{-}CH{=}CH_2$
(B) $H_2C{=}C(Cl){-}CH{=}CH_2$
(C) $H_2C{=}CH{-}C{\equiv}CH$
(D) $H_2C{=}C(CH_3){-}CH{=}CH_2$

Correct Answer: (B) $H_2C{=}C(Cl){-}CH{=}CH_2$

Solution:

Step 1: Understanding the Question:
The question asks to identify the monomer unit that polymerizes to form neoprene, a type of synthetic rubber.

Step 2: Detailed Explanation:
Neoprene is the trade name for polychloroprene. It is a synthetic rubber produced by the free-radical polymerization of its monomer, chloroprene.
The IUPAC name for chloroprene is 2-chloro-1,3-butadiene. Its structure is $H_2C{=}C(Cl){-}CH{=}CH_2$.

$$n \underbrace{H_2C = C(Cl) - CH = CH_2}_{\text{Chloroprene (2-chloro-1,3-butadiene)}} \xrightarrow{\text{Polymerization}} \underbrace{-[CH_2 - C(Cl) = CH - CH_2]_n -}_{\text{Neoprene (Polychloroprene)}}$$

Let's analyze the other options:

- (A) $H_2C{=}CH{-}CH{=}CH_2$ is 1,3-butadiene, the monomer for Buna rubbers (like Buna-S and Buna-N).
- (C) $H_2C{=}CH{-}C{\equiv}CH$ is vinylacetylene, not a common monomer for addition polymerization.
- (D) $H_2C{=}C(CH_3){-}CH{=}CH_2$ is isoprene (2-methyl-1,3-butadiene), which is the monomer for natural rubber.

Step 3: Final Answer:
The monomer for neoprene is chloroprene, which is 2-chloro-1,3-butadiene ($H_2C{=}C(Cl){-}CH{=}CH_2$).

Quick Tip

Memorize the monomers of important polymers:

- **Natural Rubber** → Isoprene (2-**methyl**-1,3-butadiene)
- **Neoprene** → Chloroprene (2-**chloro**-1,3-butadiene)

The structures are very similar, only differing by a CH_3 group versus a Cl atom.

---

20. Some tranquilizers are listed below. Which one from the following belongs to barbiturates?

(A) Chlordiazepoxide
(B) Meprobamate
(C) Valium
(D) Veronal

Correct Answer: (D) Veronal

Solution:

Step 1: Understanding the Question:
The question asks to identify which of the given tranquilizers is a derivative of barbituric acid, i.e., a barbiturate. Tranquilizers are drugs used to reduce anxiety and tension.

Step 2: Detailed Explanation:
Tranquilizers are broadly classified into several groups. Let's classify the given drugs:

- **Chlordiazepoxide** and **Valium (Diazepam)**: These are mild tranquilizers belonging to the class of benzodiazepines. They are widely used to relieve anxiety.

- **Meprobamate**: This is another mild tranquilizer, but it is not a benzodiazepine or a barbiturate. It belongs to the carbamate class. Equanil is a common brand name.

- **Veronal (Barbital)**: This is a derivative of barbituric acid. Barbiturates are a class of drugs that act as central nervous system depressants. They are used as hypnotics (sleep-inducing agents) and sedatives. Other examples of barbiturates include Luminal (Phenobarbital), Seconal, and Amytal.

Step 3: Final Answer:
Among the given options, Veronal is the only drug that belongs to the class of barbiturates.

Quick Tip

In the context of "Chemistry in Everyday Life," it's helpful to remember key examples for each drug class. For tranquilizers, associate:

- **Barbiturates:** Veronal, Luminal, Seconal (often end in "-al").
- **Benzodiazepines:** Valium (Diazepam), Chlordiazepoxide.
- **Non-barbiturate/Non-benzodiazepine:** Meprobamate (Equanil).

---

21. The element expected to form largest ion to achieve the nearest noble gas configuration is :

(A) O
(B) F
(C) N
(D) Na

Correct Answer: (C) N

Solution:

Step 1: Understanding the Question:
The question asks to identify which element, upon forming an ion to achieve a noble gas configuration, will have the largest ionic radius.

Step 2: Detailed Explanation:
First, let's determine the ions each element will form to achieve the nearest noble gas configuration (which is that of Neon, $1s^2 2s^2 2p^6$).

- **O** (Atomic number 8, [He] $2s^2 2p^4$) will gain 2 electrons to form the oxide ion, $\mathbf{O^{2-}}$.
- **F** (Atomic number 9, [He] $2s^2 2p^5$) will gain 1 electron to form the fluoride ion, $\mathbf{F^{-}}$.
- **N** (Atomic number 7, [He] $2s^2 2p^3$) will gain 3 electrons to form the nitride ion, $\mathbf{N^{3-}}$.
- **Na** (Atomic number 11, [Ne] $3s^1$) will lose 1 electron to form the sodium ion, $\mathbf{Na^{+}}$.

Now we need to compare the radii of the ions O^{2-}, F^{-}, N^{3-}, and Na^{+}. All these ions have the same number of electrons (10 electrons), making them an **isoelectronic series**.

For isoelectronic species, the ionic radius decreases as the nuclear charge (atomic number, Z) increases. This is because the same number of electrons are being attracted by a progressively larger number of protons, pulling the electron cloud closer to the nucleus.

Let's list the ions and their nuclear charges (Z):

- N^{3-}: Z = 7
- O^{2-}: Z = 8
- F^{-}: Z = 9
- Na^{+}: Z = 11

The ion with the lowest nuclear charge (N^{3-}) will have the weakest attraction for its 10 electrons and will therefore be the largest. The ion with the highest nuclear charge (Na^{+}) will be the smallest.
The order of ionic radii is: $\mathbf{N^{3-}} > \mathbf{O^{2-}} > \mathbf{F^{-}} > \mathbf{Na^{+}}$.

Step 3: Final Answer:
The nitride ion (N^{3-}) will be the largest among the given options.

Quick Tip

For an isoelectronic series (species with the same number of electrons), the rule is simple: **more protons = smaller ion**. The greater the nuclear charge, the stronger the pull on the electron cloud. Anions will always be larger than cations in the same isoelectronic series. The higher the negative charge on the anion, the larger its size.

---

22. Select the correct statements from the following:
A. Atoms of all elements are composed of two fundamental particles.
B. The mass of the electron is 9.10939×10^{-31} kg.
C. All the isotopes of a given element show same chemical properties.
D. Protons and electrons are collectively known as nucleons.
E. Dalton's atomic theory, regarded the atom as an ultimate particle of matter.
Choose the correct answer from the options given below :

(A) A, B and C only
(B) C, D and E only
(C) A and E only
(D) B, C and E only

Correct Answer: (D) B, C and E only

Solution:

Step 1: Understanding the Question:
The question asks to identify the correct statements from a given list of five statements related to atomic structure and theory.

Step 2: Detailed Explanation:
Let's evaluate each statement:

- **A. Atoms of all elements are composed of two fundamental particles.** This is **incorrect**. Atoms are composed of three fundamental particles: protons, neutrons, and electrons. (An exception is protium, the isotope ^{1}H, which has no neutrons, but the statement says "atoms of all elements").

- **B. The mass of the electron is 9.10939 $\times$ 10^{-31} kg.** This is **correct**. This is the accepted value for the rest mass of an electron.

- **C. All the isotopes of a given element show same chemical properties.** This is **correct**. Isotopes of an element have the same number of protons and electrons, and thus the same electron configuration. Since chemical properties are primarily determined by electron configuration, isotopes exhibit nearly identical chemical behavior.

- **D. Protons and electrons are collectively known as nucleons.** This is **incorrect**. **Protons and neutrons** are the particles found in the nucleus and are collectively called nucleons. Electrons orbit the nucleus.

- **E. Dalton's atomic theory, regarded the atom as an ultimate particle of matter.** This is **correct**. A key postulate of John Dalton's original atomic theory (early 19th century) was that the atom is indivisible and is the fundamental, ultimate particle of matter. We now know this is incorrect, but the statement accurately reflects Dalton's theory.

Step 3: Final Answer:
The correct statements are B, C, and E.

Quick Tip

When evaluating statements about historical scientific theories like Dalton's, answer based on the theory itself, not on modern knowledge. Dalton's theory *did* state that atoms are indivisible, even though we now know they are made of subatomic particles.

---

23. Consider the following reaction and identify the product (P).
CH_3-$CH(CH_3)$-$CH(OH)$-CH_3 $\xrightarrow{HBr}$ Product (P)

(3-Methylbutan-2-ol)

(A) CH_3-C(Br)(CH_3)-CH_2-CH_3
(B) CH_3-CH=CH-CH_3
(C) CH_3-CH(CH_3)-CH(Br)-CH_3
(D) CH_3-C(CH_3)$_2$-CH_2Br

Correct Answer: (A) CH_3-C(Br)(CH_3)-CH_2-CH_3

Solution:

Step 1: Understanding the Question:
The question asks for the major product of the reaction between 3-methylbutan-2-ol (a secondary alcohol) and HBr. This is a reaction that proceeds via a carbocation intermediate.

Step 2: Detailed Explanation:
The reaction follows an S_N1-type mechanism:
1. **Protonation of the alcohol:** The lone pair on the oxygen of the hydroxyl group attacks the proton (H^+) from HBr, forming a protonated alcohol (an oxonium ion). This makes the hydroxyl group a good leaving group (H_2O).

2. **Formation of carbocation:** The C-O bond breaks, and the water molecule leaves, generating a secondary carbocation at C-2.

3. **Carbocation rearrangement (Hydride Shift):** The initially formed secondary (2°) carbocation can rearrange to form a more stable tertiary (3°) carbocation if possible. In this case, a hydride ion (H^-) from the adjacent carbon (C-3) can shift to the positively charged carbon (C-2).

This rearrangement results in a more stable tertiary carbocation at C-3.

4. **Nucleophilic attack:** The bromide ion (Br^-), which is a good nucleophile, attacks the tertiary carbocation to form the final major product.

The major product is 2-bromo-2-methylbutane. This corresponds to the structure in option (A).
The minor product, 2-bromo-3-methylbutane (option C), would be formed if there were no rearrangement, which is less likely. Option (B) is an elimination product. Option (D) would require a methyl shift, which is not possible here to create a more stable cation.

Step 3: Final Answer:
The major product of the reaction is 2-bromo-2-methylbutane, formed via a hydride shift.

Quick Tip

Whenever you see a reaction involving a secondary alcohol with an acid (like HBr, H_2SO_4) that proceeds via a carbocation, always check for the possibility of rearrangement! A 1,2-hydride shift or a 1,2-methyl shift will occur if it leads to a more stable carbocation (usually 2° → 3°). The stability order is 3° ¿ 2° ¿ 1°.

