NEET UG 2023 E6 Chemistry Question Paper with Solutions

Time Allowed :3 Hour 20 Minutes	**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

51. 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) $\mathrm{n}_m = 2l^2 + 1$
(D) $\mathrm{n}_m = l + 2$

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

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 for 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 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 these values (n_m), we can count them. The number of negative values is l, the number of positive values is l, and there is one zero value.
So, the total number of values is:

$$\mathrm{n}_m = l + l + 1$$

$$\mathrm{n}_m = 2l + 1$$

This is the standard formula relating the number of orbitals in a subshell (n_m) to the azimuthal quantum number (l).
The question asks for a formula that expresses l in terms of n_m. We need to rearrange the formula:

$$\mathrm{n}_m = 2l + 1$$

Subtract 1 from both sides:

$$\mathrm{n}_m - 1 = 2l$$

Divide by 2:

$$l = \frac{\mathrm{n}_m - 1}{2}$$

Step 4: Final Answer:
The correct relationship is $l = \frac{\mathrm{n}_m - 1}{2}$, which corresponds to option (A).

Quick Tip

Remember that the number of orbitals in a subshell is always an odd number (1 for s, 3 for p, 5 for d, 7 for f). This is because the formula is $2l+1$, which always yields an odd integer for integer values of l.

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52. 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 which of the given elements will form the largest ion when it achieves a stable noble gas electron configuration.

Step 2: Detailed Explanation:
First, let's determine the ion each element forms to attain a noble gas configuration:

- **O (Oxygen, Z=8):** Belongs to Group 16. It gains 2 electrons to form the oxide anion, O^{2-}, which has the electron configuration of Neon (Ne). The ion has 8 protons and 10 electrons.
- **F (Fluorine, Z=9):** Belongs to Group 17. It gains 1 electron to form the fluoride anion, F^{-}, which also has the configuration of Neon. The ion has 9 protons and 10 electrons.
- **N (Nitrogen, Z=7):** Belongs to Group 15. It gains 3 electrons to form the nitride anion, N^{3-}, which also has the configuration of Neon. The ion has 7 protons and 10 electrons.
- **Na (Sodium, Z=11):** Belongs to Group 1. It loses 1 electron to form the sodium cation, Na^{+}, which also has the configuration of Neon. The ion has 11 protons and 10 electrons.

All four resulting ions (N^{3-}, O^{2-}, F^{-}, and Na^{+}) are **isoelectronic**, meaning they have the same number of electrons (10 electrons).

Step 3: Comparing Ionic Radii of Isoelectronic Species:
For isoelectronic species, the ionic radius is inversely proportional to the nuclear charge (the

number of protons). A higher nuclear charge exerts a stronger electrostatic pull on the same number of electrons, thus shrinking the ion's size.
Let's compare the number of protons (nuclear charge) for each ion:

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

The order of nuclear charge is: N ¡ O ¡ F ¡ Na.
Since ionic radius is inversely related to nuclear charge for isoelectronic species, the order of ionic radii will be:

$$N^{3-} > O^{2-} > F^{-} > Na^{+}$$

Step 4: Final Answer:
The nitride ion, N^{3-}, has the fewest protons pulling on the 10 electrons, resulting in the weakest effective nuclear charge and therefore the largest ionic radius.

Quick Tip

For isoelectronic species (same number of electrons), the ion with the lowest atomic number (fewest protons) will be the largest. Conversely, the one with the highest atomic number will be the smallest.

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53. 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 molecule that undergoes polymerization to form the polymer known as neoprene.

Step 2: Detailed Explanation:
Neoprene is a type of synthetic rubber that is known for its chemical stability and resistance to oil, heat, and weathering. It is produced by the free-radical polymerization of its monomer

unit.

The monomer of neoprene is **chloroprene**.

Let's analyze the chemical structures of the given options to identify chloroprene.

(A) $H_2C = CH - CH = CH_2$: This is 1,3-Butadiene. It is a monomer for other synthetic rubbers like Buna-S and Buna-N.

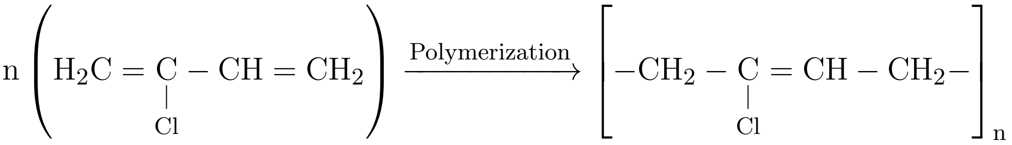
(B) $H_2C = C(Cl) - CH = CH_2$: The IUPAC name for this molecule is 2-chloro-1,3-butadiene. This is the chemical structure of **chloroprene**. Its polymerization yields neoprene (polychloroprene).

(C) $H_2C = CH - C \equiv CH$: This is Vinylacetylene.

(D) $H_2C = C(CH_3) - CH = CH_2$: The IUPAC name for this molecule is 2-methyl-1,3-butadiene. This is the chemical structure of **isoprene**, which is the monomer unit of natural rubber.

Step 3: Final Answer:

The molecule that polymerizes to produce neoprene is chloroprene, which is 2-chloro-1,3-butadiene, corresponding to option (B).



$$n\left(H_2C = \underset{\substack{|\\ Cl}}{C} - CH = CH_2\right) \xrightarrow{\text{Polymerization}} \left[-CH_2 - \underset{\substack{|\\ Cl}}{C} = CH - CH_2-\right]_n$$

(Chloroprene) (Neoprene)

Quick Tip

Remember the key monomers for common rubbers: Isoprene (2-methyl-1,3-butadiene) for natural rubber, and Chloroprene (2-chloro-1,3-butadiene) for neoprene. Notice the structural similarity, with a methyl group replaced by a chlorine atom.

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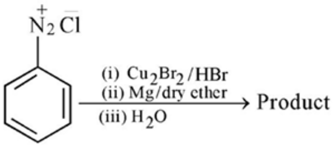
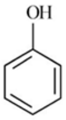
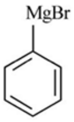
54. Identify the product in the following reaction:



(1) 

(2) 

(3) 

(4) 

Correct Answer: (B) Benzene

Solution:

Step 1: Understanding the Question:
The question shows a three-step reaction starting from benzene diazonium chloride and asks for the final product. We need to analyze each step sequentially.

Step 2: Detailed Explanation:
Step (i): Benzene diazonium chloride + Cu_2Br_2/HBr
This is a Sandmeyer reaction. The diazonium group (-$N_2^+Cl^-$) is a very good leaving group and is replaced by a bromide ion (Br^-) from the reagent.
The product of this step is bromobenzene.

Step (ii): Bromobenzene + Mg/dry ether
This reaction is the formation of a Grignard reagent. Bromobenzene reacts with magnesium metal in the presence of dry ether as a solvent.
The product is phenylmagnesium bromide (Ph-MgBr).

Step (iii): Phenylmagnesium bromide + H_2O
This step is the hydrolysis of the Grignard reagent. Grignard reagents are strong bases and react with any source of protons, such as water. The phenyl anion part of the Grignard reagent abstracts a proton (H^+) from water.
The product is benzene (C_6H_6) and magnesium hydroxybromide (Mg(OH)Br).

Step 3: Final Answer:
The final product of the three-step reaction sequence is benzene. This corresponds to option (B).

Quick Tip

Remember the reactivity of Grignard reagents. They are strong nucleophiles and strong bases. Any reaction with a protic solvent like water, alcohol, or acid will protonate the carbanion part of the Grignard reagent to form an alkane (or in this case, an arene).

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55. 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 and asks to calculate the cell constant (G* or l/A).

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

$$\text{Conductivity}(\kappa) = \frac{1}{\text{Resistance}(R)} \times \text{Cell Constant}(G^*)$$

The term $(1/R)$ is known as conductance (G).
So, $\kappa = G \times G^*$.
We can rearrange this formula to solve for the cell constant:

$$\text{Cell Constant}(G^*) = \text{Conductivity}(\kappa) \times \text{Resistance}(R)$$

Step 3: Detailed Explanation:
We are given the following values:
Conductivity (κ) = 0.0210 ohm^{-1} cm^{-1}
Resistance (R) = 60 ohm
Now, we can substitute these values into the rearranged formula:

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

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

The 'ohm^{-1}' and 'ohm' units will cancel out, leaving the unit 'cm^{-1}'.

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

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

Step 4: Final Answer:
The value of the cell constant is 1.26 cm^{-1}. This corresponds to option (C).

Quick Tip

Remember the fundamental formula: Resistance $R = \rho\frac{l}{A}$. Taking the reciprocal of both sides gives Conductance $G = \kappa\frac{A}{l}$. Rearranging gives Conductivity $\kappa = G \times \frac{l}{A}$, where $\frac{l}{A}$ is the cell constant. This helps derive the final working formula $G^* = \kappa \times R$.

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56. 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 the allotropes of carbon (List-I) with their corresponding properties or uses (List-II).

Step 3: Detailed Explanation:
Let's match each item from List-I to List-II:

- **A. Coke:** Coke is an impure, amorphous form of carbon. It is widely used in metallurgy as a fuel and as a strong reducing agent to reduce metal oxides to metals (e.g., in a blast furnace). So, **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 requires the carbon atoms to be sp^3 hybridized. So, **B matches I**.
- **C. Fullerene:** Fullerenes (like C_60, Buckyball) are molecules composed entirely of carbon, in the form of a hollow sphere, ellipsoid, or tube. They are often described as cage-like molecules. So, **C matches IV**.
- **D. Graphite:** Graphite has a layered structure. The layers are held by weak van der Waals forces, allowing them to slide over one another. This property makes graphite an excellent solid or dry lubricant. So, **D matches II**.

The correct matching is: A → III, B → I, C → IV, D → II.

Step 4: Final Answer:
The option that corresponds to the correct matching (A-III, B-I, C-IV, D-II) is (C).

Quick Tip

Associate each carbon allotrope with its key feature: Diamond → sp^3, hard; Graphite → sp^2, layers, lubricant; Fullerene → cage, sphere; Coke/Charcoal → amorphous, reducing agent.

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57. 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 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: (B) Both A and R are true and R is NOT the correct explanation of A.

Solution:

Step 1: Understanding the Question:
The question presents an Assertion about the possibility of zero activation energy and a Reason that defines activation energy. We need to evaluate both statements and their relationship.

Step 2: Detailed Explanation:
Analysis of Assertion A:
Assertion A states that a reaction can have zero activation energy. Activation energy (E_a) is the energy barrier that must be overcome for reactants to be converted into products. For most reactions, this barrier is significant. However, for reactions between highly reactive species, such as free radicals, the activation energy can be very low or effectively zero. For example, the recombination of two methyl radicals:

$$\cdot CH_3 + \cdot CH_3 \rightarrow CH_3\text{–}CH_3$$

This reaction occurs almost on every collision without an energy barrier. Therefore, the statement that a reaction can have zero activation energy is correct. **Assertion A is true**.

Analysis of Reason R:
Reason R gives the definition of activation energy: "The minimum extra amount of energy absorbed by reactant molecules so that their energy becomes equal to threshold value, is called activation energy." This is the precise and correct definition of activation energy according to collision theory. Reactant molecules have some average kinetic energy, and they need to gain

an additional amount of energy (E_a) to reach the total threshold energy required for a reaction to occur. **Reason R is true**.

Connecting A and R:
Now, we must determine if Reason R is the correct explanation for Assertion A. Assertion A makes a claim about a specific case ($E_a = 0$). Reason R provides the general definition of what E_a is. The definition itself does not explain *why* or in which cases E_a can be zero. The explanation for $E_a = 0$ lies in the high reactivity and inherent instability of the reactants (like radicals), meaning they are already at a high energy state and do not require an additional energy push to react. Thus, the general definition (R) does not explain the specific phenomenon (A).

Step 3: Final Answer:
Both Assertion A and Reason R are true statements, but Reason R is not the correct explanation for Assertion A. Therefore, the correct option is (B).

Quick Tip

For Assertion-Reason questions, first validate each statement independently. Then, to check if R explains A, phrase it as "A is true *because* R is true." If the resulting sentence doesn't make logical sense, then R is not the correct explanation of A.

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58. 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. A homoleptic complex is a coordination complex where the central metal ion is bonded to only one type of ligand. In contrast, a heteroleptic complex has more than one type of ligand.

Step 2: Detailed Explanation:
Let's examine the ligands attached to the central metal ion in each complex:
1. **Potassium trioxalatoaluminate (III):**
The complex ion is $[Al(C_2O_4)_3]^{3-}$.
The central metal is Aluminium (Al).
The ligand is oxalato ($C_2O_4{}^{2-}$). There are three oxalato ligands.

Since there is only **one type** of ligand, this is a **homoleptic** complex.

2. **Diamminechloridonitrito - N - platinum (II):**
The complex ion is $[Pt(NH_3)_2(Cl)(NO_2)]$.
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.

3. **Pentaamminecarbonatocobalt (III) chloride:**
The complex ion 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.

4. **Triamminetriaquachromium (III) chloride:**
The complex ion 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 3: Final Answer:
Only the complex in option (A) contains a single type of ligand (oxalato). Therefore, it is the homoleptic complex.

