NEET UG 2025 Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**720	**Total Questions :**180

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The total duration of the examination is 3 hours. The question paper comprises a single section covering the following subjects:
   Physics, Chemistry, and Biology (Botany & Zoology)
2. The total number of questions is 180, carrying a maximum of 720 marks.
3. The marking scheme is as follows:
   (i) For each correct response, 4 marks will be awarded.
   (ii) For each incorrect response, 1 mark will be deducted.
   (iii) No marks will be awarded or deducted for unattempted questions.
4. The medium of the question paper is available in multiple languages including English, Hindi, and others as specified by NTA.
5. The examination will be conducted in Pen and Paper-based Test (PBT) mode.
6. Candidates must follow the instructions provided during the exam for filling out the OMR sheet and submitting their answers.

Chemistry

46. Given below are two statements:

Statement I: Ferromagnetism is considered as an extreme form of paramagnetism.
Statement II: The number of unpaired electrons in a Cr^{2+} ion (Z = 24) is the same as that of a Nd^{3+} ion (Z = 60).

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

(1) Both Statement I and Statement II are false
(2) Statement I is true but Statement II is false
(3) Statement I is false but Statement II is true
(4) Both Statement I and Statement II are true

Correct Answer: (2) Statement I is true but Statement II is false

Solution:
Statement I: Ferromagnetism is considered as an extreme form of paramagnetism.

In paramagnetism, the magnetic moments of individual atoms or ions are randomly oriented, but they tend to align with an external magnetic field. In ferromagnetism, there is spontaneous alignment of the magnetic moments, even in the absence of an external field, resulting in a much stronger magnetization. Therefore, Ferromagnetism is considered as an extreme case of Paramagnetism, making the statement accurate.

Statement II: The number of unpaired electrons in a Cr^{2+} ion (Z = 24) is the same as that of a Nd^{3+} ion (Z = 60).

Cr (Chromium) has an electronic configuration of [Ar] $3d^5$ $4s^1$. When it becomes Cr^{2+}, it loses the 4s electron and one 3d electron giving [Ar] $3d^4$, resulting in four unpaired electrons.
Nd (Neodymium) has an electronic configuration of [Xe] $4f^4$ $6s^2$. When it becomes Nd^{3+}, it loses the two 6s electrons and one 4f electron giving [Xe] $4f^3$, resulting in three unpaired electrons.
Therefore, the number of unpaired electrons is incorrect

Statement I is TRUE, statement II is FALSE.

Quick Tip

To determine the number of unpaired electrons in ions, subtract electrons based on ion charge and refer to orbital filling rules (3d, 4f, etc.).

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47. For the reaction $A(g) \rightleftharpoons 2B(g)$, the backward reaction rate constant is higher than the forward reaction rate constant by a factor of 2500, at 1000 K.
[Given: $R = 0.0831$ atm mol^{-1} K^{-1}]

K_p for the reaction at 1000 K is:

(1) 2.077×10^5
(2) 0.033
(3) 0.021
(4) 83.1

Correct Answer: (2) 0.033

Solution:
We are given: - Backward rate constant, $k_b = 2500 \times k_f$ - Therefore, $\frac{k_f}{k_b} = \frac{1}{2500}$ - Also, for a gaseous equilibrium reaction:

$$K_p = K_c(RT)^{\Delta n}$$

But since we are dealing with rate constants, we can use the relation:

$$K_c = \frac{k_f}{k_b} = \frac{1}{2500}$$

Given reaction: $A(g) \rightleftharpoons 2B(g)$, so $\Delta n = 2 - 1 = 1$

Use the formula:

$$K_p = K_c(RT)^{\Delta n}$$

Substitute values:

$$K_p = \frac{1}{2500} \times (0.0831 \times 1000)^1 = \frac{1}{2500} \times 83.1$$

$$K_p = \frac{83.1}{2500} = 0.03324 \approx 0.033$$

Hence, the value of K_p is approximately 0.033.

Quick Tip

When backward rate constant is given as a multiple of the forward rate constant, use $K_c = \frac{k_f}{k_b}$, and relate it to K_p using $(RT)^{\Delta n}$.

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48. Total number of possible isomers (both structural as well as stereoisomers) of cyclic ethers of molecular formula C_4H_8O is:

(1) 8
(2) 10
(3) 11
(4) 6

Correct Answer: (4) 6

Solution:
We are asked to count all possible isomers (structural and stereoisomers) for cyclic ethers with the molecular formula C_4H_8O. This formula corresponds to saturated cyclic ethers (with one ring and one oxygen atom, no double bonds).