---

24. The stability of Cu^{2+} is more than Cu^{+} salts in aqueous solution due to -

(A) first ionisation enthalpy.
(B) enthalpy of atomization.
(C) hydration energy.
(D) second ionisation enthalpy.

Correct Answer: (C) hydration energy.

Solution:

Step 1: Understanding the Question:
The question asks for the thermodynamic reason why the copper(II) ion (Cu^{2+}) is more stable than the copper(I) ion (Cu^{+}) in an aqueous solution, even though forming Cu^{2+} from Cu requires more energy (higher second ionization enthalpy).

Step 2: Detailed Explanation:
Let's analyze the energetics. The formation of Cu^{2+} from Cu(g) requires more energy than the formation of Cu^{+} because of the second ionization enthalpy (IE_2).

$$\mathrm{Cu(g)} \xrightarrow{IE_1} \mathrm{Cu^{+}(g)} \xrightarrow{IE_2} \mathrm{Cu^{2+}(g)}$$

Based on gas-phase energetics alone, Cu^{+} should be more stable as it has a stable d^{10} configuration.

However, the question specifies stability in **aqueous solution**. In solution, the stability of an ion is determined by the overall enthalpy change, which includes the energy released during hydration.

Hydration Energy (or Enthalpy of Hydration): This is the energy released when one mole of gaseous ions dissolves in sufficient water to give an infinitely dilute solution. The hydration energy depends on the charge density of the ion (charge/size ratio).

- The Cu^{2+} ion has a higher positive charge (+2) and a smaller ionic radius compared to the Cu^{+} ion (+1).
- This gives Cu^{2+} a much higher charge density.

- Due to its high charge density, the Cu^{2+} ion attracts water molecules much more strongly, leading to a very large, negative (exothermic) enthalpy of hydration.

The very high hydration energy released by Cu^{2+} more than compensates for the high energy required for the second ionization. This makes the overall process of forming $Cu^{2+}(aq)$ from Cu(s) more favorable than forming $Cu^{+}(aq)$, leading to the higher stability of Cu^{2+} in water. In fact, Cu^{+} salts are unstable in aqueous solution and tend to disproportionate into Cu^{2+} and Cu.

$$2\mathrm{Cu}^{+}(\mathrm{aq}) \rightarrow \mathrm{Cu}^{2+}(\mathrm{aq}) + \mathrm{Cu}(\mathrm{s})$$

Step 3: Final Answer:
The greater stability of $Cu^{2+}(aq)$ over $Cu^{+}(aq)$ is due to its much higher hydration energy.

Quick Tip

When comparing the stability of ions, always check the specified state. In the gas phase, stability is governed by ionization energies and electron configurations. In aqueous solution, the hydration energy often becomes the dominant factor, especially for small, highly charged ions.

---

25. Which one of the following statements is correct?

(A) The daily requirement of Mg and Ca in the human body is estimated to be 0.2 - 0.3 g.
(B) All enzymes that utilise ATP in phosphate transfer require Ca as the cofactor.
(C) The bone in human body is an inert and unchanging substance.
(D) Mg plays roles in neuromuscular function and interneuronal transmission.

Correct Answer: (A) The daily requirement of Mg and Ca in the human body is estimated to be 0.2 - 0.3 g.

Solution:

Step 1: Understanding the Question:
The question asks to identify the correct statement regarding the biological importance of magnesium (Mg) and calcium (Ca).

Step 2: Detailed Explanation:
Let's analyze each statement:

- **(A) The daily requirement of Mg and Ca in the human body is estimated to be 0.2 - 0.3 g.** This statement is **correct**. The estimated daily requirement for an adult is around 200–300 mg (or 0.2–0.3 g) for magnesium. The requirement for calcium is higher, typically around 1000-1200 mg (1.0-1.2 g), but the value given in the option (200-300 mg) is a reasonable estimate for magnesium. Some sources might give overlapping ranges.

Given the other options are clearly incorrect, this is the intended correct statement.

- **(B) All enzymes that utilise ATP in phosphate transfer require Ca as the cofactor.** This is **incorrect**. Enzymes that utilize ATP in phosphate transfer, such as kinases, almost universally require **magnesium (Mg)** as the cofactor. Mg^{2+} ions form a complex with ATP ($MgATP^{2-}$), which is the true substrate for these enzymes.

- **(C) The bone in human body is an inert and unchanging substance.** This is **incorrect**. Bone is a dynamic, living tissue that is constantly being remodeled (resorbed and reformed). It also serves as a reservoir of calcium, which can be mobilized into the bloodstream to maintain calcium homeostasis.

- **(D) Mg plays roles in neuromuscular function and interneuronal transmission.** This statement describes the role of **Calcium (Ca)**, not magnesium. Calcium ions are critical for the release of neurotransmitters at synapses and for muscle contraction. While magnesium is involved in neuromuscular function (often as an antagonist to calcium), the primary role in transmission is attributed to Ca^{2+}.

Step 3: Final Answer:

The most accurate statement among the choices is (A), regarding the daily requirement of Mg and Ca.

Quick Tip

Remember the key biological roles:

- **Calcium (Ca^{2+})**: Bones and teeth, muscle contraction, nerve transmission, blood clotting.
- **Magnesium (Mg^{2+})**: Cofactor for ATP-dependent enzymes (kinases), component of chlorophyll, stabilizes ribosomes and nucleic acids.

The association of Mg^{2+} with ATP is a very important concept.

Section - B

26. Weight (g) of two moles of the organic compound, which is obtained by heating sodium ethanoate with sodium hydroxide in presence of calcium oxide is :

(A) 16
(B) 32
(C) 30
(D) 18

Correct Answer: (B) 32

Solution:

Step 1: Understanding the Question:
The question describes a chemical reaction and asks for the mass of two moles of the organic product formed. The reaction is the decarboxylation of sodium ethanoate using soda lime.

Step 2: Key Formula or Approach:
1. Write the balanced chemical equation for the reaction. 2. Identify the organic product. 3. Calculate the molar mass of the product. 4. Calculate the mass of two moles of the product.
Mass = number of moles × Molar mass

Step 3: Detailed Explanation:
1. **The Reaction:** The reaction is heating sodium ethanoate (CH_3COONa) with sodium hydroxide (NaOH) in the presence of calcium oxide (CaO). The mixture of NaOH and CaO is known as soda lime. This is a standard laboratory method for the decarboxylation of carboxylic acid salts to produce alkanes. The CaO does not directly participate but helps to keep the NaOH dry.

$$\underset{\text{Sodium ethanoate}}{CH_3COONa(s)} + \underset{\text{Sodium hydroxide}}{NaOH(s)} \xrightarrow[\Delta]{CaO} \underset{\text{Methane}}{CH_4(g)} + \underset{\text{Sodium carbonate}}{Na_2CO_3(s)}$$

2. **The Product:** The organic product of this reaction is methane (CH_4).

3. **Molar Mass of Methane:**
Molar mass of CH_4 = (Atomic mass of C) + 4 × (Atomic mass of H)
Molar mass of CH_4 = 12.01 g/mol + 4 × 1.008 g/mol ≈ 12 + 4 = 16 g/mol.

4. **Mass of Two Moles:**
The question asks for the weight of two moles of the product.
Weight = 2 moles × 16 g/mol = 32 g.

Step 4: Final Answer:
The weight of two moles of methane is 32 g.

Quick Tip

Decarboxylation with soda lime is a "step-down" reaction for alkanes. It removes the -COO group from the carboxylate salt and replaces it with an -H, forming an alkane with one less carbon atom than the parent carboxylic acid. For example, sodium ethanoate (2 carbons) gives methane (1 carbon).

---

27. Amongst the given options which of the following molecules / ion acts as a Lewis acid?

(A) NH_3
(B) H_2O
(C) BF_3
(D) OH^-

Correct Answer: (C) BF_3

Solution:

Step 1: Understanding the Question:
The question asks to identify the Lewis acid among the given options.

Step 2: Key Formula or Approach:
We need to apply the Lewis definition of acids and bases:

- A **Lewis acid** is a chemical species that is an "electron pair acceptor." It must have a vacant orbital to accept the electron pair.
- A **Lewis base** is a chemical species that is an "electron pair donor." It must have at least one lone pair of electrons to donate.

Step 3: Detailed Explanation:
Let's analyze each species:

- **(A) NH_3 (Ammonia):** The nitrogen atom has a lone pair of electrons which it can donate. Therefore, NH_3 acts as a **Lewis base**.

- **(B) H_2O (Water):** The oxygen atom has two lone pairs of electrons which it can donate. Therefore, H_2O acts as a **Lewis base**.

- **(C) BF_3 (Boron Trifluoride):** The central boron atom is bonded to three fluorine atoms. Boron has 3 valence electrons, and after forming 3 bonds, it has only 6 electrons in its valence shell (an incomplete octet). It has a vacant p-orbital and can accept a pair of electrons to complete its octet. Therefore, BF_3 acts as a **Lewis acid**.

- **(D) OH^- (Hydroxide ion):** The oxygen atom has three lone pairs of electrons and a negative charge. It is a strong electron pair donor. Therefore, OH^- acts as a **Lewis base**.

Step 4: Final Answer:
BF_3 is the Lewis acid among the given options because it is an electron-deficient molecule.

Quick Tip

Common examples of Lewis acids to look for:

- Molecules with incomplete octets (e.g., BF_3, $AlCl_3$).
- Cations (e.g., H^+, Ag^+, Fe^{3+}).
- Molecules with central atoms that can expand their octet (e.g., SiF_4, $SnCl_4$).

Common Lewis bases have lone pairs (e.g., NH_3, H_2O, ROH) or are anions (e.g., OH^-, Cl^-, CN^-).

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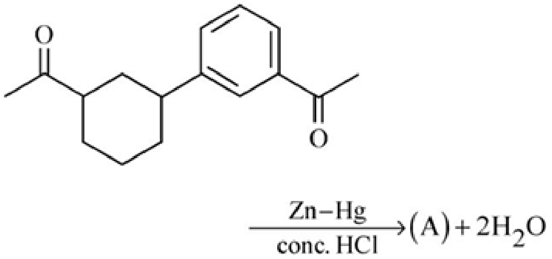
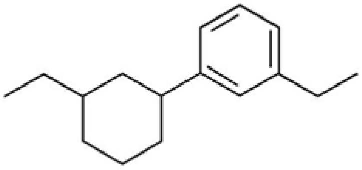
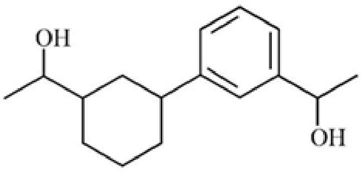
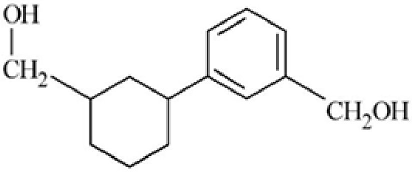
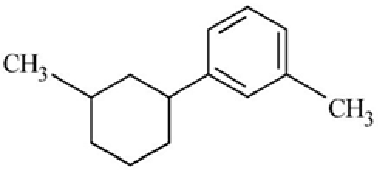
28. Identify product (A) in the following reaction:

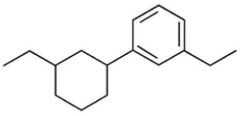


(1) 

(2) 

(3) 

(4) 

Correct Answer: (A) 

Solution:

Step 1: Understanding the Question:
The question shows a reaction of a diketone with Zn-Hg and concentrated HCl and asks to identify the product (A).