Quick Tip

The prefixes "homo-" means "same" and "hetero-" means "different". To quickly identify a homoleptic complex from its name, look for only one ligand name before the metal name (e.g., "trioxalato"). If you see multiple ligand names (e.g., "diamminechlorido..."), it's heteroleptic.

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59. 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 structure of an ionic compound formed from elements A and B. We are given the lattice type formed by B and the location of A in the voids of this lattice. We need to determine the empirical formula (A_xB_y) and then calculate the sum x + y.

Step 2: Key Formula or Approach:
In a close-packed structure (like ccp or hcp), if the number of atoms forming the lattice is N, then:

- Number of Octahedral Voids = N
- Number of Tetrahedral Voids = 2N

The cubic close-packed (ccp) structure is also known as the face-centered cubic (fcc) structure.

Step 3: Detailed Explanation:
1. **Determine the effective number of atoms of B:**
Element B forms a ccp lattice. Let's assume the number of atoms of B in the unit cell is N.
So, the effective number of B atoms = N.

2. **Determine the effective number of atoms of A:**
Atoms of A occupy 1/3 of the tetrahedral voids.
The total number of tetrahedral voids is 2N.
So, the effective number of A atoms = $\frac{1}{3} \times (\text{Number of tetrahedral voids}) = \frac{1}{3} \times (2N) = \frac{2}{3}N$.

3. **Determine the ratio and formula:**
The ratio of atoms A : B in the compound is:

$$A : B = \frac{2}{3}N : N$$

To get the simplest whole number ratio, we can multiply both sides by 3:

$$A : B = \left(\frac{2}{3}N \times 3\right) : (N \times 3)$$

$$A : B = 2N : 3N$$

$$A : B = 2 : 3$$

Thus, the empirical formula of the compound is A_2B_3.

4. **Calculate x + y:**
Comparing the derived formula A_2B_3 with the given format A_xB_y, we get:
x = 2
y = 3
The value of x + y = 2 + 3 = 5.

Step 4: Final Answer:
The value of x + y is 5. The correct option is (A).

Quick Tip

For problems involving crystal lattices, always start by assuming the number of atoms forming the main lattice is 'N'. Then, calculate the number of atoms occupying the voids relative to 'N'. Finally, simplify the ratio to find the empirical formula.

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60. 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:
The question asks for the mass of carbon dioxide (CO_2) produced from the thermal decomposition of a given mass of impure limestone. We need to use stoichiometry, considering the purity of the sample.

Step 2: Key Formula or Approach:
1. Calculate the mass of pure calcium carbonate ($CaCO_3$) in the limestone sample.
2. Use the balanced chemical equation to relate the moles of $CaCO_3$ to the moles of CO_2.
3. Convert the moles of CO_2 to mass.
The balanced equation is: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Step 3: Detailed Explanation:
Part 1: Calculate the mass of pure $CaCO_3$
Total mass of limestone sample = 20 g.
Purity of limestone = 20%.
This means only 20% of the sample is $CaCO_3$.

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

Part 2: Calculate Molar Masses
We need the molar masses of $CaCO_3$ and CO_2. (Atomic masses: Ca=40, C=12, O=16)
Molar mass of $CaCO_3 = 40 + 12 + 3(16) = 40 + 12 + 48 = 100$ g/mol.
Molar mass of $CO_2 = 12 + 2(16) = 12 + 32 = 44$ g/mol.

Part 3: Stoichiometric Calculation
From the balanced chemical equation:

$$CaCO_3 \rightarrow CaO + CO_2$$

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.
We have 4 g of pure $CaCO_3$. We can set up a proportion to find the mass of CO_2 produced.

$$\frac{\text{Mass of } CO_2}{\text{Mass of } CaCO_3} = \frac{\text{Molar mass of } CO_2}{\text{Molar mass of } CaCO_3}$$
$$\frac{\text{Mass of } CO_2}{4 \text{ g}} = \frac{44 \text{ g/mol}}{100 \text{ g/mol}}$$
$$\text{Mass of } CO_2 = 4 \text{ g} \times \frac{44}{100}$$
$$\text{Mass of } CO_2 = 1.76 \text{ g}$$

Step 4: Final Answer:
The mass of CO_2 produced by heating 20 g of 20% pure limestone is 1.76 g.

Quick Tip

In problems involving impure reactants, always start by calculating the actual mass of the pure reactant that participates in the reaction. The impurities are assumed to be non-reactive.

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61. 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 pairs of halides of Group 13 elements. This relates to the concept of the inert pair effect.

Step 2: Key Formula or Approach:

Inert Pair Effect: In the p-block, as we move down a group, the stability of the lower oxidation state increases while the stability of the higher oxidation state decreases. For Group 13 (B, Al, Ga, In, Tl), the possible oxidation states are +3 and +1. The stability of the +1 oxidation state increases down the group, and it becomes the most stable state for the heaviest element, Thallium (Tl).

Stability order for +3 state: $Al^{3+} > Ga^{3+} > In^{3+} > Tl^{3+}$

Stability order for +1 state: $Tl^{+} > In^{+} > Ga^{+} > Al^{+}$

Step 3: Detailed Explanation:

Let's analyze each option based on this principle:

(A) $TlCl_3$ > TlCl:

In $TlCl_3$, Thallium is in the +3 oxidation state. In TlCl, it is in the +1 oxidation state. Due to the pronounced inert pair effect in Thallium, the +1 oxidation state is significantly more stable than the +3 oxidation state. Therefore, TlCl is more stable than $TlCl_3$. This statement is incorrect.

(B) InI_3 > InI:

In InI_3, Indium is in the +3 oxidation state. In InI, it is in the +1 oxidation state. For Indium, the +3 state is generally more stable than the +1 state. However, the large size of the iodide ion (I^-) makes it a poor oxidizing agent, and it cannot stabilize the higher oxidation state of indium well. Thus, InI is more stable than InI_3. This statement is incorrect.

(C) AlCl > $AlCl_3$:

In AlCl, Aluminum is in the +1 oxidation state. In $AlCl_3$, it is in the +3 oxidation state. For Aluminum, a lighter element in the group, the +3 oxidation state is overwhelmingly more stable than the +1 state. The inert pair effect is negligible for Al. Thus, $AlCl_3$ is much more stable than AlCl. This statement is incorrect.

(D) TlI > TlI_3:

In TlI, Thallium is in the +1 oxidation state. In TlI_3, it appears to be in the +3 state. As established for Thallium, the +1 state is more stable than the +3 state. Thus, TlI is more stable than a compound with Tl^{3+}. In fact, TlI_3 is an ionic compound composed of Tl^+ and $I_3{}^-$ ions, which further emphasizes the stability of the Tl^+ ion. The relationship TlI > TlI_3 in terms of stability is correct.

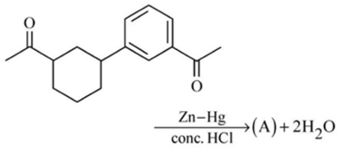
Step 4: Final Answer:

The correct stability relationship is TlI > TlI_3.

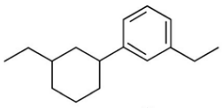
Quick Tip

Remember the trend for the inert pair effect: stability of the lower oxidation state (Group number - 2) increases down the p-block. For Group 13, Tl(+1) is more stable than Tl(+3). For Group 14, Pb(+2) is more stable than Pb(+4). For Group 15, Bi(+3) is more stable than Bi(+5).

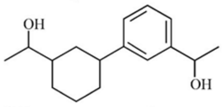
62. Identify product (A) in the following reaction:



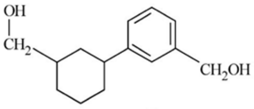
(1)



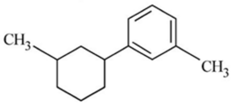
(2)



(3)



(4)



Correct Answer: (A) (structure of 1-ethyl-3-cyclohexylbenzene)

Solution:

Step 1: Understanding the Question:
The question asks to predict the major product (A) of a reaction involving a diketone and the reagent Zn-Hg/conc. HCl. The reactant is 4-(3-acetylphenyl)cyclohexan-1-one.

Step 2: Key Formula or Approach:
The reagents Zn-Hg (zinc amalgam) and concentrated HCl are used for the **Clemmensen Reduction**. This reaction specifically reduces the carbonyl group (C=O) of aldehydes and ketones to a methylene group (CH_2).

$$¿\mathrm{C{=}O} \xrightarrow[\text{conc. HCl}]{\text{Zn-Hg}} ¿\mathrm{CH_2} + \mathrm{H_2O}$$

Step 3: Detailed Explanation:
The starting material has two ketone functional groups that can be reduced by the Clemmensen reagent:

1. The carbonyl group of the acetyl group ($-COCH_3$) attached to the benzene ring.
2. The carbonyl group (C=O) within the cyclohexanone ring.

Both of these carbonyl groups will be reduced to methylene groups.

- Reduction of the acetyl group: The $-C(=O)CH_3$ group will be reduced to an ethyl group ($-CH_2CH_3$).
- Reduction of the cyclohexanone ring: The C=O group in the ring will be reduced to a CH_2 group, converting the cyclohexanone ring into a cyclohexane ring.

Therefore, the final product (A) will be 1-ethyl-3-cyclohexylbenzene.

Step 4: Final Answer:
Looking at the options, option (A) correctly shows the structure of 1-ethyl-3-cyclohexylbenzene, where both carbonyl groups have been completely reduced to methylene groups. Options (B) and (C) show alcohols, which would be products of reduction with reagents like $NaBH_4$ or $LiAlH_4$, not Clemmensen reduction. Option (D) shows incorrect reduction. The correct product is shown in option (A).

Quick Tip

Recognize key named reactions by their reagents. Zn-Hg/HCl signifies Clemmensen Reduction (ketone → alkane). Wolff-Kishner reduction (N_2H_4/KOH) does the same but under basic conditions. $NaBH_4$/$LiAlH_4$ reduce ketones to secondary alcohols.

---

63. 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 evaluate five statements related to atomic structure and identify the combination of correct statements.

Step 2: Detailed Explanation:
Let's analyze each statement individually:
A. Atoms of all elements are composed of two fundamental particles.
This statement is **incorrect**. Atoms are composed of three fundamental particles: protons, neutrons, and electrons. An exception is the protium isotope of hydrogen (^{1}H), which has one proton and one electron but no neutron, but the statement refers to atoms of "all elements" in general.

B. The mass of the electron is 9.10939×10^{-31} kg.
This statement is **correct**. This is the experimentally determined and accepted value for the rest mass of an electron.

C. All the isotopes of a given element show same chemical properties.
This statement is **correct**. Isotopes are atoms of the same element with the same number of protons but different numbers of neutrons. Since chemical properties are primarily determined by the electron configuration, which is dictated by the number of protons (atomic number), isotopes of an element exhibit identical chemical properties.

D. Protons and electrons are collectively known as nucleons.
This statement is **incorrect**. Nucleons are the particles found in the atomic nucleus. The nucleus contains protons and neutrons. Therefore, protons and neutrons are collectively known as nucleons.

E. Dalton's atomic theory, regarded the atom as an ultimate particle of matter.
This statement is **correct**. A key postulate of John Dalton's atomic theory was that atoms are indivisible and indestructible particles, which he considered the ultimate (fundamental) particles of matter. Although this was later proven incorrect, the statement accurately describes a tenet of his theory.

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

Quick Tip

Remember the definitions: Isotopes (same Z, different A), Isobars (different Z, same A), Isotones (same number of neutrons). Chemical properties depend on electrons (and thus Z), while nucleons are just protons + neutrons in the nucleus.

---

64. 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 provides the rate law for a reaction and asks how the initial reaction rate changes

when the concentration of one reactant, A, is tripled, while the concentration of the other reactant, B, is kept constant.

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

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

where k is the rate constant, [A] is the concentration of reactant A, and [B] is the concentration of reactant B. We need to compare the initial rate with the new rate after changing [A].

Step 3: Detailed Explanation:
Let the initial rate be R_1. According to the rate law,

$$R_1 = k[\text{A}]^2[\text{B}]$$

Now, the initial concentration of A is tripled. Let the new concentration of A be [A]'.

$$[\text{A}]' = 3[\text{A}]$$

The concentration of B remains constant.
Let the new rate be R_2. The rate law for the new conditions is:

$$R_2 = k[\text{A}']^2[\text{B}]$$

Substitute the value of [A]':

$$R_2 = k(3[\text{A}])^2[\text{B}]$$
$$R_2 = k(9[\text{A}]^2)[\text{B}]$$
$$R_2 = 9 \times (k[\text{A}]^2[\text{B}])$$

Since $R_1 = k[\text{A}]^2[\text{B}]$, we can substitute this into the equation for R_2:

$$R_2 = 9 \times R_1$$

Step 4: Final Answer:
The new rate (R_2) is nine times the initial rate (R_1). Therefore, the initial rate would increase by a factor of nine.

Quick Tip

To quickly find the effect of a concentration change on the rate, take the factor by which the concentration is changed and raise it to the power of the order of the reaction with respect to that reactant. Here, concentration of A is tripled (factor of 3) and the order is 2, so the rate changes by a factor of $3^2 = 9$.