Let us identify the different ring sizes and substitutions:

1. Three-membered ring ethers (Oxiranes/Epoxy compounds): - Ethyloxirane (1-ethyl-oxirane) - Methylmethyloxirane (2-methyl-oxirane, both cis and trans isomers) → 2 stereoisomers
2. Four-membered ring ethers (Oxetanes): - Methyl-substituted oxetane (on different carbon positions) - 2 stereoisomers (cis/trans) possible depending on substitution pattern
3. Tetrahydrofuran derivative (5-membered ring): - 2-methyltetrahydrofuran → exists as cis/trans stereoisomers
So we have:
- 1 from ethyloxirane
- 2 from methylmethyloxirane (cis/trans)
- 1 from methyl-substituted oxetane
- 2 from methyltetrahydrofuran (cis/trans)

Total = 1 + 2 + 1 + 2 = 6 isomers

Quick Tip

When counting isomers, always consider both ring size and possible stereoisomers (cis/trans) due to ring strain and substituents.

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49. Given below are two statements:

Statement I: A hypothetical diatomic molecule with bond order zero is quite stable.
Statement II: As bond order increases, the bond length increases.

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

(1) Both Statement I and Statement II are false
(2) Statement I is true but Statement II is false
(3) Statement I is false but Statement II is true
(4) Both Statement I and Statement II are true

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

Solution:
Statement I: Bond order is an indicator of stability in molecules. A bond order of zero means there is no bond formation between the two atoms, hence the molecule cannot exist in a stable form. Therefore, this statement is **false**.

Statement II: As bond order increases, the number of bonding electrons increases, strengthening the bond and pulling the atoms closer together. Thus, bond length **decreases** with increasing bond order. Hence, this statement is also **false**.

Thus, both the statements are incorrect.

Quick Tip

Remember: Higher bond order implies stronger bonds and shorter bond lengths; a bond order of zero means the molecule is unstable.

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50. Identify the suitable reagent for the following conversion:

$\mathrm{Ph} - \mathrm{C} = \mathrm{OCH_3} \longrightarrow \mathrm{Ph} - \mathrm{CHO}$

(1) (i) $AlH(iBu)_2$ (ii) H_2O
(2) (i) $NaBH_4$, (ii) H^+/H_2O
(3) H_2 / $Pd\text{-}BaSO_4$
(4) (i) $LiAlH_4$, (ii) H^+/H_2O

Correct Answer: (1) (i) $AlH(iBu)_2$ (ii) H_2O

Solution:
The transformation is from an ester ($Ph-COOCH_3$) to an aldehyde ($Ph-CHO$). This selective reduction requires a mild and bulky reducing agent that reduces esters only to aldehydes without further reducing to alcohols.
- **Option (1):** Diisobutylaluminium hydride (DIBAL-H or $AlH(iBu)_2$) at low temperatures (–78°C), followed by hydrolysis, reduces esters to aldehydes. This is the correct reagent.
- **Option (2):** $NaBH_4$ is too mild to reduce esters.
- **Option (3):** $H_2/Pd\text{-}BaSO_4$ is used for Rosenmund reduction (acid chlorides to aldehydes), not esters.
- **Option (4):** $LiAlH_4$ is strong and will reduce esters all the way to primary alcohols.

Thus, only DIBAL-H allows selective conversion of ester to aldehyde.

Quick Tip

Use DIBAL-H for selective reduction of esters to aldehydes; $LiAlH_4$ over-reduces to alcohols.

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51. The major product of the following reaction is:

$Ph-C{=}OH_2CH_2-CN$
(i) CH_3MgBr (excess)   (ii) H^+/H_2O

(1) $Ph-CH_3-CH_2-COCH_3$
(2) $Ph-OH_3-{}_2CH_3$
(3) $Ph-CO-CH_2CH_2CH_3$
(4) $Ph-CH_3-CH_2-CN$

Correct Answer: (1) $Ph-CH_3-CH_2-COCH_3$

Solution:
The given compound is a substituted aryl ketone with a cyano group at the terminal position. Reagent: excess CH_3MgBr (a Grignard reagent) + acidic hydrolysis.
Step 1: Grignard Reaction with Ketone
- CH_3MgBr adds a methyl group to the carbonyl carbon of the ketone (nucleophilic attack), forming a tertiary alcohol after hydrolysis.
Step 2: Reaction with –CN group
- Since excess Grignard reagent is used, it also reacts with the nitrile group (–CN) to give an imine intermediate, which on hydrolysis gives a ketone.
Net Result:
- The carbonyl group (initial ketone) gives a tertiary alcohol: $Ph-OH_3-CH_2-CH_2-CN$
- The –CN gets converted into a ketone group: $-CH_2-COCH_3$

After tautomerization or rearrangement, we obtain the product: $\text{Ph} — \text{CH}_3 — \text{CH}_2 — \text{COCH}_3$ — this matches option (1).