Step 2: Key Formula or Approach:
The reagent combination, zinc amalgam (Zn-Hg) and concentrated hydrochloric acid (conc. HCl), is used for the **Clemmensen reduction**. This reaction is a powerful method to reduce the carbonyl group (C=O) of aldehydes and ketones to a methylene group (CH_2).

$$R - C(= O) - R' \xrightarrow{Zn-Hg,\ conc.\ HCl} R - CH_2 - R'$$

Step 3: Detailed Explanation:
The starting material is 1-(3-acetylphenyl)ethan-1-one, which has two ketone groups. One is directly attached to the benzene ring, and the other is on the side chain (part of an acetyl group). The Clemmensen reduction will reduce both of these carbonyl groups completely to methylene groups.

- The ketone group on the ring (-C(=O)CH_3) will be reduced to an ethyl group (-CH_2CH_3).
- The problem is that the structure shown in the question is a cyclohexyl ring, not a benzene ring. Let's assume the question meant 1-(3-acetylcyclohexyl)ethan-1-one. The Clemmensen reduction works on both aryl and alkyl ketones.

The product (A) is 1,3-diethylcyclohexane. This matches the structure given in option (1).
The other options show incomplete reduction or reduction to alcohols:

- (2) shows reduction to alcohol groups (-OH), which is characteristic of reduction with $NaBH_4$ or $LiAlH_4$, not Clemmensen.
- (3) shows reduction of one ketone to alcohol and the other to CH_2OH, which is incorrect.
- (4) shows the removal of the carbonyl oxygen atoms, leaving methyl groups, which is incorrect.

Step 4: Final Answer:
The product of the Clemmensen reduction of 1,3-diacetylcyclohexane is 1,3-diethylcyclohexane.

Quick Tip

Remember the two main ways to reduce a ketone to an alkane:

- **Clemmensen Reduction:** Zn-Hg, conc. HCl. Works under **acidic** conditions.
- **Wolff-Kishner Reduction:** NH_2NH_2, KOH/ethylene glycol. Works under **basic** conditions.

Choose the appropriate method based on whether other functional groups in the molecule are acid-sensitive or base-sensitive.

---

29. Taking stability as the factor, which one of the following represents correct relationship?

(A) $TlCl_3 > TlCl$
(B) $InI_3 > InI$
(C) $AlCl > AlCl_3$
(D) $TlI > TlI_3$

Correct Answer: (D) $TlI > TlI_3$

Solution:

Step 1: Understanding the Question:
The question asks to identify the correct stability relationship between halides of Group 13 elements in different oxidation states (+1 and +3). This relates to the concept of the inert pair effect.

Step 2: Key Formula or Approach:
Inert Pair Effect: In the p-block, particularly for heavier elements (Periods 4, 5, 6), the two electrons in the valence s-orbital (the "s-pair") are more tightly held by the nucleus and are reluctant to participate in bonding. This leads to the stability of an oxidation state that is two less than the group oxidation state.
For Group 13 (B, Al, Ga, In, Tl), the group oxidation state is +3. Due to the inert pair effect, the stability of the +1 oxidation state increases down the group, while the stability of the +3 oxidation state decreases.
Stability order of +3 state: Al^{3+} ¿ Ga^{3+} ¿ In^{3+} ¿ Tl^{3+}.
Stability order of +1 state: Al^{+} ¡ Ga^{+} ¡ In^{+} ¡ Tl^{+}.

Step 3: Detailed Explanation:
Let's analyze the options based on this trend:

- **(A) $TlCl_3$ ¿ TlCl:** Thallium (Tl) is the heaviest element in Group 13. The inert pair effect is most pronounced for Tl. Therefore, the +1 oxidation state (in TlCl) is significantly more stable than the +3 oxidation state (in $TlCl_3$). This statement is **incorrect**.

- **(B) InI_3 ¿ InI:** For Indium (In), the +3 oxidation state is still more stable than the +1 state, although the inert pair effect is becoming noticeable. So, InI_3 is generally more stable than InI. This statement is likely correct, but let's check the others.

- **(C) AlCl ¿ $AlCl_3$:** Aluminum (Al) is high up in the group. The inert pair effect is negligible. Its only stable oxidation state in compounds is +3. $AlCl_3$ is very stable, while AlCl is not. This statement is **incorrect**.

- **(D) TlI ¿ TlI$_3$:** As explained for (A), for Thallium, the +1 state is much more stable than the +3 state. TlI exists and is stable, whereas TlI$_3$ does not exist as a simple Tl^{3+} salt. It actually exists as $Tl^+(I_3{}^-)$, containing Tl in the +1 state. Therefore, TlI is more stable than TlI$_3$. This statement is **correct**.

Comparing (B) and (D), the stability of Tl^+ over Tl^{3+} is a much more definitive and pronounced effect. TlI$_3$ is unstable with respect to decomposition, reinforcing that TlI is the more stable compound. Thus, (D) is the most correct representation of stability.

Step 4: Final Answer:
The correct stability relationship is TlI ¿ TlI$_3$.

Quick Tip

Remember the trend for Group 13 stability: "Down the group, +1 gets better, +3 gets worse." For Thallium (Tl), the last element, the +1 state is the most stable. For Aluminum (Al), the first main element, only the +3 state is stable.

---

30. Homoleptic complex from the following complexes is :

(A) Potassium trioxalatoaluminate (III)
(B) Diamminechloridonitrito - N - platinum (II)
(C) Pentaamminecarbonatocobalt (III) chloride
(D) Triamminetriaquachromium (III) chloride

Correct Answer: (A) Potassium trioxalatoaluminate (III)

Solution:

Step 1: Understanding the Question:
The question asks to identify the homoleptic complex among the given options.

Step 2: Key Formula or Approach:
We need to understand the definitions of homoleptic and heteroleptic complexes:

- **Homoleptic complex:** A coordination complex in which the central metal atom is bonded to only **one type** of ligand.
- **Heteroleptic complex:** A coordination complex in which the central metal atom is bonded to **more than one type** of ligand.

Step 3: Detailed Explanation:
Let's analyze the ligands in each complex:

- **(A) Potassium trioxalatoaluminate (III):** The name indicates the complex anion is $[Al(C_2O_4)_3]^{3-}$. The central metal is aluminum (Al), and it is bonded to three oxalate ($C_2O_4{}^{2-}$) ligands. Since there is only one type of ligand (oxalate), this is a **homoleptic** complex.

- **(B) Diamminechloridonitrito-N-platinum (II):** The complex is $[Pt(NH_3)_2Cl(NO_2)]$. The central metal is platinum (Pt). The ligands are ammine (NH_3), chlorido (Cl^-), and nitrito-N ($NO_2{}^-$). Since there are three different types of ligands, this is a **heteroleptic** complex.

- **(C) Pentaamminecarbonatocobalt (III) chloride:** The complex cation is $[Co(NH_3)_5(CO_3)]^+$. The central metal is cobalt (Co). The ligands are ammine (NH_3) and carbonato ($CO_3{}^{2-}$). Since there are two different types of ligands, this is a **heteroleptic** complex.

- **(D) Triamminetriaquachromium (III) chloride:** The complex cation is $[Cr(NH_3)_3(H_2O)_3]^{3+}$. The central metal is chromium (Cr). The ligands are ammine (NH_3) and aqua (H_2O). Since there are two different types of ligands, this is a **heteroleptic** complex.

Step 4: Final Answer:
Potassium trioxalatoaluminate (III) is the only homoleptic complex among the given options.

Quick Tip

The prefixes ”homo-” means ”same” and ”hetero-” means ”different”. To identify a homoleptic complex, just look at the name. If you see prefixes indicating only one type of ligand (like ”trioxalato”, ”hexaaqua”, ”tetracarbonyl”), it’s homoleptic. If you see names with multiple different ligand types mentioned (like ”diamminechlorido...”), it’s heteroleptic.

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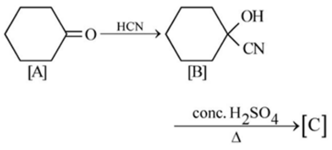
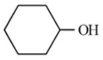
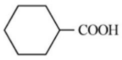
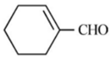
31. Complete the following reaction :

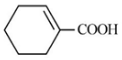


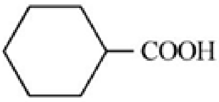
[C] is ________.

(1) 

(2) 

(3) 

(4) 

Correct Answer: (B) 

Solution:

Step 1: Understanding the Question:
The question asks for the final product [C] of a three-step reaction sequence starting from cyclohexanone [A].

Step 2: Detailed Explanation:
Let's trace the reaction pathway step-by-step:
1. **Step 1: Formation of [B]**
A
is cyclohexanone. It reacts with HCN. This is a nucleophilic addition reaction to the carbonyl group. The cyanide ion (CN^-) acts as the nucleophile, attacking the electrophilic carbonyl carbon. The oxygen atom is then protonated. This reaction forms a cyanohydrin.
Compound [B] is cyclohexanone cyanohydrin.

2. **Step 2: Formation of [C]**
Compound [B] is treated with concentrated sulfuric acid (conc. H_2SO_4) and heated (Δ). This condition causes the hydrolysis of the nitrile group (-CN). A nitrile group hydrolyzes completely under strong acidic conditions to form a carboxylic acid group (-COOH).
The reaction proceeds through an amide intermediate, but with strong acid and heat, it goes all the way to the carboxylic acid.
Product [C] is 1-hydroxycyclohexanecarboxylic acid. This structure matches option (B).
Option (D) has the carboxylic acid group directly attached to the ring, which would imply loss of the -OH group. This is incorrect. The -OH group from the cyanohydrin remains.
Option (A) is the starting cyanohydrin.
Option (C) is an aldehyde, which is incorrect.