65. 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 asks to evaluate the correctness of two statements related to the structure of nucleosides and nucleotides, which are the building blocks of nucleic acids (DNA and RNA).

Step 3: Detailed Explanation:
Analysis of Statement I:
A nucleoside is a structural subunit of nucleic acids.
It is formed when a nitrogenous base (like adenine, guanine, cytosine, thymine, or uracil) is attached to a pentose sugar (either ribose or deoxyribose) via a β-glycosidic bond.
This bond is specifically formed between the C-1' of the sugar and a nitrogen atom of the base (N-9 for purines, N-1 for pyrimidines).
Therefore, Statement I, "A unit formed by the attachment of a base to 1' position of sugar is known as nucleoside," is correct.

Analysis of Statement II:
A nucleotide is formed when a phosphate group is attached to a nucleoside.
This attachment occurs through a phosphoester bond between the phosphate group and the hydroxyl group at the 5'-position of the sugar moiety of the nucleoside.
The phosphate group is derived from **phosphoric acid (H_3PO_4)**, not phosphorous acid (H_3PO_3).
Therefore, Statement II, "When nucleoside is linked to phosphorous acid at 5'-position of sugar moiety, we get nucleotide," is false due to the mention of "phosphorous acid".

Step 4: Final Answer:
Based on the analysis, Statement I is true and Statement II is false. Thus, the correct option is (C).

Quick Tip

In biochemistry, pay close attention to the specific names of chemical compounds. A small difference, like "phosphoric acid" vs. "phosphorous acid," can change the entire meaning and correctness of a statement.

---

66. 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 from the given options. A Lewis acid is a chemical species that can accept an electron pair from a Lewis base.

Step 3: Detailed Explanation:
Let's analyze each option based on the definition of a Lewis acid:

- **NH_3 (Ammonia):** The nitrogen atom in ammonia has a lone pair of electrons which it can donate. Therefore, NH_3 acts as a Lewis base.
- **H_2O (Water):** The oxygen atom in water has two lone pairs of electrons available for donation. Thus, H_2O acts as a Lewis base.
- **BF_3 (Boron trifluoride):** The central boron atom in BF_3 has only six electrons in its valence shell (three covalent bonds). Its octet is incomplete, making it electron-deficient. It can accept a pair of electrons into its vacant p-orbital to complete its octet. Therefore, BF_3 acts as a Lewis acid.
- **OH^- (Hydroxide ion):** The oxygen atom in the hydroxide ion has lone pairs of electrons and a negative charge, making it an excellent electron-pair donor. Thus, OH^- acts as a Lewis base.

Step 4: Final Answer:
Among the given options, only BF_3 is an electron-deficient molecule and can accept an electron pair, making it a Lewis acid. The correct option is (C).

Quick Tip

To identify Lewis acids, look for molecules with an incomplete octet on the central atom (like BF_3, $AlCl_3$), cations (like H^+, Mg^{2+}), or molecules with central atoms that can expand their octet.

---

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

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

(B) $CH_3CN \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}}$ Product

(C) $CH_3NC \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}}$ Product

(D) $CH_3CONH_2 \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}}$ Product

Correct Answer: (C) $CH_3NC \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}}$ Product

Solution:

Step 1: Understanding the Question:
The question asks to identify which of the given reactions does not produce a primary amine ($R\text{-}NH_2$).

Step 2: Detailed Explanation:
Let's analyze the product of each reaction:
1. $\mathbf{CH_3CONH_2 \xrightarrow{Br_2/KOH}}$ **Product**: This is the **Hofmann bromamide degradation** reaction. It converts a primary amide into a primary amine with one less carbon atom.

$$CH_3CONH_2 \xrightarrow{Br_2/KOH} CH_3NH_2 + 2KBr + K_2CO_3 + 2H_2O$$

The product is methylamine (CH_3NH_2), which is a primary amine.

2. $\mathbf{CH_3CN \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}}}$ **Product**: This is the reduction of a nitrile (cyanide) using a strong reducing agent, lithium aluminium hydride ($LiAlH_4$). Nitriles are reduced to primary amines.

$$CH_3C \equiv N \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}} CH_3CH_2NH_2$$

The product is ethylamine ($CH_3CH_2NH_2$), which is a primary amine.

3. $\mathbf{CH_3NC \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}}}$ **Product**: This is the reduction of an isonitrile (isocyanide). The reduction of an isonitrile yields a **secondary amine**.

$$CH_3N \equiv C \xrightarrow{\text{(i) LiAlH}_4 \text{ (ii) H}_3\text{O}^{\oplus}} CH_3NHCH_3$$

The product is N-methylmethanamine (dimethylamine), which is a secondary amine.

4. **CH_3CONH_2** $\xrightarrow{\text{(i) LiAlH}_4\text{ (ii) H}_3\text{O}^{\oplus}}$ **Product**: This is the reduction of an amide. $LiAlH_4$ reduces the carbonyl group (C=O) of the amide to a methylene group (CH_2).

$$CH_3CONH_2 \xrightarrow{\text{(i) LiAlH}_4\text{ (ii) H}_3\text{O}^{\oplus}} CH_3CH_2NH_2$$

The product is ethylamine ($CH_3CH_2NH_2$), which is a primary amine.

Step 3: Final Answer:
The reaction of methyl isocyanide with $LiAlH_4$ (option C) is the only one that produces a secondary amine. Therefore, it is the reaction that will NOT give a primary amine as the product.

Quick Tip

A key distinction to remember for synthesis of amines: Reduction of nitriles (R-CN) gives primary amines (R-CH_2NH_2), while reduction of isonitriles (R-NC) gives secondary amines (R-$NHCH_3$).

---

68. 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 us to identify and count the number of molecules from the given list that do not follow 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.

Step 2: Detailed Explanation:
Let's analyze the number of valence electrons around the central atom for each species:

- **NH_3 (Ammonia):** The central atom is Nitrogen (N). Nitrogen has 5 valence electrons. It forms 3 single covalent bonds with 3 Hydrogen atoms. It also has 1 lone pair of electrons. Total electrons around N = (3 bond pairs × 2 electrons/pair) + (1 lone pair × 2 electrons) = 6 + 2 = 8 electrons. NH_3 follows the octet rule.

- **$AlCl_3$ (Aluminum Chloride):** The central atom is Aluminum (Al). Aluminum has 3 valence electrons. It forms 3 single covalent bonds with 3 Chlorine atoms.
  Total electrons around Al = 3 bond pairs × 2 electrons/pair = 6 electrons. $AlCl_3$ is electron-deficient and does NOT follow the octet rule.

- **$BeCl_2$ (Beryllium Chloride):** The central atom is Beryllium (Be). Beryllium has 2 valence electrons. It forms 2 single covalent bonds with 2 Chlorine atoms.
  Total electrons around Be = 2 bond pairs × 2 electrons/pair = 4 electrons. $BeCl_2$ is electron-deficient and does NOT follow the octet rule.

- **CCl_4 (Carbon Tetrachloride):** The central atom is Carbon (C). Carbon has 4 valence electrons. It forms 4 single covalent bonds with 4 Chlorine atoms.
  Total electrons around C = 4 bond pairs × 2 electrons/pair = 8 electrons. CCl_4 follows the octet rule.

- **PCl_5 (Phosphorus Pentachloride):** The central atom is Phosphorus (P). Phosphorus has 5 valence electrons. It forms 5 single covalent bonds with 5 Chlorine atoms.
  Total electrons around P = 5 bond pairs × 2 electrons/pair = 10 electrons. PCl_5 has an expanded octet and does NOT follow the octet rule.

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

Quick Tip

To check for the octet rule, calculate the total number of valence electrons around the central atom. Count 2 electrons for each single bond, 4 for a double bond, 6 for a triple bond, and 2 for each lone pair. Species with fewer than 8 electrons are "electron-deficient," and those with more than 8 are said to have an "expanded octet."

---

69. 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.

(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 requires identifying the incorrect statements about hydrogen and its compounds from the given list.

Step 3: Detailed Explanation:
Let's evaluate each statement:
Statement A: Hydrogen is used to reduce heavy metal oxides to metals.
This is a correct statement. Hydrogen is a good reducing agent, especially for oxides of metals that are less reactive than iron (e.g., Cu, Pb, W). For example: $CuO + H_2 \rightarrow Cu + H_2O$.

Statement B: Heavy water is used to study reaction mechanism.
This is a correct statement. Heavy water (D_2O) is used as a tracer to study the mechanisms of chemical and biological reactions due to the kinetic isotope effect.

Statement C: Hydrogen is used to make saturated fats from oils.
This is a correct statement. The process is called hydrogenation, where unsaturated fats (oils) are treated with hydrogen in the presence of a catalyst (like Ni, Pt, or Pd) to form saturated fats (like vanaspati ghee).

Statement D: The H-H bond dissociation enthalpy is lowest as compared to a single bond between two atoms of any element.
This is an incorrect statement. The H-H bond dissociation enthalpy is very high (435.9 kJ/mol), which is one of the highest for a single bond between two atoms of the same element. For instance, the F-F bond (158.8 kJ/mol) is much weaker.

Statement E: Hydrogen reduces oxides of metals that are more active than iron.
This is an incorrect statement. According to the reactivity series, hydrogen can only reduce the oxides of metals that are less reactive than it. It cannot reduce the oxides of highly reactive metals like Na, K, Ca, Mg, Al, or even Fe, which are more active than iron. It can reduce oxides of copper, lead, tin, etc., which are less active than iron.

Step 4: Final Answer:
The statements that are NOT correct are D and E. Therefore, the correct option is (C).

Quick Tip

Remember the reactivity series of metals. Hydrogen can reduce oxides of metals placed below it in the series (e.g., Cu, Ag, Au), but not those above it (e.g., K, Na, Ca, Mg, Al, Zn, Fe).

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70. 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 asks for the weight of two moles of the organic product formed from the reaction of sodium ethanoate with sodium hydroxide and calcium oxide. This reaction is a classic example of decarboxylation.

Step 2: Key Formula or Approach:
The reaction is the soda-lime decarboxylation of a carboxylic acid salt. The general reaction is:

$$\text{RCOONa} + \text{NaOH} \xrightarrow{\text{CaO},\Delta} \text{R-H} + \text{Na}_2\text{CO}_3$$

The mixture of NaOH and CaO is known as soda-lime. The reaction produces an alkane with one less carbon atom than the parent carboxylate salt.

Step 3: Detailed Explanation:
1. **Identify the reactants and reaction type:**
Reactant: Sodium ethanoate (CH_3COONa).
Reagent: Sodium hydroxide (NaOH) in the presence of calcium oxide (CaO), which is soda-lime.
Reaction: Soda-lime decarboxylation.

2. **Write the specific chemical equation:**

$$\text{CH}_3\text{COONa} + \text{NaOH} \xrightarrow{\text{CaO},\Delta} \text{CH}_4 + \text{Na}_2\text{CO}_3$$

The organic compound obtained is methane (CH_4).

3. **Calculate the molar mass of the product (methane):**
Molar mass of CH_4 = (Atomic mass of C) + 4 × (Atomic mass of H)

Molar mass of CH_4 = 12 g/mol + 4 × 1 g/mol = 16 g/mol.

4. **Calculate the weight of two moles of the product:**
Weight = Number of moles × Molar mass
Weight = 2 mol × 16 g/mol = 32 g.

Step 4: Final Answer:
The weight of two moles of the organic product, methane, is 32 g. Therefore, the correct option is (B).

Quick Tip

Soda-lime decarboxylation is a straightforward way to step down a carbon chain. It removes the -COONa group and replaces it with an H atom, forming an alkane. Remember the product will always have one carbon less than the starting carboxylate salt.

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71. 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 requires us to determine the total number of sigma (σ) bonds, pi (π) bonds, and lone pairs of electrons in a molecule of pyridine (C_5H_5N). First, we need to know the structure of pyridine. Pyridine is a six-membered aromatic heterocyclic compound containing one nitrogen atom.

Step 2: Detailed Explanation:
The structure of pyridine is:
Let's count each type of bond and the lone pairs:

1. Counting σ bonds:
Every single bond is a σ bond, and every double bond contains one σ bond.

- Bonds within the ring: There are 6 atoms in the ring, so there are 6 σ bonds forming the ring skeleton (4 C-C and 2 C-N).

- Bonds to hydrogen: There are 5 carbon atoms, and each is bonded to one hydrogen atom. This gives 5 C-H σ bonds.

Total σ bonds = 6 (in ring) + 5 (C-H) = **11 σ bonds**.

2. Counting π bonds:
The aromatic ring of pyridine has three double bonds to satisfy the valency of carbon and nitrogen and to form the delocalized π system. Each double bond contains one π bond.
Total π bonds = **3 π bonds**.

3. Counting lone pairs:

- Carbon (Group 14) has 4 valence electrons. In pyridine, each carbon forms 3 σ bonds and 1 π bond, using all 4 valence electrons. So, no lone pairs on carbon.
- Nitrogen (Group 15) has 5 valence electrons. In pyridine, the nitrogen atom forms 2 σ bonds (with two adjacent carbons) and 1 π bond. This uses 3 of its valence electrons. The remaining 2 electrons exist as a **lone pair**.