Quick Tip

Grignard reagents attack both carbonyl and nitrile groups; nitriles give ketones, while aldehydes/ketones give alcohols after hydrolysis.

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52. If the molar conductivity (Λ_m) of a 0.050 mol L^{-1} solution of a monobasic weak acid is 90 S cm^2 mol^{-1}, its extent (degree) of dissociation will be:

[**Assume:** Λ^0 **= 349.6 S cm^2 mol^{-1} and** Λ^0_{acid} **= 50.4 S cm^2 mol^{-1}**]

(1) 0.125
(2) 0.225
(3) 0.215
(4) 0.115

Correct Answer: (2) 0.225

Solution:
The degree of dissociation (α) is defined as the ratio of the molar conductivity at a given concentration (Λ_m) to the limiting molar conductivity at infinite dilution (Λ_0). In this case, the limiting molar conductivity of the weak acid (Λ_0) can be calculated by summing the limiting molar conductivities of the ions it dissociates into, i.e., H^+ and A^-:

$$\Lambda_0 = \Lambda^0_{H^+} + \Lambda^0_{\text{acid}^-}$$

Given that $\Lambda^0_{H^+} = 349.6$ S cm^2 mol^{-1} and $\Lambda^0_{\text{acid}^-} = 50.4$ S cm^2 mol^{-1}, we can calculate Λ_0:

$$\Lambda_0 = 349.6 + 50.4 = 400.0 \text{ S cm}^2 \text{ mol}^{-1}$$

Now, we can calculate the degree of dissociation (α) using the following formula:

$$\alpha = \frac{\Lambda_m}{\Lambda_0}$$

Given that $\Lambda_m = 90$ S cm^2 mol^{-1}, we have:

$$\alpha = \frac{90}{400} = 0.225$$

Thus, the degree of dissociation is approximately 0.225.

Quick Tip

For weak electrolytes, use $\alpha = \frac{\Lambda_m}{\Lambda_m^0}$ to find the degree of dissociation from molar conductivities.

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53. Which one of the following reactions does NOT belong to "Lassaigne's test"?

(1) $2Na+S \xrightarrow{\Delta} Na_2S$
(2) $Na + X \xrightarrow{\Delta} NaX$
(3) $2CuO+C \xrightarrow{\Delta} 2Cu+CO_2$
(4) $Na + C+N \xrightarrow{\Delta} NaCN$

Correct Answer: (3) $2CuO+C \xrightarrow{\Delta} 2Cu+CO_2$

Solution:
Lassaigne's test is used to detect the presence of extra elements (like nitrogen, sulfur, halogens) in organic compounds. In this test, organic compounds are fused with sodium to convert these elements into their ionic detectable forms: - Nitrogen → NaCN - Sulfur → Na_2S - Halogens → NaX (NaCl, NaBr, NaI)
Now evaluate the reactions: - **Option (1)**: Formation of Na_2S → Used to test sulfur — part of Lassaigne's test.
- **Option (2)**: Formation of NaX (halide salts) → Used to test halogens — part of Lassaigne's test.
- **Option (3)**: This is a reduction reaction of CuO by carbon — NOT related to detection of any element in organic analysis. **Not part of Lassaigne's test.**
- **Option (4)**: Formation of NaCN — used for nitrogen detection — is part of Lassaigne's test.

Therefore, only option (3) is unrelated to Lassaigne's test.

Quick Tip

Lassaigne's test involves converting N, S, and halogens into ionic compounds using sodium for easy detection. Redox reactions like CuO + C are not included.

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54. The correct order of decreasing acidity of the following aliphatic acids is:

(1) $CH_3COOH > (CH_3)_2CHCOOH > (CH_3)_3CCOOH > HCOOH$
(2) $HCOOH > CH_3COOH > (CH_3)_2CHCOOH > (CH_3)_3CCOOH$
(3) $HCOOH > (CH_3)_3CCOOH > (CH_3)_2CHCOOH > CH_3COOH$
(4) $(CH_3)_3CCOOH > (CH_3)_2CHCOOH > CH_3COOH > HCOOH$

Correct Answer: (2) $HCOOH > CH_3COOH > (CH_3)_2CHCOOH$ ¿ $(CH_3)_3CCOOH$

Solution:
The acidity of carboxylic acids depends on the stability of the conjugate base formed after losing a proton (i.e., the carboxylate anion). This stability is influenced by the inductive effect of alkyl groups:
- Electron-donating groups (like alkyl groups) destabilize the carboxylate ion by increasing electron density, thus **decreasing acidity**.
- Electron-withdrawing groups stabilize the anion, **increasing acidity**.