Step 3: Final Answer:
The final product [C] is 1-hydroxycyclohexanecarboxylic acid.

Quick Tip

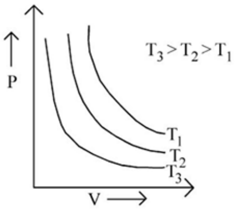
Remember the fate of the nitrile group (-CN) upon hydrolysis:

- **Partial Hydrolysis** (e.g., conc. HCl at room temp, or alkaline H_2O_2): Nitrile → **Amide** ($-CONH_2$).
- **Complete Hydrolysis** (e.g., dilute acid or base with heating): Nitrile → **Carboxylic Acid** (-COOH).

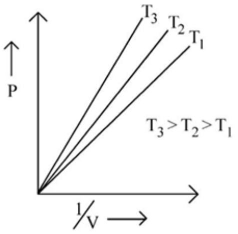
Since the conditions are strong acid and heat, complete hydrolysis is expected.

32. Which amongst the following options is correct graphical representation of Boyle's Law?

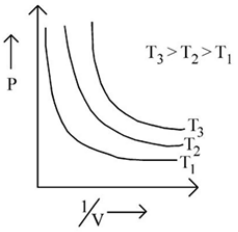
(1)



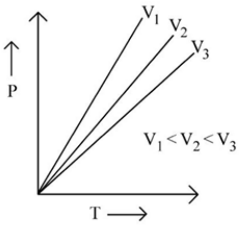
(2)



(3)



(4)



(A) Graph (1)
(B) Graph (2)
(C) Graph (3)
(D) Graph (4)

Correct Answer: (B) Graph (2)

Solution:

Step 1: Understanding the Question:
The question asks to identify the correct graphical representation of Boyle's Law from the given options. Boyle's Law describes the relationship between the pressure (P) and volume (V) of a gas at a constant temperature (T).

Step 2: Key Formula or Approach:
According to Boyle's Law, at a constant temperature, the pressure of a fixed mass of gas is inversely proportional to its volume.

$$P \propto \frac{1}{V}$$

This can be written as:

$$P = k\left(\frac{1}{V}\right)$$

where k is a constant. The value of k depends on the temperature and the amount of gas. According to the ideal gas equation, $PV = nRT$, the constant $k = nRT$.

Step 3: Detailed Explanation:
The equation $P = (nRT)\frac{1}{V}$ is in the form of a linear equation $y = mx$, where:
- $y = P$ (Pressure)
- $x = \frac{1}{V}$ (Inverse of Volume)
- $m = nRT$ (Slope of the line)

This implies that a graph of P versus 1/V should be a straight line passing through the origin. The slope of this line, $m = nRT$, is directly proportional to the absolute temperature (T). Therefore, as the temperature increases, the slope of the P vs 1/V graph also increases.
The given condition is $T_3 > T_2 > T_1$. This means the slope of the line for temperature T_3 should be the steepest, followed by T_2, and then T_1.
Graph (2) correctly depicts this relationship: it shows straight lines passing through the origin, and the slope increases with temperature from T_1 to T_3.
Graph (1) shows P vs V, which are hyperbolas, another correct representation, but the P vs 1/V graph provides a linear relationship which is often preferred for analysis.
Graph (3) is incorrect as it shows curves instead of straight lines for a P vs 1/V plot.
Graph (4) represents Gay-Lussac's Law (P vs T at constant V), not Boyle's Law.

Step 4: Final Answer:
Based on the analysis, the correct graphical representation of Boyle's Law among the given options is the plot of P vs 1/V, which is shown in Graph (2).

Quick Tip

For gas law graphs, remember the basic relationships:

- **Boyle's Law (constant T):** $P \propto 1/V$. P vs V is a hyperbola. P vs 1/V is a straight line through the origin.
- **Charles's Law (constant P):** $V \propto T$. V vs T is a straight line.
- **Gay-Lussac's Law (constant V):** $P \propto T$. P vs T is a straight line.

Always check the axes and the relationship between the variables.

---

33. The right option for the mass of CO_2 produced by heating 20 g of 20% pure limestone is (Atomic mass of Ca = 40)

[**$CaCO_3 \xrightarrow{1200K} CaO + CO_2$**]

(A) 1.12 g
(B) 1.76 g
(C) 2.64 g
(D) 1.32 g

Correct Answer: (B) 1.76 g

Solution:

Step 1: Understanding the Question:
We need to calculate the mass of carbon dioxide (CO_2) produced from the thermal decomposition of a 20 g sample of limestone that is only 20% pure. Limestone is primarily calcium carbonate ($CaCO_3$).

Step 2: Key Formula or Approach:
The solution involves a stoichiometric calculation based on a balanced chemical equation.

1. Calculate the mass of pure $CaCO_3$ in the sample.
2. Calculate the molar masses of $CaCO_3$ and CO_2.
3. Use the mole ratio from the balanced equation to find the moles of CO_2 produced.
4. Convert the moles of CO_2 to mass.

Step 3: Detailed Explanation:
1. Mass of pure $CaCO_3$:
The sample of limestone is 20 g and its purity is 20%.

$$\text{Mass of pure } CaCO_3 = 20 \text{ g} \times \frac{20}{100} = 4 \text{ g}$$

2. Molar masses:
We need the molar masses of $CaCO_3$ and CO_2. (Atomic masses: Ca=40, C=12, O=16)

$$\text{Molar mass of } CaCO_3 = 40 + 12 + 3(16) = 40 + 12 + 48 = 100 \text{ g/mol}$$
$$\text{Molar mass of } CO_2 = 12 + 2(16) = 12 + 32 = 44 \text{ g/mol}$$

3. Stoichiometric calculation:
The balanced chemical equation is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

From the equation, 1 mole of $CaCO_3$ produces 1 mole of CO_2.
In terms of mass, 100 g of $CaCO_3$ produces 44 g of CO_2.

4. Mass of CO_2 produced:
We can use a ratio to find the mass of CO_2 produced from 4 g of pure $CaCO_3$.

$$\frac{\text{Mass of CO}_2\text{ produced}}{\text{Mass of CaCO}_3\text{ reacted}} = \frac{\text{Molar mass of CO}_2}{\text{Molar mass of CaCO}_3}$$

$$\text{Mass of CO}_2 = \left(\frac{44\text{ g CO}_2}{100\text{ g CaCO}_3}\right) \times 4\text{ g CaCO}_3$$

$$\text{Mass of CO}_2 = 0.44 \times 4 = 1.76\text{ g}$$

Step 4: Final Answer:
The mass of CO_2 produced is 1.76 g. This corresponds to option (B).

Quick Tip

In stoichiometry problems involving impure substances, always calculate the mass of the pure reactant first before proceeding with mole calculations. Purity percentage is a common trick in competitive exams.

---

34. For a certain reaction, the rate = k$[A]^2[B]$, when the initial concentration of A is tripled keeping concentration of B constant, the initial rate would

(A) decrease by a factor of nine.
(B) increase by a factor of six.
(C) increase by a factor of nine.
(D) increase by a factor of three.

Correct Answer: (C) increase by a factor of nine.

Solution:

Step 1: Understanding the Question:
The question asks how the rate of a reaction changes when the concentration of one reactant is changed, given the rate law for the reaction.

Step 2: Key Formula or Approach:
The given rate law is:

$$\text{rate} = k[A]^2[B]$$

We need to compare the initial rate with the new rate after changing the concentration of A.

Step 3: Detailed Explanation:
Let the initial rate be r_1.
The initial concentrations are [A] and [B].

$$r_1 = k[A]^2[B]$$

Now, the concentration of A is tripled, and B is kept constant.
Let the new concentrations be [A'] and [B'].

$$[A'] = 3[A]$$
$$[B'] = [B]$$

Let the new rate be r_2.

$$r_2 = k[A']^2[B']$$

Substitute the new concentrations into the rate equation:

$$r_2 = k(3[A])^2[B]$$
$$r_2 = k(9[A]^2)[B]$$
$$r_2 = 9 \times (k[A]^2[B])$$

Since $r_1 = k[A]^2[B]$, we can substitute r_1 into the expression for r_2:

$$r_2 = 9 \times r_1$$

This shows that the new rate (r_2) is nine times the initial rate (r_1).

Step 4: Final Answer:
The initial rate would increase by a factor of nine. This corresponds to option (C).

Quick Tip

To quickly solve such problems, focus on the reactant whose concentration is changing and its order in the rate law. If the concentration of a reactant is changed by a factor 'x' and its order is 'n', the rate changes by a factor of x^n. Here, x = 3 and n = 2, so the rate changes by $3^2 = 9$.

---

35. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R :
Assertion A: In equation $\Delta G = - nFE_{cell}$, value of ΔG depends on n.
Reason R: E_{cell} is an intensive property and ΔG is an extensive property.
In the light of the above statements, choose the correct answer from the options given below :

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true and R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

Correct Answer: (A) Both A and R are true and R is the correct explanation of A.

Solution:

Step 1: Understanding the Question:
This question requires an analysis of two statements, an Assertion (A) and a Reason (R), related to the thermodynamics of an electrochemical cell. We must determine if each statement is true and if the Reason correctly explains the Assertion.

Step 2: Key Formula or Approach:
The core equation is the relationship between Gibbs free energy change (ΔG), cell potential ($\mathrm{E_{cell}}$), and the number of moles of electrons transferred (n):

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

We also need to understand the definitions of intensive and extensive properties. - **Extensive Property:** Depends on the amount of substance (e.g., mass, volume, ΔG). - **Intensive Property:** Independent of the amount of substance (e.g., temperature, pressure, $\mathrm{E_{cell}}$).

Step 3: Detailed Explanation:
Analysis of Assertion A:
The equation is $\Delta G = -nFE_{\text{cell}}$.
- ΔG is the Gibbs free energy change.
- n is the number of moles of electrons transferred in the balanced cell reaction.
- F is Faraday's constant (a constant value).
- $\mathrm{E_{cell}}$ is the standard cell potential.
The equation clearly shows that ΔG is directly proportional to 'n'. If we double the size of the system (i.e., double the stoichiometric coefficients in the reaction), 'n' doubles, and consequently, ΔG also doubles. Therefore, the value of ΔG depends on n. **Assertion A is true.**

Analysis of Reason R:
- **$\mathbf{E_{cell}}$ (Cell Potential):** This is an electrical potential difference, which is an intrinsic property of the chemical system. It does not depend on the size of the electrodes or the amount of electrolyte. Hence, $\mathrm{E_{cell}}$ is an **intensive property**.
- **ΔG (Gibbs Free Energy):** This represents the total energy available to do work. If you have twice the amount of reactants, the total energy change will be twice as large. Therefore, ΔG is an **extensive property**.
So, the statement that $\mathrm{E_{cell}}$ is an intensive property and ΔG is an extensive property is correct. **Reason R is true.**

Connecting Reason R and Assertion A:
The Assertion states that ΔG depends on n. The Reason provides the thermodynamic nature of ΔG and $\mathrm{E_{cell}}$. The relationship $\Delta G = -nFE_{\text{cell}}$ links an extensive property (ΔG) with an intensive property ($\mathrm{E_{cell}}$). For this relationship to hold, there must be a factor that accounts for the amount of substance. This factor is 'n', the number of moles of electrons transferred. Because ΔG is extensive (it depends on the amount) while $\mathrm{E_{cell}}$ is intensive (it doesn't), ΔG must depend on 'n'. Thus, the Reason provides the fundamental explanation for why the Assertion is true.