Total lone pairs = **1 lone pair** (on the nitrogen atom).

Step 3: Final Answer:
The counts are 11 σ bonds, 3 π bonds, and 1 lone pair. This corresponds to option (C).

Quick Tip

For aromatic rings like benzene or pyridine, the number of σ bonds is equal to the number of atoms in the molecule (e.g., in pyridine C_5H_5N, total atoms = 5+5+1 = 11, so 11 σ bonds). This shortcut works for simple, single-ring systems.

---

72. 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: (D) Mg plays roles in neuromuscular function and interneuronal transmission.

Solution:

Step 1: Understanding the Question:
The question asks to identify the correct statement among the given options regarding the roles

and properties of Magnesium (Mg) and Calcium (Ca) in the human body.

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 incorrect. The estimated daily requirement for an adult is about 1000-1200 mg (1.0-1.2 g) of Calcium and about 300-400 mg (0.3-0.4 g) of Magnesium. The range 0.2-0.3 g (200-300 mg) is closer to the requirement for Mg but significantly underestimates the requirement for Ca.

(B) All enzymes that utilise ATP in phosphate transfer require Ca as the cofactor.

This statement is incorrect. The vast majority of enzymes that utilize ATP in phosphate transfer, such as kinases, require Magnesium (Mg^{2+}) as a cofactor. The Mg^{2+} ion forms a complex with ATP ($MgATP^{2-}$), which is the actual substrate for these enzymes. Calcium (Ca^{2+}) is a cofactor for other enzymes but not typically for ATP-dependent phosphate transfer.

(C) The bone in human body is an inert and unchanging substance.

This statement is incorrect. Bone is a dynamic, living tissue that is constantly being remodeled throughout life. There is a continuous process of old bone being broken down (resorption) by osteoclasts and new bone being formed (deposition) by osteoblasts. This allows bones to repair damage and adapt to mechanical stress.

(D) Mg plays roles in neuromuscular function and interneuronal transmission.

This statement is correct. Magnesium ions (Mg^{2+}) are essential for the transmission of nerve impulses and for neuromuscular coordination. Mg^{2+} acts as a natural calcium antagonist at the neuromuscular junction, helping to regulate muscle contraction and nerve excitability. It is crucial for maintaining a stable heartbeat and normal nerve function.

Step 3: Final Answer:

Based on the analysis, the only correct statement is that Mg plays roles in neuromuscular function and interneuronal transmission.

Quick Tip

Remember the primary biological roles: Ca^{2+} is key for bones, teeth, blood clotting, and muscle contraction signaling. Mg^{2+} is crucial for hundreds of enzymes (especially those using ATP) and for stabilizing nerve and muscle function.

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73. 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:
This question asks to evaluate the correctness of an Assertion and a Reason concerning the properties of a solution of sodium in liquid ammonia.

Step 2: Detailed Explanation:
Analysis of Assertion A:
When alkali metals like sodium dissolve in liquid ammonia, they ionize to form the metal cation and release an electron. Both species get solvated by ammonia molecules.

$$\text{Na(s)} + (x+y)\text{NH}_3\text{(l)} \rightarrow [\text{Na}(\text{NH}_3)_x]^+ + [e(\text{NH}_3)_y]^-$$

The solvated electron, known as the **ammoniated electron**, absorbs energy in the visible region of light, which imparts a deep blue color to the solution. This unpaired electron is also responsible for the solution being paramagnetic. Therefore, **Assertion A is true**.

Analysis of Reason R:
Reason R states that the blue color is due to the formation of amide. The formation of sodium amide ($NaNH_2$) occurs when the blue solution is allowed to stand for a long time, or in the presence of a catalyst like Fe_2O_3.

$$2\text{Na} + 2\text{NH}_3 \rightarrow 2\text{NaNH}_2 + \text{H}_2$$

As the amide is formed, the ammoniated electrons are consumed, and the blue color of the solution fades. Thus, the formation of amide is a subsequent reaction that leads to the disappearance of the blue color, not the cause of it. Therefore, **Reason R is false**.

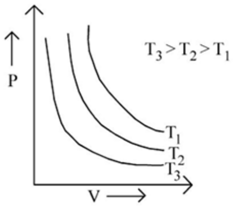
Step 3: Final Answer:
Assertion A is a true statement, but Reason R is a false statement. The correct option is (C).

Quick Tip

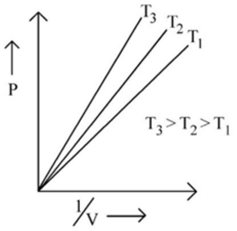
Remember that the key species in alkali metal-liquid ammonia solutions is the ammoniated electron ($[e(NH_3)y]^-$). It is the cause of the blue color, electrical conductivity, reducing nature, and paramagnetism of these solutions.

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

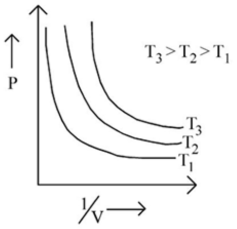
(1)



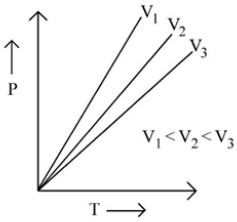
(2)



(3)



(4)



Correct Answer: (B)

Solution:

Step 1: Understanding the Question:
The question asks to identify the graph that correctly represents Boyle's Law. Boyle's law describes the relationship between the pressure and volume of a gas at a constant temperature.

Step 2: Key Formula or Approach:
Boyle's Law states that for a fixed mass of an ideal gas at constant temperature, the pressure (P) is inversely proportional to the volume (V).

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

This can be written as an equation:

$$PV = k$$

where k is a constant. From the ideal gas law, $PV = nRT$, we see that $k = nRT$. Since n and R are constants, k is directly proportional to the absolute temperature (T).
We can rearrange the equation as:

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

This equation is in the form of a straight line, $y = mx$, where $y = P$, $x = 1/V$, and the slope $m = k = nRT$.

Step 3: Detailed Explanation of Graphs:

- **Graph (1): P vs. V.** This plot should show a rectangular hyperbola for an isotherm (constant temperature). According to $PV = k = nRT$, as temperature T increases, the product PV increases, so the curve moves further away from the origin. The graph shows curves for T_1, T_2, T_3 getting closer to the origin, while the label says T_3 ¿ T_2 ¿ T_1. This is contradictory. The curve for T_3 should be the farthest out.
- **Graph (2): P vs. 1/V.** As derived above, this plot should be a straight line passing through the origin. The slope of the line is $m = nRT$. This means the slope is directly proportional to the temperature T. A higher temperature will result in a line with a steeper slope. The graph shows three lines with increasing slopes for temperatures T_1, T_2, and T_3. The labels indicate that T_3 ¿ T_2 ¿ T_1, which corresponds to slope(T_3) ¿ slope(T_2) ¿ slope(T_1). This representation is perfectly consistent with Boyle's Law.
- **Graph (3): P vs. 1/V.** This graph shows hyperbolic curves, which is incorrect. The relationship between P and 1/V is linear.
- **Graph (4): P vs. T.** This graph represents Gay-Lussac's Law ($P \propto T$ at constant V), not Boyle's Law.

Step 4: Final Answer:
Graph (2) correctly depicts the linear relationship between Pressure (P) and the reciprocal of Volume (1/V) at different constant temperatures, with the slope of the lines increasing with temperature, which is the correct graphical representation of Boyle's Law.

Quick Tip

To analyze gas law graphs, rearrange the ideal gas law $PV = nRT$ to match the axes. For a P vs 1/V graph, rearrange to $P = (nRT) \times (1/V)$. This is a straight line $y = mx$ with slope $m = nRT$. A higher T gives a larger slope.

---

75. 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 increasing order of energy for the molecular orbitals (MOs) of the dinitrogen (N_2) molecule. The N_2 molecule has a total of 14 electrons.

Step 2: Detailed Explanation:
According to Molecular Orbital Theory (MOT), the order of energy levels of MOs for diatomic molecules of the second period depends on the extent of mixing between 2s and 2p atomic orbitals.
For diatomic molecules up to N_2 (i.e., B_2, C_2, N_2, with ≤ 14 electrons), the s-p mixing is significant. This mixing causes the energy of the $\sigma 2p_z$ molecular orbital to be raised above the energy of the $\pi 2p_x$ and $\pi 2p_y$ orbitals.
The resulting energy order for N_2 is:

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

For diatomic molecules beyond N_2 (i.e., O_2, F_2, Ne_2, with > 14 electrons), the s-p mixing is not significant, and the order of the $\sigma 2p_z$ and $\pi 2p$ orbitals is reversed:

$$... < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < ...$$

Let's compare the correct order for N_2 with the given options:

- Option (A) matches the correct sequence for N_2 with s-p mixing.
- Option (B) shows the energy sequence for molecules like O_2 and F_2 (without s-p mixing effect).
- Options (C) and (D) show incorrect sequences for the molecular orbitals.

Step 3: Final Answer:
The correct order of energies of molecular orbitals for the N_2 molecule is given in option (A).

Quick Tip

A simple way to remember the MO energy order: For diatomic molecules with 14 or fewer electrons (like N_2), the order is π, σ for the 2p-derived bonding orbitals. For molecules with more than 14 electrons (like O_2), the order is σ, π.

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76. 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 classified as a barbiturate.

Step 2: Detailed Explanation:
Tranquilizers are a class of drugs that reduce stress, anxiety, and tension. They are broadly classified into several groups. Let's analyze the given options:

- **Barbiturates:** These are derivatives of barbituric acid. They act as central nervous system depressants and are used as sedatives and hypnotics. Examples include Veronal, Luminal, and Seconal.

- **Benzodiazepines:** This is another major class of tranquilizers. They are generally considered safer than barbiturates. Examples include Chlordiazepoxide and Diazepam (Valium).

- **Other tranquilizers:** There are other non-barbiturate, non-benzodiazepine tranquilizers, like Meprobamate.

Now let's classify each option:
(A) Chlordiazepoxide: This is a well-known benzodiazepine tranquilizer.
(B) Meprobamate: This is a carbamate derivative used as an anxiolytic drug. It is not a barbiturate.
(C) Valium: This is the trade name for Diazepam, which is one of the most famous benzodiazepine tranquilizers.
(D) Veronal: This is the trade name for barbital, which was one of the first barbiturate sedatives to be synthesized and marketed. It is a derivative of barbituric acid.

Step 3: Final Answer:
Based on the classification, Veronal is the drug that belongs to the barbiturates class.

Quick Tip

For exams, remember the major classes of tranquilizers and one or two key examples. Barbiturates (e.g., Veronal, Luminal) and Benzodiazepines (e.g., Diazepam/Valium, Chlordiazepoxide) are the most frequently asked categories.

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77. The given compound

$$C_6H_5\text{–}CH{=}CH\text{–}CH(X)\text{–}CH_2\text{–}CH_3$$

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).

Step 3: Detailed Explanation:
Let's analyze the structure of the compound and the definitions of different types of halides:

- **Aryl halide:** The halogen atom is directly bonded to a carbon atom of an aromatic ring. In the given compound, X is not directly attached to the benzene ring.
- **Vinylic halide:** The halogen atom is bonded to an sp^2-hybridized carbon atom of a carbon-carbon double bond (C=C-X). In the given compound, X is not attached to either of the carbons in the C=C double bond.
- **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-C-X). In the given compound, the halogen X is attached to a carbon which is sp^3-hybridized and is directly next to the 'CH=CH' double bond. This fits the definition of an allylic halide.
- **Benzylic halide:** The halogen atom is bonded to an sp^3-hybridized carbon atom that is directly attached to an aromatic ring. While there is a benzene ring, the carbon atom bonded to X is not directly attached to it.

The carbon atom bearing the halogen (X) is in the allylic position relative to the double bond. Therefore, the compound is an allylic halide.

Step 4: Final Answer:
The given compound is an example of an allylic halide. The correct option is (C).

Quick Tip

To quickly classify halides, remember the position of the halogen:

- **Aryl:** Halogen on the ring.
- **Vinylic:** Halogen on the C=C bond.
- **Allylic:** Halogen on the carbon *next to* the C=C bond.
- **Benzylic:** Halogen on the carbon *next to* the benzene ring.

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78. 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. It is important to distinguish between intermolecular forces (forces *between* molecules) and intramolecular forces (forces *within* a molecule).

Step 2: Detailed Explanation:
Let's analyze each option:
A. Dipole-dipole forces: These are electrostatic forces of attraction between polar molecules that have permanent dipoles. This is a type of intermolecular force.
B. Dipole-induced dipole forces: These forces arise when a polar molecule induces a temporary dipole in a neighboring nonpolar molecule. This is a type of intermolecular force.
C. Hydrogen bonding: This is a special, strong type of dipole-dipole interaction that occurs when hydrogen is bonded to a highly electronegative atom (N, O, or F). It is an intermolecular

force.
D. Covalent bonding: This is the force that holds atoms together *within* a molecule through the sharing of electrons. It is a strong chemical bond and an example of an **intramolecular** force, not an intermolecular force.
E. Dispersion forces (or London forces): These are weak forces that arise from temporary, instantaneous dipoles in molecules. They exist between all types of molecules and are the only intermolecular force for nonpolar molecules. This is a type of intermolecular force.