Now, analyze each acid: - HCOOH (Formic acid): No alkyl group → Highest acidity.
- **CH_3COOH (Acetic acid):** One methyl group → lower than formic acid.
- **$(CH_3)_2CHCOOH$:** Isopropyl group → stronger +I effect → lower acidity.
- **$(CH_3)_3CCOOH$:** Tertiary butyl group → even more +I effect → least acidic.

Hence, the correct order of decreasing acidity is:

$$HCOOH > CH_3COOH > (CH_3)_2CHCOOH > (CH_3)_3CCOOH$$

Quick Tip

More alkyl groups mean stronger electron-donating (+I) effect, which reduces acid strength by destabilizing the conjugate base.

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55. Match List I with List II:

List I (Name of Vitamin) **List II (Deficiency Disease)**

List I (Name of Vitamin)		List II (Deficiency Disease)
A. Vitamin B_{12}		**I.** Cheilosis
B. Vitamin D		**II.** Convulsions
C. Vitamin B_2		**III.** Rickets
D. Vitamin B_6		**IV.** Pernicious anaemia

Choose the correct answer from the options given below:

(1) A-IV, B-III, C-I, D-II
(2) A-II, B-III, C-I, D-IV
(3) A-IV, B-III, C-II, D-I
(4) A-I, B-III, C-II, D-IV

Correct Answer: (1) A-IV, B-III, C-I, D-II

Solution:
Match each vitamin with its deficiency disorder:
- **Vitamin B_{12} → Pernicious anaemia** (A–IV)
- **Vitamin D → Rickets** (B–III), a bone disorder due to calcium/phosphate imbalance
- **Vitamin B_2 (Riboflavin) → Cheilosis** (C–I), characterized by cracked lips and inflammation at mouth corners
- **Vitamin B_6 (Pyridoxine) → Convulsions** (D–II), due to its role in neurotransmitter synthesis

Correct match: **A–IV, B–III, C–I, D–II**

Quick Tip

To remember vitamin deficiencies: B_{12} → blood (anaemia), D → D-bone (rickets), B_2 → lips (cheilosis), B_6 → brain (convulsions).

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56. Out of the following complex compounds, which of the compound will be having the minimum conductance in solution?

(1) $[Co(NH_3)_4Cl_2]Cl$
(2) $[Co(NH_3)_6]Cl_3$
(3) $[Co(NH_3)_5Cl]Cl$
(4) $[Co(NH_3)_3Cl_3]$

Correct Answer: (4) $[Co(NH_3)_3Cl_3]$

Solution:
The conductance of a solution depends on the number of ions present in the solution. When coordination complexes dissolve in water, the counter-ions dissociate, contributing to the conductance. Ligands inside the coordination sphere do not dissociate.
Let's analyze each complex:

1. $[Co(NH_3)_4Cl_2]Cl$ dissociates into $[Co(NH_3)_4Cl_2]^+$ and Cl^-. This gives 2 ions in solution.
2. $[Co(NH_3)_6]Cl_3$ dissociates into $[Co(NH_3)_6]^{3+}$ and $3Cl^-$. This gives 4 ions in solution.
3. $[Co(NH_3)_5Cl]Cl_2$ dissociates into $[Co(NH_3)_5Cl]^{2+}$ and $2Cl^-$. This gives 3 ions in solution.
4. $[Co(NH_3)_3Cl_3]$ does not have any counter-ions outside the coordination sphere. Therefore, it does not dissociate into any ions in solution. It exists as a neutral molecule in solution. Therefore, this is not an electrolyte, and has minimum conductance.

Therefore, the complex with the minimum conductance will be the one that produces the fewest ions in solution.

Thus, the compound with the minimum conductance is $[Co(NH_3)_3Cl_3]$.

Quick Tip

For complex compounds, the conductance is directly related to the number of ions produced during dissociation. Neutral complexes have the minimum conductance.

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57. Sugar 'X':

A. is found in honey.
B. is a keto sugar.

C. exists in α and β anomeric forms.
D. is laevorotatory.

'X' is:

(1) D-Fructose
(2) Sucrose
(3) Maltose
(4) D-Glucose

Correct Answer: (1) D-Fructose

Solution:
Let's analyze each statement:
- A. Fructose is commonly found in honey, making it a suitable candidate.
- B. Fructose is a keto sugar because it contains a ketone functional group (unlike glucose, which is an aldose).
- C. Fructose exists in α and β anomeric forms when it cyclizes to form a furanose ring.
- D. Fructose is laevorotatory, meaning it rotates plane-polarized light to the left.