Step 4: Final Answer:

Both Assertion A and Reason R are true, and Reason R is the correct explanation for Assertion A. This corresponds to option (A).

Quick Tip

Remember the distinction between intensive and extensive properties. Intensive properties (like potential, temperature, density) don't change with system size. Extensive properties (like energy, mass, volume) do. In the equation $\Delta G = -nFE_{\text{cell}}$, the extensive nature of ΔG is balanced by the 'n' term, which scales with the size of the reaction, while E_{cell} remains constant for a given reaction regardless of scale.

---

36. Match List - I with List - II :

List - I (Oxoacids of Sulphur)

A. Peroxodisulphuric acid
B. Sulphuric acid
C. Pyrosulphuric acid
D. Sulphurous acid

List - II (Bonds)

I. Two S-OH, Four S=O, One S-O-S
II. Two S-OH, One S=O
III. Two S-OH, Four S=O, One S-O-O-S
IV. Two S-OH, Two S=O

Choose the correct answer from the options given below :

(A) A-I, B-III, C-II, D-IV
(B) A-III, B-IV, C-I, D-II
(C) A-I, B-III, C-IV, D-II
(D) A-III, B-IV, C-II, D-I

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

Solution:

Step 1: Understanding the Question:

The question requires us to match four different oxoacids of sulfur with the correct description of the chemical bonds present in their structures.

Step 2: Key Formula or Approach:

To solve this, we need to know the chemical structures of each oxoacid and then count the number of S-OH, S=O, S-O-S, and S-O-O-S bonds.

Step 3: Detailed Explanation:

A. Peroxodisulphuric acid ($H_2S_2O_8$), also known as Marshall's acid:

The structure is HO-SO_2-O-O-SO_2-OH.

Counting the bonds:
- Two S-OH bonds.
- Four S=O bonds (two on each sulfur atom).
- One peroxide linkage (S-O-O-S).

This matches description **III**.

B. Sulphuric acid (H_2SO_4):

The structure is HO-SO_2-OH.

Counting the bonds:
- Two S-OH bonds.
- Two S=O bonds.

This matches description **IV**.

C. Pyrosulphuric acid ($H_2S_2O_7$), also known as Oleum:

The structure is HO-SO_2-O-SO_2-OH.

Counting the bonds:
- Two S-OH bonds.
- Four S=O bonds (two on each sulfur atom).
- One S-O-S linkage.

This matches description **I**.

D. Sulphurous acid (H_2SO_3):

The structure is HO-SO-OH.

Counting the bonds:
- Two S-OH bonds.
- One S=O bond.

This matches description **II**.

Step 4: Final Answer:

Based on the analysis, the correct matching is:
- A → III
- B → IV
- C → I
- D → II

This corresponds to option (B).

Quick Tip

Drawing the Lewis structures for oxoacids is a fundamental skill. Remember that sulfur can expand its octet. For peroxodisulphuric acid, the "peroxo" prefix indicates the presence of an -O-O- linkage. For pyrosulphuric acid, the "pyro" prefix often indicates the formation by heating one acid, leading to the loss of a water molecule and the formation of an oxygen bridge (like S-O-S).

---

37. Which of the following statements are INCORRECT?
A. All the transition metals except scandium form MO oxides which are ionic.
B. The highest oxidation number corresponding to the group number in transition metal oxides is attained in Sc_2O_3 to Mn_2O_7.
C. Basic character increases from V_2O_3 to V_2O_4 to V_2O_5.
D. V_2O_4 dissolves in acids to give VO_4^+ salts.
E. CrO is basic but Cr_2O_3 is amphoteric.
Choose the correct answer from the options given below :

(A) A and E only
(B) B and D only
(C) C and D only
(D) B and C only

Correct Answer: (C) C and D only

Solution:

Step 1: Understanding the Question:
We need to identify the incorrect statements from the given five statements concerning the properties of transition metals and their oxides.

Step 2: Key Formula or Approach:
Analyze each statement based on the principles of inorganic chemistry, specifically the trends in properties of d-block elements.

Step 3: Detailed Explanation:
Statement A: All the transition metals except scandium form MO oxides which are ionic.
This statement is a broad generalization. While many transition metals form MO type oxides (e.g., FeO, NiO) that are largely ionic, oxides of metals in higher oxidation states (e.g., V_2O_5, CrO_3) are covalent. Also, oxides like ZnO have significant covalent character. However, in the context of typical exam questions, this might be considered correct by focusing on common +2 oxidation state oxides. Scandium only forms Sc_2O_3. Let's evaluate other statements which might be more clearly incorrect.

Statement B: The highest oxidation number corresponding to the group number in transition metal oxides is attained in Sc_2O_3 to Mn_2O_7.
- Sc (Group 3) shows +3 in Sc_2O_3. - Ti (Group 4) shows +4 in TiO_2. - V (Group 5) shows +5 in V_2O_5. - Cr (Group 6) shows +6 in CrO_3. - Mn (Group 7) shows +7 in Mn_2O_7. This statement is **correct**.

Statement C: Basic character increases from V_2O_3 to V_2O_4 to V_2O_5.
The acidic character of metal oxides increases with an increase in the oxidation state of the metal. - V_2O_3 (V^{3+}) is basic. - V_2O_4 (V^{4+}) is amphoteric. - V_2O_5 (V^{5+}) is acidic. Therefore, the basic character decreases, it does not increase. This statement is **incorrect**.

Statement D: V_2O_4 dissolves in acids to give VO_4^+ salts.
V_2O_4 is an oxide of Vanadium in the +4 oxidation state. In acidic solutions, Vanadium(IV) exists as the vanadyl ion, $[VO]^{2+}$. The ion VO_4^+ is not the correct species. The reaction is: $V_2O_4 + 4H^+ \rightarrow 2VO^{2+} + 2H_2O$. This statement is **incorrect**.

Statement E: CrO is basic but Cr_2O_3 is amphoteric.
Similar to Vanadium, the character of chromium oxides depends on the oxidation state. - CrO (Cr^{2+}) is basic. - Cr_2O_3 (Cr^{3+}) is amphoteric. - CrO_3 (Cr^{6+}) is acidic. This statement is **correct**.

Step 4: Final Answer:
The incorrect statements are C and D. Therefore, the correct option is (C).

Quick Tip

A key trend for metal oxides is that their acidity increases with the oxidation state of the metal. Lower oxidation state oxides are typically basic, intermediate ones are amphoteric, and higher oxidation state oxides are acidic. Memorizing this trend can help quickly solve many related problems.

---

38. Which complex compound is most stable?

(A) $[Co(NH_3)_4(H_2O)Br](NO_3)_2$
(B) $[Co(NH_3)_3(NO_3)_3]$
(C) $[CoCl_2(en)_2]NO_3$
(D) $[Co(NH_3)_6]_2(SO_4)_3$

Correct Answer: (C) $[CoCl_2(en)_2]NO_3$

Solution:

Step 1: Understanding the Question:
The question asks to identify the most stable coordination compound from the given options. Stability of coordination compounds is influenced by several factors, most notably the chelate effect.

Step 2: Key Formula or Approach:
The stability of a complex is greatly enhanced if it contains polydentate ligands that form rings with the central metal ion. This phenomenon is called the **chelate effect**. A polydentate ligand is also known as a chelating agent.

Step 3: Detailed Explanation:
Let's analyze the ligands present in each complex:
- **(A) $[Co(NH_3)_4(H_2O)Br](NO_3)_2$:** The ligands inside the coordination sphere are ammonia

(NH_3), water (H_2O), and bromide (Br^-). All of these are monodentate ligands.
- **(B) [$Co(NH_3)_3(NO_3)_3$]:** The ligands are ammonia (NH_3) and nitrate (NO_3^-). Both are monodentate ligands.
- **(C) [$CoCl_2(en)_2$]NO_3:** The ligands are chloride (Cl^-) which is monodentate, and ethylenediamine (en), which is a bidentate ligand. A bidentate ligand can form two coordinate bonds with the central metal ion, creating a stable ring structure (a chelate ring). The presence of two 'en' ligands results in two such rings.
- **(D) [$Co(NH_3)_6$]$_2$(SO_4)$_3$:** The ligand is ammonia (NH_3), which is a monodentate ligand.

According to the chelate effect, complexes with chelating ligands (polydentate ligands) are thermodynamically more stable than similar complexes with only monodentate ligands. This is primarily due to a large positive entropy change (ΔS) during the formation of the chelate complex.
Since option (C) is the only complex containing a chelating ligand (ethylenediamine), it will be the most stable among the choices.

Step 4: Final Answer:
The complex [$CoCl_2(en)_2$]NO_3 is the most stable due to the chelate effect provided by the bidentate ethylenediamine ligands.

Quick Tip

When comparing the stability of coordination complexes, always look for the presence of polydentate (chelating) ligands first. Complexes with chelate rings are almost always more stable than those without. The more rings and the more stable the ring size (5- or 6-membered rings are generally most stable), the greater the stability.

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39. Consider the following compounds/species:
i. Naphthalene, ii. A bicyclic ketone, iii. Cyclobutadiene, iv. Cyclopropenyl cation, v. Cyclopentadienyl anion, vi. Benzene, vii. Azulene
The number of compounds/species which obey Huckel's rule is ______

(A) 4
(B) 6
(C) 2
(D) 5

Correct Answer: (A) 4

Solution:

Step 1: Understanding the Question:
The question asks to count how many of the given seven chemical species are aromatic accord-

ing to Hückel's rule.

Step 2: Key Formula or Approach:
Hückel's rule states that a compound is aromatic if it meets the following criteria: 1. It must be cyclic. 2. It must be planar. 3. It must be fully conjugated (have a continuous ring of p-orbitals). 4. It must have (4n + 2) π electrons, where n is a non-negative integer (n = 0, 1, 2, ...).