Step 3: Final Answer:
The forces A, B, C, and E are all types of intermolecular forces. Force D, covalent bonding, is an intramolecular force. Therefore, the correct combination is A, B, C, and E. The correct option is (C).

Quick Tip

Remember the key distinction: **Inter**molecular forces are *between* molecules (like people in an international meeting), while **intra**molecular forces are *within* a single molecule (like bones in an individual). Covalent and ionic bonds are intramolecular.

---

79. 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. Catalysis is classified based on the physical state (phase) of the reactants and the catalyst.

- **Homogeneous catalysis:** The reactants and the catalyst are in the same phase (e.g., all gaseous or all in the same liquid solution).
- **Heterogeneous catalysis:** The reactants and the catalyst are in different phases (e.g., gaseous reactants and a solid catalyst).

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

(1) **Oxidation of sulphur dioxide:** $2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$.
Reactants (SO_2, O_2) and catalyst (NO) are all in the gaseous phase. This is an example of **homogeneous** catalysis (Lead chamber process).

(2) **Hydrolysis of sugar:** $C_12H_22O_11(aq) + H_2O(l) \xrightarrow{H^+(aq)} C_6H_12O_6(aq) + C_6H_12O_6(aq)$.
The reactant (sugar solution) and catalyst (H^+ ions) are both in the aqueous phase. This is **homogeneous** catalysis.

(3) **Decomposition of ozone:** $2O_3(g) \xrightarrow{NO(g)} 3O_2(g)$.
Reactant (O_3) and catalyst (NO) are both in the gaseous phase. This is **homogeneous** catalysis.

(4) **Formation of ammonia:** $N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$.
The reactants (N_2, H_2) are in the gaseous phase, while the catalyst (finely divided iron) is in the solid phase. Since the reactants and catalyst are in different phases, this is an example of **heterogeneous** catalysis (Haber's process).

Step 3: Final Answer:
The combination of dinitrogen and dihydrogen to form ammonia in the presence of finely divided iron is the correct example of heterogeneous catalysis. The correct option is (D).

Quick Tip

To distinguish between homogeneous and heterogeneous catalysis, simply compare the physical states (s, l, g, aq) of the reactants and the catalyst. If they are the same, it's homogeneous. If they are different, it's heterogeneous.

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80. 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:
This is an Assertion-Reason question. We need to evaluate the truthfulness of both Assertion (A) and Reason (R) and then determine if R correctly explains A.

Step 2: Detailed Explanation:
Analyzing Assertion A:
"Helium is used to dilute oxygen in diving apparatus."
This statement is **true**. For deep-sea diving, the air mixture (nitrox) is replaced with a mixture of helium and oxygen (heliox). This is done because at the high pressures experienced deep underwater, nitrogen from the air dissolves in the bloodstream to a significant extent. When the diver ascends too quickly, this dissolved nitrogen can form bubbles in the blood, leading to a painful and dangerous condition called decompression sickness or "the bends". Helium is used because it has very low solubility in blood, even under high pressure, thus preventing this condition.

Analyzing Reason R:
"Helium has high solubility in O_2."
This statement is **false** and misleading. Firstly, gases are generally miscible with each other, so "solubility" in this context is not the primary concern. Secondly, and more importantly, the reason for using helium in diving apparatus has nothing to do with its solubility in oxygen. The critical factor is its **low solubility in blood**. The statement given in the reason is irrelevant and factually incorrect as the key property. The reason helium is used is its *low* solubility in aqueous media like blood plasma.

Step 3: Final Answer:
Assertion A is a true statement. Reason R is a false statement. Therefore, the correct option is (C).

Quick Tip

The use of helium in deep-sea diving is a classic application of Henry's Law. Helium is used because of its very low Henry's law constant, which means it has very low solubility in blood compared to nitrogen.

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81. 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 to identify the primary reason why the copper(II) ion (Cu^{2+}) is more stable than the copper(I) ion (Cu^{+}) when dissolved in water (aqueous solution).

Step 2: Detailed Explanation:
The stability of an ion in an aqueous solution is determined by the overall energy change involved in its formation and dissolution in water. This involves two main energy terms:
1. **Ionization Enthalpy (IE):** The energy required to remove electrons from a gaseous atom. To form Cu^{+} from Cu, the first ionization enthalpy (IE_1) is required. To form Cu^{2+} from Cu, both IE_1 and the second ionization enthalpy (IE_2) are required. The value of IE_2 for copper is very high, which would suggest that the formation of Cu^{2+} is energetically unfavorable compared to Cu^{+}.
2. **Hydration Enthalpy (ΔH_{hyd}):** The energy released when one mole of gaseous ions dissolves in water to form hydrated ions.

Step 3: Comparing Cu^{+} and Cu^{2+}:
Although the second ionization enthalpy of copper is high, making the formation of gaseous Cu^{2+} difficult, the situation changes in an aqueous solution.
The Cu^{2+} ion is smaller and has a much higher charge density (charge-to-size ratio) than the Cu^{+} ion.
Due to its higher charge density, the Cu^{2+} ion attracts water molecules much more strongly.
This results in a significantly more negative (i.e., a much larger release of energy) hydration enthalpy for Cu^{2+} compared to Cu^{+}.
This large amount of energy released during the hydration of Cu^{2+} more than compensates for the high energy required for the second ionization (IE_2).
Therefore, the overall energy change for the formation of hydrated Cu^{2+} is more favorable, making it more stable in an aqueous solution.
The Cu^{+} ion, on the other hand, is unstable in aqueous solution and undergoes disproportionation:

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

Step 4: Final Answer:
The high hydration energy of Cu^{2+} is the driving force for its greater stability in aqueous solutions compared to Cu^{+}.

Quick Tip

For transition metals, stability of ions in aqueous solution is a balance between ionization enthalpy (energy cost) and hydration enthalpy (energy released). A high charge density (small size, high charge) leads to a very high hydration enthalpy, which can often overcome a high ionization enthalpy.

82. Consider the following reaction and identify the product (P).
CH_3–$CH(CH_3)$–$CH(OH)$–CH_3 $\xrightarrow{\text{HBr}}$ Product (P)
(3-Methylbutan-2-ol)

(A) CH_3–$C(Br)(CH_3)$–CH_2–CH_3
(B) CH_3CH=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 shows the reaction of a secondary alcohol, 3-methylbutan-2-ol, with hydrogen bromide (HBr) and asks for the major product (P). This is a nucleophilic substitution reaction.

Step 2: Key Formula or Approach:
The reaction of secondary alcohols with hydrogen halides typically proceeds through an S_N1 mechanism, which involves the formation of a carbocation intermediate. Carbocations can undergo rearrangement to form a more stable carbocation if possible. The order of carbocation stability is: Tertiary > Secondary > Primary.

Step 3: Detailed Explanation:
1. **Protonation of the alcohol:** The lone pair on the oxygen of the hydroxyl group attacks the H^+ from HBr, forming a protonated alcohol (oxonium ion), which is a good leaving group.

$$CH_3\text{–}CH(CH_3)\text{–}CH(OH)\text{–}CH_3 + H^+ \rightarrow CH_3\text{–}CH(CH_3)\text{–}CH(OH_2^+)\text{–}CH_3$$

2. **Formation of carbocation:** The protonated alcohol loses a water molecule to form a secondary carbocation.

$$CH_3\text{–}CH(CH_3)\text{–}CH(OH_2^+)\text{–}CH_3 \rightarrow CH_3\text{–}CH(CH_3)\text{–}\overset{+}{C}H\text{–}CH_3 + H_2O$$

This is a 2° carbocation.

3. **Carbocation rearrangement:** We check if a more stable carbocation can be formed. The adjacent carbon (C-3) has a hydrogen atom. A 1,2-hydride shift from C-3 to C-2 will result in a more stable tertiary carbocation.

$$CH_3\text{–}CH(CH_3)\text{–}\overset{+}{C}H\text{–}CH_3 \xrightarrow{\text{1,2-Hydride shift}} CH_3\text{–}\overset{+}{C}(CH_3)\text{–}CH_2\text{–}CH_3$$

This is a 3° carbocation, which is more stable.

4. **Nucleophilic attack:** The bromide ion (Br^-) attacks the more stable tertiary carbocation to form the final major product.

$$\text{CH}_3-\overset{+}{\text{C}}\,(\text{CH}_3)-\text{CH}_2-\text{CH}_3 + \text{Br}^- \rightarrow \text{CH}_3-\text{C}(\text{Br})(\text{CH}_3)-\text{CH}_2-\text{CH}_3$$

The product is 2-Bromo-2-methylbutane.

Step 4: Final Answer:

The major product formed after carbocation rearrangement is 2-Bromo-2-methylbutane. This corresponds to the structure given in option (A). Option (C) is the minor product formed without rearrangement.

Quick Tip

In reactions involving carbocation intermediates (like S_N1 reactions of alcohols or dehydration), always be on the lookout for potential rearrangements (1,2-hydride or 1,2-alkyl shifts) that can lead to a more stable carbocation. The major product will always be derived from the most stable carbocation.

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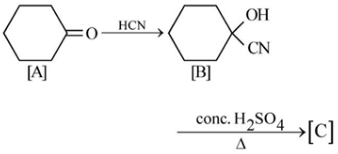
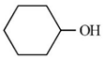
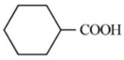
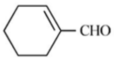
83. Complete the following reaction :

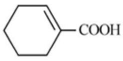


[C] is ________.

(1) 

(2) 

(3) 

(4) 

Correct Answer: (D)

Solution:

Step 1: Understanding the Question:

The question asks to identify the final product [C] in a two-step reaction starting from cyclohexanone [A].

Step 2: Detailed Explanation:

Step 1: Formation of [B]

The starting material [A] is cyclohexanone. It reacts with hydrogen cyanide (HCN) in a nucleophilic addition reaction. The cyanide ion (CN^-) acts as a nucleophile and attacks the electrophilic carbonyl carbon. The oxygen atom is then protonated.

The product [B] is a cyanohydrin, specifically cyclohexanone cyanohydrin (1-hydroxycyclohexanecarbonitrile).

Step 2: Formation of [C]
The cyanohydrin [B] is treated with concentrated sulfuric acid (conc. H_2SO_4) and heated (Δ). This condition leads to two subsequent reactions:
a) Hydrolysis of the nitrile group (-CN): In the presence of strong acid and heat, the nitrile group undergoes hydrolysis to form a carboxylic acid group (-COOH).
b) Dehydration of the alcohol group (-OH): Concentrated H_2SO_4 is a strong dehydrating agent. The tertiary alcohol in the intermediate (1-hydroxycyclohexanecarboxylic acid) gets dehydrated. The -OH group and a hydrogen atom from an adjacent carbon are eliminated as a water molecule, forming a double bond. This elimination leads to the formation of an α, β-unsaturated carboxylic acid.

Step 3: Final Answer:
The final product [C] is cyclohex-1-enecarboxylic acid. This structure matches option (D).

Quick Tip

Remember the dual role of concentrated H_2SO_4 with heat: it acts as a catalyst for hydrolysis (like nitrile to carboxylic acid) and as a powerful dehydrating agent (eliminating water from alcohols to form alkenes).

---

84. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R :
Assertion A : In equation $\Delta_r G = -nFE_{cell}$, value of $\Delta_r G$ depends on n.
Reason R : E_{cell} is an intensive property and $\Delta_r G$ 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:
The question asks to evaluate an Assertion and a Reason related to the Gibbs free energy change ($\Delta_r G$) and cell potential (E_{cell}) in an electrochemical cell.

Step 2: Detailed Explanation:
Analysis of Assertion A:

The equation relating Gibbs free energy change and cell potential is $\Delta_r G = -nFE_{cell}$.
Here, $\Delta_r G$ is the Gibbs free energy change, 'n' is the number of moles of electrons transferred in the balanced cell reaction, 'F' is the Faraday constant, and E_{cell} is the cell potential.
From the equation, it is clear that $\Delta_r G$ is directly proportional to 'n'. If the number of moles of electrons transferred changes (e.g., by balancing the equation differently or considering a different amount of reaction), the value of $\Delta_r G$ will change. Thus, **Assertion A is true**.

Analysis of Reason R:
An **intensive property** is a property of matter that does not depend on the amount of the substance. Examples include temperature, pressure, density, and cell potential (E_{cell}). The voltage of a battery is the same regardless of its size.
An **extensive property** is a property that depends on the amount of the substance. Examples include mass, volume, and energy, including Gibbs free energy ($\Delta_r G$). The total energy you can get from a battery depends on its size (the amount of reactants).
Therefore, the statement that E_{cell} is an intensive property and $\Delta_r G$ is an extensive property is correct. Thus, **Reason R is true**.

Connecting A and R:
The reason $\Delta_r G$ depends on 'n' is precisely because it is an extensive property (dependent on amount), while E_{cell} is an intensive property (independent of amount). The equation $\Delta_r G = -nFE_{cell}$ connects the intensive property (E_{cell}) to the extensive property ($\Delta_r G$) through the factor 'n', which represents the amount of substance undergoing reaction (in terms of moles of electrons). Therefore, **Reason R is the correct explanation of Assertion A**.