Step 3: Detailed Explanation:
Let's analyze each species:
i. Naphthalene: It is a bicyclic, planar, fully conjugated molecule. It has 10 π electrons. For 10 π electrons, $4n + 2 = 10 \implies 4n = 8 \implies n = 2$. It obeys Hückel's rule and is **aromatic**.

ii. Bicyclic ketone (as shown in image): This molecule contains sp^3-hybridized carbons and a C=O group which break the continuous conjugation required for aromaticity. It is **non-aromatic**.

iii. Cyclobutadiene: It is cyclic, planar, and conjugated but has 4 π electrons. This fits the 4n rule (with n=1), making it **anti-aromatic**, not aromatic. It does not obey Hückel's rule.

iv. Cyclopropenyl cation: It is a cyclic, planar, conjugated system with 2 π electrons. For 2 π electrons, $4n + 2 = 2 \implies 4n = 0 \implies n = 0$. It obeys Hückel's rule and is **aromatic**.

v. Cyclopentadienyl anion: It is a cyclic, planar, conjugated system with 6 π electrons (4 from double bonds, 2 from the lone pair). For 6 π electrons, $4n + 2 = 6 \implies 4n = 4 \implies n = 1$. It obeys Hückel's rule and is **aromatic**.

vi. Benzene: It is the archetypal aromatic compound. It is cyclic, planar, fully conjugated, and has 6 π electrons (n=1). It is **aromatic**.

vii. Azulene: It is a bicyclic, planar, fully conjugated molecule with 10 π electrons (n=2). It is a well-known non-benzenoid aromatic hydrocarbon. While it is aromatic, some strict interpretations of Hückel's rule limit its application to monocyclic systems. For the purpose of competitive exams where a specific count is required and an option for '5' is not always present or is incorrect, it's possible that non-benzenoid or more complex polycyclic systems are excluded. If we exclude Azulene based on such a strict interpretation, we are left with 4 aromatic species. Given the provided answer key, this interpretation is likely intended.

Step 4: Final Answer:
Counting the species that are unambiguously considered aromatic under Hückel's rule for typical exam purposes: Naphthalene (i), Cyclopropenyl cation (iv), Cyclopentadienyl anion (v), and Benzene (vi). This gives a total of 4 species.

Quick Tip

Hückel's rule is a powerful tool. Remember the electron counts for aromaticity: 2, 6, 10, 14... ((4n+2) π electrons). Species with 4, 8, 12... ((4n) π electrons) are anti-aromatic if planar. If a system has sp^3 carbons in the ring, it's non-aromatic. Be aware that exam questions may use a stricter definition of the rule's applicability to select the best option.

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40. What fraction of one edge centred octahedral void lies in one unit cell of fcc?

(A) $\frac{1}{2}$
(B) $\frac{1}{3}$
(C) $\frac{1}{4}$
(D) $\frac{1}{12}$

Correct Answer: (C) $\frac{1}{4}$

Solution:

Step 1: Understanding the Question:
The question asks about the contribution of a single octahedral void located at the center of an edge to one face-centered cubic (fcc) unit cell.

Step 2: Key Formula or Approach:
Visualize the position of an edge in a cubic lattice. An edge is not unique to a single unit cell; it is shared by adjacent unit cells. The contribution of any point on that edge to a single cell is the reciprocal of the number of cells sharing that edge.

Step 3: Detailed Explanation:
In a crystal lattice, a unit cell is the smallest repeating unit. To build the entire crystal, unit cells are stacked together in three dimensions.
- A corner atom is shared by 8 unit cells. - A face-centered atom is shared by 2 unit cells. - An edge-centered atom or void is shared by 4 unit cells. - A body-centered atom or void belongs entirely to 1 unit cell.

An octahedral void in an fcc lattice can be located at the body center or at the center of each of the 12 edges.
The question specifically asks about the edge-centered octahedral void. An edge of a cube is the intersection of two faces. In a 3D lattice, any single edge is shared by a total of four unit cells: the original cell, one above/below it, one next to it, and one diagonally adjacent in that plane.
Since the octahedral void is located at the center of this edge, it is equally shared among these four unit cells.
Therefore, the fraction of the void that lies within one specific unit cell is $\frac{1}{4}$.

Step 4: Final Answer:
The fraction of an edge-centered octahedral void within one fcc unit cell is $\frac{1}{4}$. This corresponds to option (C).

Quick Tip

To easily remember contributions in a cubic unit cell:

- Corner: Shared by 8 cells → 1/8 contribution.
- Edge Center: Shared by 4 cells → 1/4 contribution.
- Face Center: Shared by 2 cells → 1/2 contribution.
- Body Center: Shared by 1 cell → 1 contribution.

This applies to atoms, ions, or voids located at these positions.

---

41. Which amongst the following options is the correct relation between change in enthalpy and change in internal energy?

(A) $\Delta H = \Delta U - \Delta n_g RT$
(B) $\Delta H = \Delta U + \Delta n_g RT$
(C) $\Delta H - \Delta U = -\Delta nRT$
(D) $\Delta H + \Delta U = \Delta nR$

Correct Answer: (B) $\Delta H = \Delta U + \Delta n_g RT$

Solution:

Step 1: Understanding the Question:
The question asks for the correct thermodynamic relationship between the change in enthalpy (ΔH) and the change in internal energy (ΔU) for a chemical reaction.

Step 2: Key Formula or Approach:
The definition of enthalpy (H) is given by the equation:

$$H = U + PV$$

where U is the internal energy, P is the pressure, and V is the volume.

Step 3: Detailed Explanation:
For a change in the system at constant pressure, the equation becomes:

$$\Delta H = \Delta U + \Delta(PV)$$

If we assume the volume change is primarily due to gaseous components that behave as ideal gases, we can use the ideal gas equation:

$$PV = n_g RT$$

where n_g is the number of moles of gas.
Substituting this into the enthalpy equation, the change in the (PV) term can be written as:

$$\Delta(PV) = \Delta(n_g RT)$$

Assuming the temperature T is constant during the reaction, this simplifies to:

$$\Delta(PV) = (\Delta n_g)RT$$

Here, Δn_g is the change in the number of moles of gaseous components, calculated as:

$$\Delta n_g = (\text{moles of gaseous products}) - (\text{moles of gaseous reactants})$$

Substituting this back into the expression for ΔH gives the final relationship:

$$\Delta H = \Delta U + \Delta n_g RT$$

Step 4: Final Answer:
Comparing this derived equation with the given options, the correct relation is $\Delta H = \Delta U + \Delta n_g RT$. Option (C) is equivalent to option (A). Option (D) is incorrect. Therefore, option (B) is the correct answer.

> **Quick Tip**
>
> This is a fundamental equation in chemical thermodynamics. A simple way to remember it is to think of enthalpy as the total heat content. It includes the internal energy (U) plus the work done by the system to make space for itself (PV). For reactions involving gases, this work term is related to the change in the number of moles of gas (Δn_g).

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42. On balancing the given redox reaction,
a $Cr_2O_7^{2-}$(aq) + b SO_3^{2-}(aq) + c H^+(aq) → 2a Cr^{3+}(aq) + b SO_4^{2-}(aq) + $\frac{c}{2}$ H_2O(l)
the coefficients a, b and c are found to be, respectively -

(A) 1, 3, 8
(B) 3, 8, 1
(C) 1, 8, 3
(D) 8, 1, 3

Correct Answer: (A) 1, 3, 8

Solution:

Step 1: Understanding the Question:
We need to find the stoichiometric coefficients a, b, and c for the given redox reaction, which occurs in an acidic medium.

Step 2: Key Formula or Approach:
We will use the ion-electron method (half-reaction method) to balance the equation.

Step 3: Detailed Explanation:
1. Identify and write the half-reactions:
- Oxidation of sulfite to sulfate: ${SO_3}^{2-} \rightarrow {SO_4}^{2-}$
- Reduction of dichromate to chromium(III): ${Cr_2O_7}^{2-} \rightarrow Cr^{3+}$

2. Balance the oxidation half-reaction:
- Balance S atoms: Already balanced.
- Balance O atoms by adding H_2O: ${SO_3}^{2-} + H_2O \rightarrow {SO_4}^{2-}$
- Balance H atoms by adding H^+: ${SO_3}^{2-} + H_2O \rightarrow {SO_4}^{2-} + 2H^+$
- Balance charge by adding electrons (e^-): ${SO_3}^{2-} + H_2O \rightarrow {SO_4}^{2-} + 2H^+ + 2e^-$

3. Balance the reduction half-reaction:
- Balance Cr atoms: ${Cr_2O_7}^{2-} \rightarrow 2Cr^{3+}$
- Balance O atoms by adding H_2O: ${Cr_2O_7}^{2-} \rightarrow 2Cr^{3+} + 7H_2O$
- Balance H atoms by adding H^+: ${Cr_2O_7}^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$
- Balance charge by adding electrons (e^-): ${Cr_2O_7}^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

4. Combine the half-reactions:
To make the number of electrons equal in both half-reactions, multiply the oxidation half-reaction by 3.
- $3{SO_3}^{2-} + 3H_2O \rightarrow 3{SO_4}^{2-} + 6H^+ + 6e^-$
Now add this to the reduction half-reaction:
$({Cr_2O_7}^{2-} + 14H^+ + 6e^-) + (3{SO_3}^{2-} + 3H_2O) \rightarrow (2Cr^{3+} + 7H_2O) + (3{SO_4}^{2-} + 6H^+ + 6e^-)$

5. Simplify the final equation:
Cancel common terms ($6e^-$, $6H^+$, $3H_2O$) from both sides.
${Cr_2O_7}^{2-} + 3{SO_3}^{2-} + 8H^+ \rightarrow 2Cr^{3+} + 3{SO_4}^{2-} + 4H_2O$

Step 4: Final Answer:
Comparing the balanced equation with the given format:
$a\ {Cr_2O_7}^{2-} + b\ {SO_3}^{2-} + c\ H^+ \ldots$
We find that $a = 1$, $b = 3$, and $c = 8$. This corresponds to option (A).

Quick Tip

When balancing redox reactions in acidic medium, remember the sequence: 1. Balance elements other than O and H. 2. Balance O with H_2O. 3. Balance H with H^+. 4. Balance charge with e^-. Then, equalize the electrons in both half-reactions and add them up.

---

43. The equilibrium concentrations of the species in the reaction $A + B \rightleftharpoons C + D$ are 2, 3, 10 and 6 mol L^{-1}, respectively at 300 K. ΔG° for the reaction is ($R = 2$

cal / mol K)

(A) 1372.60 cal
(B) -137.26 cal
(C) -1381.80 cal
(D) -13.73 cal

Correct Answer: (C) -1381.80 cal

Solution:

Step 1: Understanding the Question:
We are given the equilibrium concentrations of reactants and products for a reaction and asked to calculate the standard Gibbs free energy change (ΔG°).

Step 2: Key Formula or Approach:
First, we calculate the equilibrium constant (K_c) from the given concentrations. Then, we use the relationship between ΔG° and K.

$$K_c = \frac{[\text{Products}]}{[\text{Reactants}]}$$

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

Step 3: Detailed Explanation:
The reaction is: A + B $\rightleftharpoons$ C + D
Given equilibrium concentrations:
A
= 2 mol L^{-1}
B
= 3 mol L^{-1}
C
= 10 mol L^{-1}
D
= 6 mol L^{-1}

1. Calculate the equilibrium constant (K_c):

$$K_c = \frac{[C][D]}{[A][B]} = \frac{(10)(6)}{(2)(3)} = \frac{60}{6} = 10$$

2. Calculate ΔG°:
We use the formula $\Delta G^\circ = -RT \ln K$.
Given:
R = 2 cal / mol K
T = 300 K
K = 10
The value of ln(10) is approximately 2.303.

$$\Delta G^\circ = -(2 \text{ cal/mol K}) \times (300 \text{ K}) \times \ln(10)$$

$$\Delta G^\circ = -600 \times 2.303 \text{ cal/mol}$$

$$\Delta G^\circ = -1381.8 \text{ cal/mol}$$

Step 4: Final Answer:
The standard Gibbs free energy change for the reaction is -1381.80 cal. This matches option (C).

Quick Tip

Remember the negative sign in the equation $\Delta G^\circ = -RT \ln K$. A value of K ¿ 1 implies $\ln K$ is positive, making ΔG° negative (spontaneous under standard conditions). A value of K ¡ 1 implies $\ln K$ is negative, making ΔG° positive (non-spontaneous). Also, always check the units of R. Here it's in calories, so the final answer is in calories.

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44. Pumice stone is an example of -

(A) sol
(B) gel
(C) solid sol
(D) foam

Correct Answer: (C) solid sol

Solution:

Step 1: Understanding the Question:
The question asks to classify pumice stone based on the type of colloidal system it represents. A colloidal system consists of a dispersed phase and a dispersion medium.

Step 2: Key Formula or Approach:
Pumice stone is a lightweight volcanic rock. Its structure consists of a solid rock matrix with many trapped gas bubbles. This means the dispersed phase is a gas, and the dispersion medium is a solid.

Step 3: Detailed Explanation:
Let's review the classification of colloids:

- **Sol:** Solid dispersed in a liquid.
- **Gel:** Liquid dispersed in a solid.
- **Solid Sol:** Solid dispersed in a solid.
- **Foam:** Gas dispersed in a liquid.

The colloidal system where the dispersed phase is gas and the dispersion medium is solid is called a **solid foam**. Examples include Styrofoam and pumice stone.
However, looking at the options provided, "solid foam" is not an option. In some classifications, particularly in certain textbooks (like the NCERT textbook used for competitive exams

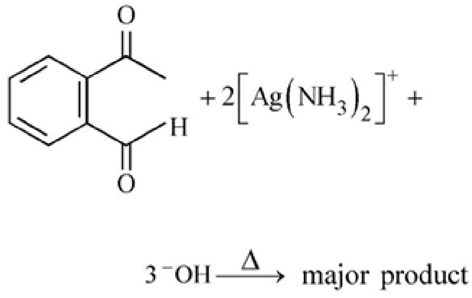
in India), the term **solid sol** is used to describe systems where the dispersion medium is a solid. This category is then shown to include both solid-in-solid (like colored glass) and gas-in-solid (like pumice stone). Given the options, "solid sol" is the intended answer based on this common classification scheme.

Step 4: Final Answer:
Pumice stone is a colloid with a gaseous dispersed phase in a solid dispersion medium. According to the classification system often used in exam contexts, this is categorized as a solid sol. Therefore, option (C) is the correct choice.

Quick Tip

The classification of colloids can sometimes have overlapping or confusing terminology. It is best to memorize the table of colloid types and their common examples as given in your standard textbook. For "gas in solid," the most specific term is "solid foam," but "solid sol" is also frequently used in textbooks.

45. Identify the major product obtained in the following reaction :



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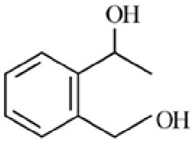

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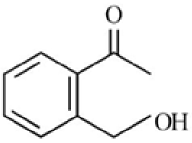

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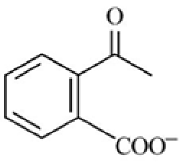

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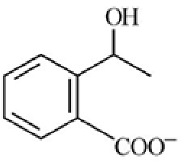

(A) Structure of salicylic acid
(B) Structure of 2-(hydroxymethyl)benzoic acid
(C) Structure of phthalate dianion
(D) Structure of terephthalate dianion

Correct Answer: (C) Structure of phthalate dianion

Solution:

Step 1: Understanding the Question:
The question shows the reaction of phthalaldehyde (benzene-1,2-dicarbaldehyde) with Tollens' reagent ($[Ag(NH_3)_2]^+$) in a basic medium (OH^-). We need to identify the major organic product.

Step 2: Key Formula or Approach:
The reaction is a Tollens' test. Tollens' reagent is a mild oxidizing agent that specifically oxidizes aldehydes to carboxylate anions, while the silver(I) complex is reduced to metallic silver, forming a silver mirror. The reaction is conducted in a basic solution.

Step 3: Detailed Explanation:
The starting material is phthalaldehyde, which has two aldehyde (-CHO) groups on adjacent carbons of a benzene ring.
Each aldehyde group will be oxidized by the Tollens' reagent.
The general reaction for an aldehyde is:

$$R - CHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow R - COO^- + 2Ag(s) + 4NH_3 + 2H_2O$$

Since phthalaldehyde has two aldehyde groups, both will undergo this oxidation. The aldehyde group (-CHO) is converted to a carboxylate anion ($-COO^-$) because the medium is basic.
Therefore, benzene-1,2-dicarbaldehyde will be oxidized to benzene-1,2-dicarboxylate, which is the phthalate dianion.
The product in option (C) correctly shows this structure.

Step 4: Final Answer:
The reaction oxidizes both aldehyde groups of phthalaldehyde to carboxylate groups, forming the phthalate dianion. This corresponds to the structure shown in option (C).

> Quick Tip
>
> Tollens' test is a classic reaction for identifying aldehydes. Remember that it's a selective, mild oxidation that works in basic conditions, hence the product is a carboxylate anion, not a carboxylic acid. It is also used to distinguish aldehydes from most ketones.

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46. Identify the final product [D] obtained in the following sequence of reactions.
$\mathbf{CH_3CHO} \xrightarrow{i) LiAlH_4, ii) H_2O} [\mathbf{A}] \xrightarrow{H_2SO_4, \Delta} [\mathbf{B}] \xrightarrow{HBr} [\mathbf{C}] \xrightarrow{Na/dry ether} [\mathbf{D}]$

(A) Benzene
(B) Biphenyl
(C) C_4H_{10}
(D) $HC\equiv C^-Na^+$

Correct Answer: (C) C_4H_{10}

Solution:

Step 1: Understanding the Question:
We need to follow a four-step reaction sequence starting from ethanal (acetaldehyde) and determine the structure of the final product [D].

Step 2: Key Formula or Approach:
We will analyze each step of the synthesis by identifying the reagents and their function.

Step 3: Detailed Explanation:
Step 1: Formation of [A]

$$CH_3CHO \xrightarrow{\text{i) LiAlH}_4\text{,ii) H}_2\text{O}} [A]$$

$LiAlH_4$ is a strong reducing agent. It reduces aldehydes to primary alcohols. Ethanal (a 2-carbon aldehyde) will be reduced to ethanol (a 2-carbon alcohol).

$$[A] = CH_3CH_2OH \quad \text{(Ethanol)}$$

Step 2: Formation of [B]

$$CH_3CH_2OH \xrightarrow{H_2SO_4,\Delta} [B]$$

Heating an alcohol with concentrated sulfuric acid is a dehydration reaction that produces an alkene. Ethanol loses a molecule of water to form ethene.

$$[B] = CH_2 = CH_2 \quad \text{(Ethene)}$$

Step 3: Formation of [C]

$$CH_2 = CH_2 \xrightarrow{HBr} [C]$$

This is an electrophilic addition reaction. HBr adds across the double bond of ethene to form an alkyl halide.

$$[C] = CH_3CH_2Br \quad \text{(Bromoethane)}$$

Step 4: Formation of [D]

$$CH_3CH_2Br \xrightarrow{\text{Na/dry ether}} [D]$$

This is the Wurtz reaction. Two molecules of an alkyl halide react with sodium in dry ether to form a new carbon-carbon bond, resulting in a longer alkane.

$$2CH_3CH_2Br + 2Na \rightarrow CH_3CH_2CH_2CH_3 + 2NaBr$$

The product [D] is butane.

Step 4: Final Answer:
The final product [D] is butane, which has the molecular formula C_4H_{10}. This corresponds to option (C).

Quick Tip

For multi-step organic synthesis problems, methodically identify the product of each step. Recognize the key name reactions and the function of common reagents. For example, $LiAlH_4$ is for reduction, conc. H_2SO_4/heat is for dehydration, and Na/dry ether with an alkyl halide indicates the Wurtz reaction for alkane synthesis.

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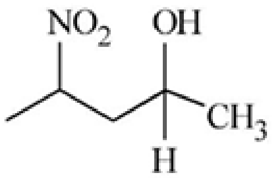
47. Which amongst the following will be most readily dehydrated under acidic conditions ?

(1)



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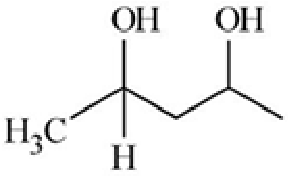

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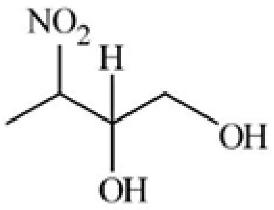

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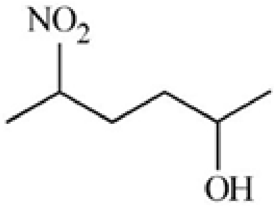

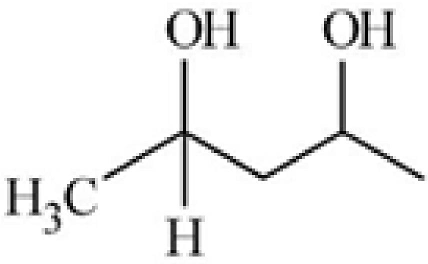

Correct Answer: (B)

Solution:

Step 1: Understanding the Question:
The question asks to identify which of the given alcohols will undergo acid-catalyzed dehydration most readily. The rate of this reaction depends on the stability of the intermediate carbocation formed.