Step 3: Final Answer:
Both Assertion A and Reason R are true, and Reason R provides the correct explanation for Assertion A. The correct option is (A).

Quick Tip

Remember: Energy (ΔG, ΔH) is always extensive (depends on amount). Potential (E_{cell}), concentration, and temperature are intensive (independent of amount). The equation $\Delta G = -nFE_{cell}$ elegantly links an extensive quantity to an intensive one.

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85. 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) $Fe_4[Fe(CN)_6]_3 \cdot xH_2O$
(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 describes a specific result from Lassaigne's test for the qualitative analysis of organic compounds. When both nitrogen (N) and sulfur (S) are present, a blood-red color is formed upon adding ferric ions (Fe^{3+}). We need to identify the chemical species responsible for this color.

Step 2: Key Formula or Approach:
The process involves two key chemical reactions:
1. Formation of sodium thiocyanate during sodium fusion.
2. Reaction of thiocyanate ions with ferric ions to form a colored complex.

Step 3: Detailed Explanation:
Reaction 1: Sodium Fusion
In Lassaigne's test, the organic compound is fused with metallic sodium. If both nitrogen and sulfur are present in the compound, they react with sodium to form sodium thiocyanate (NaSCN).

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

The resulting fused mass is extracted with distilled water to get Lassaigne's extract, which contains NaSCN.

Reaction 2: Test with $\mathbf{Fe^{3+}}$
A portion of the Lassaigne's extract is acidified (e.g., with dilute HCl) and then a few drops of ferric chloride ($FeCl_3$) solution are added. The ferric ions (Fe^{3+}) react with the thiocyanate ions (SCN^-) from NaSCN to form a complex ion.

$$\mathrm{Fe^{3+}(aq)} + \mathrm{SCN^-(aq)} \rightarrow \mathrm{[Fe(SCN)]^{2+}(aq)}$$

This complex, ferric thiocyanate (or more accurately, a series of complexes like $[Fe(SCN)(H_2O)_5]^{2+}$), has an intense blood-red color.

Let's evaluate the given options:
(A) $\mathbf{Fe_4[Fe(CN)_6]_3 \cdot xH_2O}$: This is Prussian blue, formed when only nitrogen is present (forming NaCN, which then reacts with $FeSO_4$ and $FeCl_3$).
(B) NaSCN: This is sodium thiocyanate, the colorless reactant formed during fusion, not the final colored product.
(C) $\mathbf{[Fe(CN)_5NOS]^{4-}}$: This is the purple-colored complex formed in the sodium nitroprusside test for sulfur (when S is present as S^{2-}).
(D) $\mathbf{[Fe(SCN)]^{2+}}$: This is the ferric thiocyanate complex responsible for the blood-red coloration, confirming the presence of both N and S.

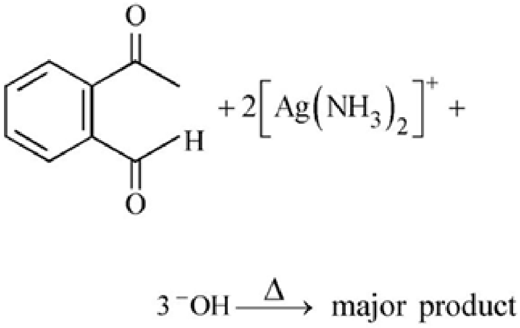
Step 4: Final Answer:
The blood-red color is due to the formation of the $[Fe(SCN)]^{2+}$ complex ion.

Quick Tip

Associate colors with Lassaigne's test results: Prussian blue for Nitrogen (Fe^{3+} test), Blood-red for N and S together (Fe^{3+} test), and Violet/Purple for Sulfur (sodium nitroprusside test).

Section B

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



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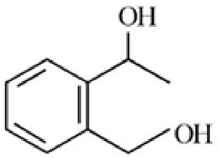

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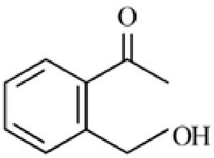

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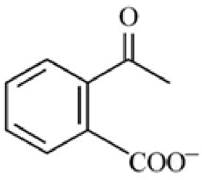

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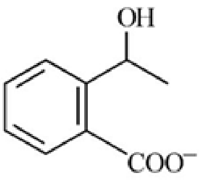

Correct Answer: (C)

Solution:

Step 1: Understanding the Question:
The question shows a reaction involving an aromatic compound with both an aldehyde and a ketone group, which is being treated with ammoniacal silver nitrate solution ($[Ag(NH_3]_2]^+$) under basic conditions (OH^-). This is the Tollen's test. We need to identify the major product.

Step 2: Key Formula or Approach:
Tollen's reagent ($[Ag(NH_3]_2]^+$) is a mild oxidizing agent. Its primary function in qualitative organic analysis is to distinguish between aldehydes and ketones.

- Aldehydes are oxidized by Tollen's reagent to the corresponding carboxylate anion. The silver(I) ion in the complex is reduced to metallic silver ($Ag(s)$), which deposits as a silver mirror on the test tube.

- Ketones (except for α-hydroxy ketones) do not react with Tollen's reagent under these mild conditions.

The overall reaction for an aldehyde R-CHO is:

$$\text{R-CHO} + 2[\text{Ag(NH}_3)_2]^+ + 3\text{OH}^- \rightarrow \text{R-COO}^- + 2\text{Ag(s)} + 4\text{NH}_3 + 2\text{H}_2\text{O}$$

Step 3: Detailed Explanation:
The starting material is 2-acetylbenzaldehyde. It contains two carbonyl groups:
1. An aldehyde group (-CHO).
2. A ketone group (-$COCH_3$).
When this compound is treated with Tollen's reagent, the mild oxidizing agent will selectively oxidize the aldehyde group to a carboxylate group (-COO^-). The ketone group will remain unchanged.
Therefore, the aldehyde group on the benzene ring is converted to a carboxylate group, while the acetyl group (ketone) remains intact.

Step 4: Final Answer:
The product is the 2-acetylbenzoate anion. This structure corresponds to option (C).

Quick Tip

Remember the selectivity of common oxidizing agents: Tollen's reagent and Fehling's solution oxidize aldehydes but not ketones. Stronger agents like $KMnO_4$ or $K_2Cr_2O_7$ can oxidize both (and ketones under harsh conditions).

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87. Match List - I with List - II :

List - I (Oxoacids of Sulphur)	**List - II (Bonds)**
A. Peroxodisulphuric acid	**I. Two S-OH, Four S=O, One S-O-S**
B. Sulphuric acid	**II. Two S-OH, One S=O**
C. Pyrosulphuric acid	**III. Two S-OH, Four S=O, One S-O-O-S**
D. Sulphurous acid	**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 matching the given oxoacids of sulphur with the correct description of the types and number of chemical bonds present in their structures.

Step 2: Detailed Explanation:
We need to determine the structure of each acid and count the specified bonds.
A. Peroxodisulphuric acid ($H_2S_2O_8$), also known as Marshall's acid:
The structure is HO-SO_2-O-O-SO_2-OH. It contains a peroxide linkage (-O-O-).
Counting the bonds:
- Two S-OH bonds
- Four S=O bonds
- One S-O-O-S peroxide linkage

This matches description **III**. So, **A** → **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**. So, **B** → **IV**.

C. Pyrosulphuric acid ($H_2S_2O_7$), also known as Oleum:
The structure is HO-SO_2-O-SO_2-OH. It contains an oxide linkage (-O-).
Counting the bonds:
- Two S-OH bonds
- Four S=O bonds
- One S-O-S linkage

This matches description **I**. So, **C** → **I**.

D. Sulphurous acid (H_2SO_3):
The structure is HO-SO-OH with one lone pair on the sulfur atom.
Counting the bonds:
- Two S-OH bonds
- One S=O bond

This matches description **II**. So, **D** → **II**.

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

Quick Tip

To solve such problems, it's essential to be able to draw the Lewis structures of common oxoacids. Remember that "peroxo" implies an -O-O- linkage, and "pyro" implies an -O- linkage formed by the dehydration of two acid molecules.

---

88. On balancing the given redox reaction,
a $Cr_2O_7{}^{2-}$ + 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:
The task is to balance the given redox reaction in an acidic medium and find the stoichiometric coefficients a, b, and c.

Step 2: Key Formula or Approach:
We will use the ion-electron (half-reaction) method to balance the equation.
1. Write the oxidation and reduction half-reactions.
2. Balance atoms other than O and H.
3. Balance O atoms by adding H_2O.
4. Balance H atoms by adding H^+.
5. Balance the charge by adding electrons (e^-).
6. Equalize the number of electrons in both half-reactions by multiplying with suitable integers.
7. Add the balanced half-reactions and simplify.

Step 3: Detailed Explanation:
Reduction Half-Reaction:

$$Cr_2O_7^{2-} \rightarrow Cr^{3+}$$

Balance Cr atoms:

$$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$$

Balance O atoms with H_2O:

$$Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$$

Balance H atoms with H^+:

$$Cr_2O_7^{2-} + 14H^+ \to 2Cr^{3+} + 7H_2O$$

Balance charge with e^- (LHS charge = -2 + 14 = +12; RHS charge = 2 × 3 = +6). Add $6e^-$ to LHS:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \to 2Cr^{3+} + 7H_2O \quad ...(i)$$

Oxidation Half-Reaction:

$$SO_3^{2-} \to SO_4^{2-}$$

S atoms are balanced.
Balance O atoms with H_2O:

$$SO_3^{2-} + H_2O \to SO_4^{2-}$$

Balance H atoms with H^+:

$$SO_3^{2-} + H_2O \to SO_4^{2-} + 2H^+$$

Balance charge with e^- (LHS charge = -2; RHS charge = -2 + 2 = 0). Add $2e^-$ to RHS:

$$SO_3^{2-} + H_2O \to SO_4^{2-} + 2H^+ + 2e^- \quad ...(ii)$$

Combining the Half-Reactions:
To equalize the electrons, multiply equation (ii) by 3.

$$3SO_3^{2-} + 3H_2O \to 3SO_4^{2-} + 6H^+ + 6e^- \quad ...(iii)$$

Now, add equation (i) and equation (iii):

$$(Cr_2O_7^{2-} + 14H^+ + 6e^-) + (3SO_3^{2-} + 3H_2O) \to (2Cr^{3+} + 7H_2O) + (3SO_4^{2-} + 6H^+ + 6e^-)$$

Cancel common species ($6e^-$, $6H^+$, $3H_2O$) from both sides:

$$Cr_2O_7^{2-} + 3SO_3^{2-} + 8H^+ \to 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$$

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

Quick Tip

Alternatively, use the oxidation number method. Cr changes from +6 to +3 (gain of $3e^-$ per atom, total $6e^-$). S changes from +4 to +6 (loss of $2e^-$). The LCM of 6 and 2 is 6. So, 1 $Cr_2O_7{}^{2-}$ is needed for every 3 $SO_3{}^{2-}$. This quickly gives a=1 and b=3. Then balance charge and atoms to find c.

89. 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 into one of the given types of colloids.

Step 2: Detailed Explanation:
A colloid is a mixture where one substance of microscopically dispersed insoluble particles is suspended throughout another substance. The classification is based on the physical state of the dispersed phase and the dispersion medium.

- **Pumice stone** is a type of volcanic rock formed when lava with a very high content of water and gases is rapidly cooled. The gases get trapped, creating a porous, foam-like solid structure.
- In pumice stone, the **dispersed phase is a gas** (the trapped bubbles).
- The **dispersion medium is a solid** (the solidified rock).

Now let's analyze the given options based on the dispersed phase (DP) and dispersion medium (DM):

- **(A) Sol:** DP is Solid, DM is Liquid.
- **(B) Gel:** DP is Liquid, DM is Solid.
- **(C) Solid sol:** This term can be used for systems where the DM is a solid. Specifically, it can refer to Solid (DP) in Solid (DM), like colored glass, or more broadly to systems with a solid medium. The colloidal system of Gas (DP) in Solid (DM) is more precisely called a ”solid foam”, but among the given options, ”solid sol” is often used in textbooks as the classification for this type of system.
- **(D) Foam:** DP is Gas, DM is Liquid.

Step 3: Final Answer:
Pumice stone consists of a gas dispersed in a solid. While the most specific term is ”solid foam,” this is not an option. In many classification schemes, ”solid sol” is used to describe colloids with a solid dispersion medium, including gas-in-solid systems. Therefore, ”solid sol” is the best fit among the given choices.

Quick Tip

Memorize the 8 types of colloids. A key example for Gas in Solid is pumice stone or styrofoam, which are often classified as solid sols or solid foams.

---

90. 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 complex among the given options.

Step 2: Key Formula or Approach:
The stability of a coordination complex is influenced by several factors, including the nature of the metal ion and the ligands. One of the most significant factors contributing to high stability is the **chelate effect**.
The chelate effect is the enhanced stability of a complex containing a chelating ligand (a polydentate ligand that can form a ring with the central metal ion) compared to a similar complex with only monodentate ligands. This increased stability is primarily due to a favorable entropy change upon formation of the chelate complex.