Step 2: Key Formula or Approach:
Acid-catalyzed dehydration of alcohols typically proceeds via an E1 mechanism. The steps are: 1. Protonation of the hydroxyl group to form a good leaving group (-OH_2^+). 2. Loss of water to form a carbocation. This is the rate-determining step. 3. Elimination of a proton (H^+) from an adjacent carbon to form a double bond. The faster the formation of the carbocation (i.e., the more stable the carbocation), the more readily the alcohol will be dehydrated.

Step 3: Detailed Explanation:
Let's analyze the stability of the carbocation formed from each alcohol:
- **(A) 3-Nitrobutan-2-ol:** Dehydration would form a secondary carbocation at C-2. This carbocation is adjacent to a methyl group on one side and a carbon bearing a strong electron-withdrawing nitro group (-NO_2) on the other. The -NO_2 group has a powerful -I (inductive) effect, which strongly destabilizes the adjacent positive charge. Dehydration will be slow.
- **(B) Butan-2,3-diol:** Dehydration of one of the -OH groups (e.g., at C-2) would form a secondary carbocation at C-2. This carbocation is adjacent to a carbon atom (C-3) which has an -OH group. The oxygen atom of this adjacent -OH group can stabilize the positive charge through resonance (+R effect) by donating a lone pair of electrons. Although oxygen also has a -I effect, the +R effect is dominant in stabilizing an adjacent carbocation. This makes the carbocation relatively stable and its formation rapid. This can also lead to a pinacol rearrangement.
- **(C) Structure shown:** This alcohol has a destabilizing -NO_2 group. Similar to (A) and (D), the electron-withdrawing nature of the nitro group will make carbocation formation difficult.
- **(D) 4-Nitrobutan-2-ol:** Dehydration forms a secondary carbocation at C-2. The electron-withdrawing -NO_2 group is at C-4. Its -I effect is weaker than in compound (A) because it is further away, but it still destabilizes the carbocation compared to a simple alkyl group.

Comparison: The carbocation formed from compound (B) is stabilized by the +R effect of an adjacent hydroxyl group. The carbocations formed from (A), (C), and (D) are all destabilized by the electron-withdrawing -NO_2 group. Therefore, butan-2,3-diol (B) will form the most stable intermediate and will be dehydrated most readily.

Step 4: Final Answer:
Compound (B) will be most readily dehydrated because it forms a resonance-stabilized carbocation.

Quick Tip

When comparing rates of E1 reactions (like acid-catalyzed dehydration), always focus on the stability of the carbocation intermediate. Electron-donating groups (like -OH, -OR, alkyl groups) stabilize carbocations, while electron-withdrawing groups (like -NO_2, -CN, -X) destabilize them. The +R effect from an adjacent atom with a lone pair is a very strong stabilizing factor.

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48. Given below are two statements :
Statement I: The nutrient deficient water bodies lead to eutrophication.
Statement II: Eutrophication leads to decrease in the level of oxygen in the water bodies.
In the light of the above statements, choose the correct answer from the options given below :

(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is correct but Statement II is false.
(D) Statement I is incorrect but Statement II is true.

Correct Answer: (D) Statement I is incorrect but Statement II is true.

Solution:

Step 1: Understanding the Question:
We need to evaluate the correctness of two statements related to the environmental phenomenon of eutrophication.

Step 2: Key Formula or Approach:
Analyze each statement based on the definition and consequences of eutrophication.

Step 3: Detailed Explanation:
Analysis of Statement I:
"The nutrient deficient water bodies lead to eutrophication."
Eutrophication is the process of nutrient enrichment of water bodies, which causes excessive growth of plant life like algae. The primary nutrients responsible are nitrates and phosphates, often from agricultural runoff or sewage. Therefore, eutrophication is caused by an **excess of nutrients**, not a deficiency. A nutrient-deficient water body is called oligotrophic. Thus, Statement I is **incorrect**.

Analysis of Statement II:
"Eutrophication leads to decrease in the level of oxygen in the water bodies."
The excessive algal growth (algal bloom) caused by nutrient enrichment blocks sunlight from reaching other aquatic plants, causing them to die. When the large amount of algae in the bloom also dies, it sinks to the bottom. Aerobic bacteria then decompose this large mass of

dead organic matter. This decomposition process consumes a significant amount of dissolved oxygen from the water. This depletion of oxygen leads to a condition called hypoxia, which can cause the death of fish and other aquatic animals. Thus, Statement II is **correct**.

Step 4: Final Answer:
Based on the analysis, Statement I is incorrect and Statement II is true. This corresponds to option (D).

Quick Tip

Remember the cause and effect of eutrophication. Cause: Nutrient (Nitrates/Phosphates) enrichment. Effect: Algal bloom → Death of algae → Decomposition by bacteria → Depletion of dissolved oxygen → Death of aquatic life.

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49. Consider the following reaction :
[Benzyl phenyl ether + HI $\xrightarrow{\Delta}$ A + B]
Identify products A and B.

(A) A = Toluene and B = Phenol
(B) A = Benzyl alcohol and B = Iodobenzene
(C) A = Benzyl iodide and B = Phenol
(D) A = Toluene and B = Iodobenzene

Correct Answer: (C) A = Benzyl iodide and B = Phenol

Solution:

Step 1: Understanding the Question:
The question asks for the products of the reaction between benzyl phenyl ether ($C_6H_5OCH_2C_6H_5$) and hydrogen iodide (HI). This is a cleavage reaction of an ether.

Step 2: Key Formula or Approach:
The cleavage of ethers by hydrogen halides (HX) involves the protonation of the ether oxygen followed by a nucleophilic attack by the halide ion (I^-). The site of the attack depends on the nature of the alkyl/aryl groups attached to the oxygen.
1. If the groups are primary or secondary alkyl groups, the mechanism is S_N2, and the halide attacks the less sterically hindered group.
2. If one of the groups can form a stable carbocation (like tertiary or benzyl), the mechanism has S_N1 character.
3. The bond between an sp^2 carbon of an aryl group and the ether oxygen is very strong and does not break. The oxygen atom remains attached to the aryl group.

Step 3: Detailed Explanation:
The structure of benzyl phenyl ether is C_6H_5-O-CH_2-C_6H_5.

The oxygen is bonded to a phenyl group (C_6H_5-) and a benzyl group (-$CH_2C_6H_5$).
- The C_{phenyl}-O bond is strong due to the sp^2 hybridization of the carbon and partial double bond character from resonance. This bond will not be cleaved by HI.
- The C_{benzyl}-O bond is a bond to an sp^3 hybridized carbon. This is the bond that will be cleaved.

The mechanism proceeds as follows: 1. **Protonation:** The ether oxygen is protonated by HI. C_6H_5-O^+(H)-$CH_2C_6H_5$
2. **Nucleophilic Attack:** The iodide ion (I^-) acts as a nucleophile. It will attack the benzylic carbon. The transition state for this attack is stabilized by the adjacent phenyl ring, whether the mechanism is S_N1 (via a stable benzyl carbocation) or S_N2. The C_{benzyl}-O bond breaks. This results in the formation of benzyl iodide and phenol.

$$C_6H_5CH_2I \quad \text{(Product A, Benzyl iodide)}$$

$$C_6H_5OH \quad \text{(Product B, Phenol)}$$

Step 4: Final Answer:
The products A and B are benzyl iodide and phenol. This corresponds to option (C).

Quick Tip

A key rule for the cleavage of alkyl aryl ethers with HX is that the O-Aryl bond is preserved. The halide ion always attacks the alkyl group, cleaving the O-Alkyl bond. This results in the formation of a phenol and an alkyl halide.

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50. The reaction that does NOT take place in a blast furnace between 900 K to 1500 K temperature range during extraction of iron is:

(A) $Fe_2O_3 + CO \rightarrow 2FeO + CO_2$
(B) $FeO + CO \rightarrow Fe + CO_2$
(C) $C + CO_2 \rightarrow 2CO$
(D) $CaO + SiO_2 \rightarrow CaSiO_3$

Correct Answer: (A) $Fe_2O_3 + CO \rightarrow 2FeO + CO_2$

Solution:

Step 1: Understanding the Question:
We need to identify which of the given chemical reactions does not occur in the specified temperature range (900 K to 1500 K) within a blast furnace used for iron extraction.

Step 2: Key Formula or Approach:
The blast furnace has different temperature zones, and specific reactions occur in each zone. We need to recall the chemistry of the blast furnace.

- **Top Zone (Cooler region, 500 K - 800 K):** Initial reduction of iron oxides.
- **Middle/Bottom Zone (Hotter region, 900 K - 1500 K and above):** Final reduction, slag formation, and melting.

Step 3: Detailed Explanation:

Let's analyze each reaction based on the temperature at which it occurs:

- **(A) Fe_2O_3 + CO → 2FeO + CO_2:** This is the first step in the reduction of iron ore (hematite, Fe_2O_3). According to the Ellingham diagram for the Fe-O system, this reduction is thermodynamically favorable at lower temperatures. It occurs in the upper part of the blast furnace, where the temperature is in the range of 500 K to 800 K. By the time the ore reaches the 900 K zone, this reaction is largely complete.
- **(B) FeO + CO → Fe + CO_2:** This is the final and main reduction step where iron(II) oxide (wüstite) is converted to molten iron. This reaction requires higher temperatures and is the predominant reduction reaction in the 900 K to 1500 K range.
- **(C) C + CO_2 → 2CO:** This is the Boudouard reaction. It is an endothermic reaction that regenerates the reducing agent, carbon monoxide. It is favored at high temperatures (above 1000 K) and thus occurs in the 900 K - 1500 K zone and hotter regions below.
- **(D) CaO + SiO_2 → $CaSiO_3$:** This is the slag formation reaction. Limestone ($CaCO_3$) decomposes to CaO at around 1150 K. The basic flux CaO then reacts with the acidic impurity silica (SiO_2) to form molten calcium silicate (slag). This process occurs in the high-temperature zone of the furnace.

Step 4: Final Answer:

The reaction that does NOT occur in the 900 K to 1500 K range is the reduction of Fe_2O_3 to FeO, as this happens at lower temperatures in the upper part of the furnace. Therefore, option (A) is the correct answer.

Quick Tip

To solve questions about metallurgy, it's helpful to visualize the blast furnace as a vertical reactor with a temperature gradient. The top is coolest, and the bottom is hottest. The reduction of iron oxides happens in stages as the ore descends into hotter zones: $Fe_2O_3 \rightarrow Fe_3O_4 \rightarrow FeO \rightarrow Fe$.