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

- **(A) $[Co(NH_3)_4(H_2O)Br]^{2+}$:** The ligands 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) $[CoCl_2(en)_2]^+$:** The ligands are chloride (Cl^-) and ethylenediamine (en). Chloride is a monodentate ligand. Ethylenediamine ($H_2N\text{-}CH_2\text{-}CH_2\text{-}NH_2$) is a bidentate ligand. Since it has two donor atoms, it can bind to the central cobalt ion at two positions, forming a stable five-membered ring. This is a chelate complex.

- **(D) $[Co(NH_3)_6]^{3+}$:** The ligand is ammonia (NH_3), which is a monodentate ligand.

Step 4: Final Answer:
Complex (C) is the only option containing a chelating ligand (ethylenediamine). Due to the chelate effect, complexes with chelating ligands are significantly more stable than complexes with only monodentate ligands. Therefore, $[CoCl_2(en)_2]NO_3$ is the most stable complex among the choices.

Quick Tip

When asked to compare the stability of coordination complexes, always look for the presence of chelating (polydentate) ligands like ethylenediamine (en), oxalate (ox), or EDTA. The chelate effect is a powerful stabilizing factor.

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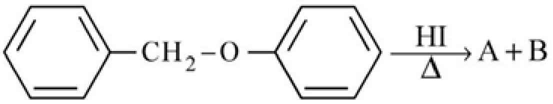
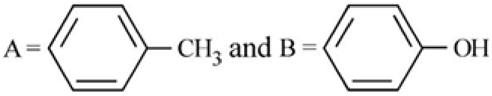
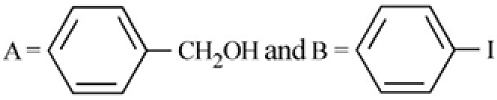
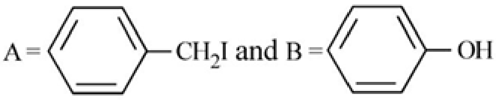
91. Consider the following reaction :

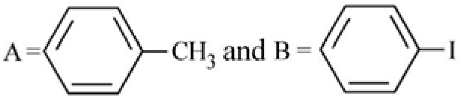


Identify products A and B.

(1) 

(2) 

(3) 

(4) 

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

Solution:

Step 1: Understanding the Question:
The question shows the cleavage of an unsymmetrical ether, benzyl phenyl ether, using hydroiodic acid (HI). We need to predict the two products, A and B.

Step 2: Key Formula or Approach:
The cleavage of ethers with HX (where X = Cl, Br, I) involves two main steps: 1. Protonation

of the ether oxygen to form a good leaving group. 2. Nucleophilic attack by the halide ion (I^-) on one of the carbons adjacent to the oxygen.

The site of the nucleophilic attack depends on the nature of the alkyl/aryl groups attached to the oxygen.

- If both groups are primary or secondary alkyl groups, the mechanism is S_N2, and the halide attacks the less hindered carbon. - If one of the groups can form a stable carbocation (like tertiary alkyl, benzyl, or allyl), the mechanism tends towards S_N1, and the halide attacks the carbon that forms the stable carbocation. - The bond between an sp^2-hybridized carbon (like in a phenyl ring) and the oxygen is very strong and not easily broken. Attack on the phenyl ring carbon does not occur.

Step 3: Detailed Explanation:

The starting ether is benzyl phenyl ether (C_6H_5-CH_2-O-C_6H_5).

1. **Protonation:** The oxygen atom is protonated by HI.

$$C_6H_5\text{-}CH_2\text{-}O\text{-}C_6H_5 + HI \rightarrow C_6H_5\text{-}CH_2\text{-}\overset{+}{O}H\text{-}C_6H_5 + I^-$$

2. **Cleavage:** We have two possible cleavage sites: the benzyl-oxygen bond and the phenyl-oxygen bond.

- Cleavage of the phenyl-oxygen bond is unfavorable because the sp^2 carbon of the benzene ring is resistant to nucleophilic attack, and the phenyl cation is very unstable. - Cleavage of the benzyl-oxygen bond is favorable. The benzyl group can stabilize a positive charge very effectively, so the reaction proceeds readily via an S_N1-like mechanism, forming a stable benzyl carbocation. The nucleophile I^- will then attack this carbocation.

$$C_6H_5\text{-}CH_2\text{-}\overset{+}{O}H\text{-}C_6H_5 \rightarrow C_6H_5\text{-}CH_2^+ + C_6H_5OH \text{ (Phenol)}$$
$$C_6H_5\text{-}CH_2^+ + I^- \rightarrow C_6H_5\text{-}CH_2I \text{ (Benzyl iodide)}$$

Even if the mechanism is considered S_N2, the attack will still occur at the benzylic carbon, as it is a better site for nucleophilic attack than the sp^2 phenyl carbon.

Step 4: Final Answer:

The products formed are Benzyl iodide and Phenol. This combination matches option (C).

Quick Tip

When cleaving an ether with a phenyl group and an alkyl group, the halide will always attach to the alkyl group, and the phenyl group will form phenol. This is because the Ar-O bond is strong and difficult to break.

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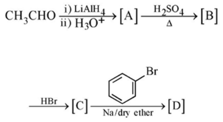
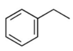
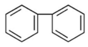
92. Identify the final product [D] obtained in the following sequence of reactions.



(1) 

(2) 

(3) C_4H_{10}

(4) $HC \equiv C^{\ominus} Na^+$

Correct Answer: (A)

Solution:

Step 1: Understanding the Question:
We need to follow a four-step reaction sequence starting from acetaldehyde (CH_3CHO) and identify the final product [D].

Step 2: Detailed Explanation:
Reaction 1: $CH_3CHO \xrightarrow{i) LiAlH_4, ii) H_3O^+}$ [A]
Lithium aluminium hydride ($LiAlH_4$) is a strong reducing agent that reduces aldehydes to primary alcohols.
Acetaldehyde is reduced to ethanol.

$$CH_3CHO \xrightarrow{\text{Reduction}} CH_3CH_2OH$$

So, [**A**] **is ethanol**.

Reaction 2: [A] $\xrightarrow{H_2SO_4, \Delta}$ [B]
This is the acid-catalyzed dehydration of ethanol. Heating an alcohol with a strong dehydrating agent like concentrated H_2SO_4 causes an elimination reaction to form an alkene.

$$CH_3CH_2OH \xrightarrow{H_2SO_4, \Delta} CH_2 = CH_2 + H_2O$$

So, [**B**] **is ethene**.

Reaction 3: [B] $\xrightarrow{HBr}$ [C]
This is the electrophilic addition of hydrogen bromide (HBr) across the double bond of ethene.

$$CH_2 = CH_2 + HBr \rightarrow CH_3CH_2Br$$

So, [**C**] **is bromoethane**.

Reaction 4: [C] + Bromobenzene $\xrightarrow{Na/dry\ ether}$ [D]
This is a Wurtz-Fittig reaction. An alkyl halide (bromoethane) and an aryl halide (bromobenzene) are coupled using sodium metal in dry ether. The ethyl group from bromoethane attaches to the phenyl ring from bromobenzene.

$$CH_3CH_2Br + C_6H_5Br + 2Na \xrightarrow{\text{dry ether}} C_6H_5CH_2CH_3 + 2NaBr$$

So, [D] **is ethylbenzene**.

Step 3: Final Answer:
The final product [D] is ethylbenzene, which corresponds to option (A).

Quick Tip

The Wurtz-Fittig reaction is a useful method for synthesizing alkylbenzenes. It involves coupling an alkyl halide and an aryl halide with sodium in dry ether. Be aware that side-products from self-coupling (Wurtz and Fittig reactions) also form.

---

93. 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 concerning the environmental phenomenon of eutrophication.

Step 2: Detailed Explanation:
Analysis of Statement I:
"The nutrient deficient water bodies lead to eutrophication."
This statement is **incorrect**. Eutrophication is the process of nutrient enrichment of a water body. It is caused by an **excess** of nutrients, particularly nitrates and phosphates, which typically come from agricultural runoff (fertilizers) and sewage. Nutrient-deficient (oligotrophic) water bodies are clear and have low biological productivity. Eutrophication is the transition from this state to a nutrient-rich (eutrophic) state.

Analysis of Statement II:
"Eutrophication leads to decrease in the level of oxygen in the water bodies."
This statement is **true**. The excess nutrients in eutrophic water cause a massive growth of algae and other aquatic plants, a phenomenon known as an "algal bloom". When these large

quantities of algae die, they sink to the bottom and are decomposed by aerobic bacteria. This decomposition process consumes a large amount of dissolved oxygen from the water. The depletion of oxygen leads to a condition called hypoxia or anoxia, which can cause the death of fish and other aquatic organisms.

Step 3: Final Answer:
Statement I is false, and Statement II is true. Therefore, the correct option is (D).

Quick Tip

Remember: Eutrophication = Nutrient Enrichment → Algal Bloom → Decomposition of dead algae → Oxygen Depletion → Death of aquatic life.

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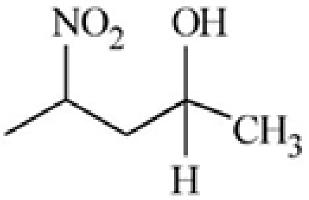
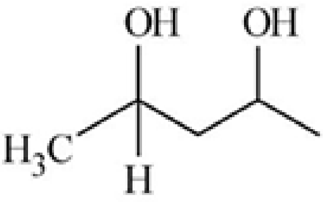
94. Which amongst the following will be most readily dehydrated under acidic conditions ?

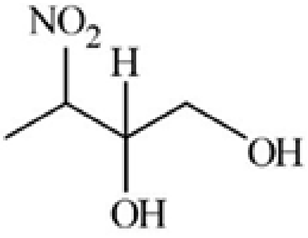
(1)



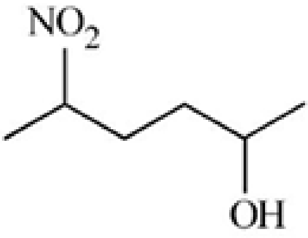
(2)



(3)



(4)



Correct Answer: (B)

Solution:

Step 1: Understanding the Question:

The question asks to identify which of the given alcohols will undergo dehydration most readily (i.e., fastest) under acidic conditions.

Step 2: Key Formula or Approach:

Acid-catalyzed dehydration of alcohols typically proceeds via an E1 mechanism. The key steps are:
1. Protonation of the hydroxyl (-OH) group by the acid to form a good leaving group (-OH_2^+).
2. Loss of the leaving group (water) to form a carbocation intermediate. This is the rate-determining step.
3. Deprotonation of a neighboring carbon atom by a base (like H_2O) to form an alkene.

The rate of the reaction depends on the stability of the carbocation formed in the rate-determining step. The more stable the carbocation, the faster the reaction. The order of carbocation stability is: Tertiary (3°) ¿ Secondary (2°) ¿ Primary (1°).

Electron-withdrawing groups (like -NO_2) destabilize carbocations through their inductive effect (-I effect).

Step 3: Detailed Explanation:

Let's analyze the carbocation that would be formed from each alcohol:

- **(A) 3-Methyl-4-nitrobutan-2-ol:** This is a secondary (2°) alcohol. It would form a secondary carbocation at C-2. This carbocation is destabilized by the -I effect of the -NO_2 group at C-4.

- **(B) 2-Methylbutane-2,3-diol:** This molecule has two hydroxyl groups. One at C-2 is a tertiary (3°) alcohol, and one at C-3 is a secondary (2°) alcohol. Dehydration will preferentially occur at the tertiary alcohol position because it leads to the formation of a highly stable tertiary carbocation.

- **(C) 3-Nitrobutan-2-ol:** This is a secondary (2°) alcohol. It would form a secondary carbocation at C-2, which is strongly destabilized by the potent -I effect of the adjacent -NO_2 group at C-3. This dehydration would be very slow.

- **(D) 4-Nitropentan-2-ol:** This is a secondary (2°) alcohol. It would form a secondary carbocation at C-2, destabilized by the -I effect of the -NO_2 group at C-4.

Step 4: Final Answer:

Comparing the options, compound (B) is the only one that contains a tertiary alcohol. The dehydration of this tertiary alcohol will proceed through the most stable intermediate (a tertiary carbocation), making it the most readily dehydrated compound among the choices.

Quick Tip

When comparing rates of alcohol dehydration, first look at the type of alcohol (3° ¿ 2° ¿ 1°). A tertiary alcohol will almost always dehydrate faster than a secondary one, as the stability of the carbocation intermediate is the dominant factor.

---

95. 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 for the contribution of a single octahedral void located at the center of an edge to one unit cell in a face-centered cubic (fcc) lattice.

Step 2: Detailed Explanation:
In a crystal lattice, atoms or voids at different positions are shared between adjacent unit cells.

- A particle at a **corner** is shared by 8 unit cells (contribution = 1/8).
- A particle at a **face center** is shared by 2 unit cells (contribution = 1/2).
- A particle at a **body center** is fully within 1 unit cell (contribution = 1).
- A particle at an **edge center** is shared by 4 unit cells. Imagine a line (the edge) being the intersection of four cubes (two on top, two on the bottom, or two in front, two behind). A point at the center of this edge is common to all four cubes.

In an fcc lattice, octahedral voids are located at the body center (1 void) and at the center of each of the 12 edges.
The question specifically refers to an "edge centred octahedral void". Since an edge center is shared by 4 adjacent unit cells, the fraction of the void that lies within any one of these unit cells is $\frac{1}{4}$.

Step 3: Final Answer:
The fraction of an edge-centered octahedral void that lies in one unit cell is $\frac{1}{4}$.

Quick Tip

Memorize the contribution of particles at different lattice points: Corner = 1/8, Face Center = 1/2, Edge Center = 1/4, Body Center = 1. This is crucial for calculating the number of atoms or voids per unit cell.

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96. 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:
The question asks to identify which of the given chemical reactions does not occur in the middle temperature zone (900 K to 1500 K) of a blast furnace used for iron extraction.

Step 2: Detailed Explanation of Blast Furnace Chemistry:
The blast furnace has different temperature zones where specific reactions occur:

- **Upper Zone (Zone of Reduction, 500 K - 800 K):** In this cooler, upper region, the iron ore (mainly Fe_2O_3) is heated and reduced by the ascending carbon monoxide gas. The main reactions are:
  $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$
  $Fe_3O_4 + CO \rightarrow 3FeO + CO_2$
  $Fe_2O_3 + CO \rightarrow 2FeO + CO_2$

- **Middle Zone (Zone of Reduction, 900 K - 1500 K):** In this hotter, central region, further reduction of iron oxides occurs. Limestone ($CaCO_3$) also decomposes here (~1200 K) into CaO and CO_2.
  $CaCO_3 \rightarrow CaO + CO_2$
  The reaction $C + CO_2 \rightarrow 2CO$ (Boudouard reaction) becomes significant above 1000 K.
  The reduction $FeO + CO \rightarrow Fe + CO_2$ continues.
  Slag formation begins: $CaO + SiO_2 \rightarrow CaSiO_3$.

- **Lower Zone (Zone of Combustion/Fusion, ¿ 1500 K):** This is the hottest region at the bottom. Coke (C) burns to produce heat and CO. Final reduction of any remaining FeO occurs, and the iron melts.

$C + O_2 \rightarrow CO_2$
$CO_2 + C \rightarrow 2CO$
$FeO + C \rightarrow Fe + CO$

Step 3: Analyzing the Options:

- **(A) $Fe_2O_3 + CO \rightarrow 2FeO + CO_2$:** This is the initial reduction of the primary ore, Fe_2O_3. It primarily takes place in the cooler, upper part of the furnace, at temperatures below 900 K. By the time the charge reaches the 900-1500 K zone, most of the Fe_2O_3 has already been converted to Fe_3O_4 or FeO.
- **(B) $FeO + CO \rightarrow Fe + CO_2$:** This reaction occurs over a broad range of temperatures, including the 900-1500 K zone.
- **(C) $C + CO_2 \rightarrow 2CO$:** This reaction is endothermic and is favored at high temperatures, typically above 1000 K. It is a key reaction in the 900-1500 K zone.
- **(D) $CaO + SiO_2 \rightarrow CaSiO_3$:** This is slag formation. It requires high temperatures for the decomposition of limestone and the subsequent reaction. This occurs in the 900-1500 K zone and above.

Step 4: Final Answer:
The reaction that is characteristic of the upper, cooler zone (below 900 K) and thus does NOT predominantly take place in the 900 K to 1500 K range is the initial reduction of Fe_2O_3. Therefore, option (A) is the correct answer.

Quick Tip

Remember the temperature gradient in a blast furnace: it's coolest at the top and hottest at the bottom. The reduction of iron oxides happens in stages, with higher oxides (Fe_2O_3) being reduced at lower temperatures (top) and the final reduction of FeO to Fe happening at higher temperatures (middle and bottom).

---

97. 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 mathematical 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:

$$H = U + PV$$

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

For a change in the system, this relationship can be written as:

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

For a process occurring at constant pressure, this simplifies to $\Delta H = \Delta U + P\Delta V$.

For chemical reactions involving gases, assuming the gases behave ideally, we can use the ideal gas equation, $PV = nRT$.

Then $\Delta(PV) = \Delta(nRT)$. If the reaction is carried out at constant temperature, this becomes:

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

where Δn_g is the change in the number of moles of gaseous components in the reaction.

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

Step 3: Detailed Explanation:

By substituting $\Delta(PV) = (\Delta n_g)RT$ back into the enthalpy change equation, we get the desired relationship:

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

Let's check the given options against this correct formula.

(A) ΔH = ΔU – Δn$_g$RT. Incorrect sign.

(B) ΔH = ΔU + Δn$_g$RT. This is the correct relationship.

(C) ΔH – ΔU = – ΔnRT. This implies $\Delta H = \Delta U - \Delta nRT$. Incorrect sign.

(D) ΔH + ΔU = ΔnR. Incorrect formula.

Step 4: Final Answer:

The correct relation is ΔH = ΔU + Δn$_g$RT.

Quick Tip

A simple way to remember the formula $\Delta H = \Delta U + \Delta n_g RT$ is to think that enthalpy (H) includes the internal energy (U) plus the work done by the system to make space for itself ($P\Delta V \approx \Delta n_g RT$).

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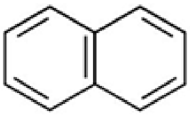
98. Consider the following compounds/species:

i.



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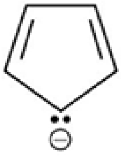

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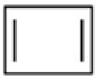
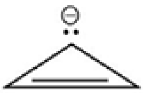
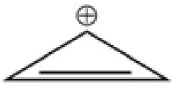


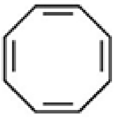
iv.



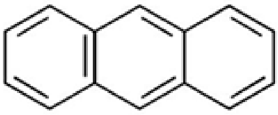
v.



vi.



vii.



The number of compounds/species which obey Huckel's rule is ____________.

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

Correct Answer: (B) 4

Solution:

Step 1: Understanding the Question:
The question asks us to count how many of the given seven species are aromatic based on Hückel's rule.

Step 2: Key Formula or Approach:
Hückel's rule states that for a species to be aromatic, it must satisfy four conditions: 1. It must be cyclic. 2. It must be planar. 3. It must be completely conjugated (every atom in the ring must have a p-orbital). 4. It must contain $(4n + 2)$ π electrons, where n is a non-negative integer (0, 1, 2, ...).

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

- **i. Naphthalene:** It is cyclic, planar, and fully conjugated. It has 10 π electrons. For $4n + 2 = 10$, $4n = 8$, so $n = 2$. It obeys Hückel's rule. **(Aromatic)**

- **ii. Cyclopentadienyl anion:** It is cyclic, planar, and fully conjugated. It has 6 π electrons (4 from double bonds, 2 from the lone pair/negative charge). For 4n + 2 = 6, 4n = 4, so n = 1. It obeys Hückel's rule. **(Aromatic)**

- **iii. Cyclopropenyl cation:** It is a three-membered ring with a positive charge. It is cyclic, planar, and fully conjugated. It has 2 π electrons. For 4n + 2 = 2, 4n = 0, so n = 0. It obeys Hückel's rule. **(Aromatic)**

- **iv. Bicyclo[1.1.0]butane:** This is a bicyclic, non-planar molecule. It is not aromatic. **(Non-aromatic)**

- **v. Cyclopropenyl cation:** This appears to be the same as species iii. Assuming it's a distinct species intended, like cyclobutadiene, which has 4π electrons (anti-aromatic), or some other non-aromatic species, it doesn't add to the count. Let's assume it is just a repeated structure.

- **vi. Cyclooctatetraene (COT):** It is cyclic and has 8 π electrons (a 4n system, where n=2). To avoid the instability of being anti-aromatic, it adopts a non-planar, tub-like shape. Since it's not planar, it is not aromatic. **(Non-aromatic)**

- **vii. Anthracene:** It is cyclic, planar, and fully conjugated. It has 14 π electrons. For 4n + 2 = 14, 4n = 12, so n = 3. It obeys Hückel's rule. **(Aromatic)**

Step 4: Final Answer:
The species that are aromatic are i, ii, iii, and vii. Counting these, we find there are 4 aromatic species. This corresponds to option (2).

Quick Tip

When applying Hückel's rule, remember to check all four criteria: Cyclic, Planar, Conjugated, and (4n+2) π electrons. A species failing even one criterion is not aromatic. Common non-aromatic examples include molecules with sp^3 carbons in the ring or non-planar systems like Cyclooctatetraene.

---

99. 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:
The question asks to calculate the standard Gibbs free energy change (ΔG°) for a given reaction using the equilibrium concentrations of reactants and products, the temperature, and the gas constant in calories.

Step 2: Key Formula or Approach:
1. First, calculate the equilibrium constant (K_c) from the given concentrations.
2. Then, use the relationship between the standard Gibbs free energy change and the equilibrium constant:

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

This can also be written as:

$$\Delta G^\circ = -2.303RT \log_{10} K_c$$

We are given R = 2 cal/mol K and T = 300 K.

Step 3: Detailed Explanation:
Part 1: Calculate the equilibrium constant (K_c)
The reaction is: A + B $\rightleftharpoons$ C + D
The expression for K_c is:

$$K_c = \frac{[\mathrm{C}][\mathrm{D}]}{[\mathrm{A}][\mathrm{B}]}$$

The given equilibrium concentrations are:
A
= 2 mol L^{-1}
B
= 3 mol L^{-1}
C
= 10 mol L^{-1}
D
= 6 mol L^{-1}
Substituting these values:

$$K_c = \frac{(10)(6)}{(2)(3)} = \frac{60}{6} = 10$$

Part 2: Calculate ΔG°
Now use the formula $\Delta G^\circ = -RT \ln K_c$.

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

We know that $\ln(10) \approx 2.303$.

$$\Delta G^\circ = -600 \times 2.303 \text{ cal/mol}$$
$$\Delta G^\circ = -1381.8 \text{ cal/mol}$$

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

Quick Tip

Remember the key relationship $\Delta G^\circ = -RT \ln K$. A value of K ¿ 1 implies $\ln K > 0$, leading to a negative ΔG° (spontaneous reaction under standard conditions). A value of K ¡ 1 implies $\ln K < 0$, leading to a positive ΔG° (non-spontaneous).

---

100. 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:
The question asks us to identify the incorrect statements about the properties of transition metal oxides from a list of five statements.

Step 2: Detailed Explanation:
Let's evaluate each statement:
A. All the transition metals except scandium form MO oxides which are ionic.
This statement is a broad generalization and is **incorrect**. While many transition metals form oxides of the type MO (e.g., MnO, FeO, NiO) which are predominantly ionic, early transition metal oxides like TiO and VO show significant metallic/covalent character. Also, not all transition metals form stable MO oxides. However, compared to other statements, its incorrectness

is a matter of degree. Let's keep evaluating.

B. The highest oxidation number corresponding to the group number in transition metal oxides is attained in Sc_2O_3 to Mn_2O_7.

This statement is **correct**. Scandium (Group 3) shows +3 in Sc_2O_3. Titanium (Group 4) shows +4 in TiO_2. Vanadium (Group 5) shows +5 in V_2O_5. Chromium (Group 6) shows +6 in CrO_3. Manganese (Group 7) shows +7 in Mn_2O_7. This trend holds true for the first half of the first transition series.

C. Basic character increases from V_2O_3 to V_2O_4 to V_2O_5.

This statement is **incorrect**. For oxides of the same element, the acidic character increases as the oxidation state of the element increases. Consequently, the basic character decreases. The oxidation states of Vanadium are +3 in V_2O_3 (basic), +4 in V_2O_4 (amphoteric), and +5 in V_2O_5 (amphoteric/acidic). The trend of basicity is V_2O_3 ¿ V_2O_4 ¿ V_2O_5. The statement claims the opposite.

D. V_2O_4 dissolves in acids to give VO_4^- salts.

This statement is **incorrect**. V_2O_4 contains Vanadium in the +4 oxidation state. When it dissolves in acid, it forms the vanadyl ion, which has the formula VO^{2+}. The ion VO_4^{3-} (orthovanadate) contains Vanadium in the +5 oxidation state and is formed from V_2O_5 in basic solution. There is no common VO_4^- ion for vanadium.

E. CrO is basic but Cr_2O_3 is amphoteric.

This statement is **correct**. This follows the same trend as with vanadium. CrO (oxidation state +2) is basic, Cr_2O_3 (oxidation state +3) is amphoteric, and CrO_3 (oxidation state +6) is acidic.

Step 3: Final Answer:

Statements C and D are definitively incorrect based on fundamental principles of inorganic chemistry. While statement A is also not perfectly accurate, C and D represent clear factual errors. The combination of incorrect statements offered in the options is (C) C and D only.

Quick Tip

A key trend for metal oxides: as the oxidation state of the metal increases, the covalent character of the oxide increases, and its acidic character increases (or basic character decreases). Low oxidation state = basic, intermediate = amphoteric, high oxidation state = acidic.