Therefore, X is D-Fructose.

Quick Tip

Fructose is the only sugar among common monosaccharides that is a keto sugar and exhibits laevorotation. It is found in honey and has α and β anomeric forms.

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58. How many products (including stereoisomers) are expected from monochlorination of the following compound?

$CH_3 — CH — CH_2 — CH_3$

(1) 3
(2) 6
(3) 5
(4) 2

Correct Answer: (1) 3

Solution:
Monochlorination involves replacing one hydrogen atom with a chlorine atom. We need to consider all possible positions where chlorine can substitute a hydrogen and whether any of these substitutions create a stereocenter.

1. **Chlorination at C1:** CH_2Cl-CH_2-CH_2-CH_3. This is 1-chlorobutane.

2. **Chlorination at C2:** CH_3-CHCl-CH_2-CH_3. This is 2-chlorobutane. Since C2 becomes a chiral center, there are two stereoisomers (enantiomers): (R)-2-chlorobutane and (S)-2-chlorobutane.
3. **Chlorination at C3:** CH_3-CH_2-CHCl-CH_3. This is 2-chlorobutane. This product is the same as when Chlorination at C2 (same as before) as the molecule is symmetric around the C2-C3 bond if we don't care about stereoisomers. The molecule now has a chiral center, again there are two stereoisomers (enantiomers): (R)-2-chlorobutane and (S)-2-chlorobutane.
4. **Chlorination at C4:** CH_3-CH_2-CH_2-CH_2Cl. This is 1-chlorobutane. Same as first molecule since it is a symmetric molecule.

Therefore, there are three distinct monochlorinated products: 1-chlorobutane, (R)-2-chlorobutane, and (S)-2-chlorobutane. The number of products including stereoisomers is 3.

Quick Tip

When monochlorinating a compound with asymmetric carbons (especially secondary carbons), be sure to account for stereoisomers.

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59. Which one of the following compounds can exist as cis-trans isomers?

(1) 2-Methylhex-2-ene
(2) 1,1-Dimethylcyclopropane
(3) 1,2-Dimethylcyclohexane
(4) Pent-1-ene

Correct Answer: (1) 2-Methylhex-2-ene

Solution:
Cis-trans isomerism occurs when there are two different groups attached to each carbon of a double bond, resulting in non-superimposable mirror images. Let's analyze each compound:

- Option (1) 2-Methylhex-2-ene: The structure has a double bond between C2 and C3, with different groups (methyl and hydrogen) on C2 and C3. This allows for cis-trans isomerism.

- Option (2) 1,1-Dimethylcyclopropane: In this case, both methyl groups are attached to the same carbon (C1) in the cyclopropane ring, and thus, cis-trans isomerism is not possible due to the symmetry of the molecule.

- Option (3) 1,2-Dimethylcyclohexane: This compound does not have a double bond and is a saturated hydrocarbon, so cis-trans isomerism does not apply here.

- Option (4) Pent-1-ene: While this compound has a double bond, there are no two different substituents attached to the same carbon in the double bond, so cis-trans isomerism does not exist.

Thus, the correct compound that can exhibit cis-trans isomerism is 2-Methylhex-2-ene.

Quick Tip

For cis-trans isomerism to occur, the compound must have a double bond with two different groups attached to each of the carbons involved in the double bond.

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60. Which one of the following reactions does NOT give benzene as the product?

(1) n-hexane $\xrightarrow{MoO_3, 673K, 10-20\text{atm}}$

(2) $H_2C{=}CH_2 \xrightarrow{\text{hot Iron Tube at 873 K}}$

(3) $C_6H_5N_3 \xrightarrow{H_2O,\text{warm}}$

(4) $C_6H_5OH \xrightarrow{\text{soda lime}}$

Correct Answer: (3) $C_6H_5N_3 \xrightarrow{H_2O,\text{warm}}$

Solution:
Let's analyze each reaction:

1. **n-Hexane with Mo_2O_3 at 773K and 10-20 atm:** This is catalytic reforming or aromatization. n-Hexane can be converted to benzene under these conditions.
2. **Acetylene (Ethyne) with Red Hot Iron Tube at 873 K:** This is a classic method for synthesizing benzene. Three molecules of acetylene undergo cyclic polymerization to form benzene.
3. **Benzenediazonium Ion with Warm Water:** Benzenediazonium ion ($C_6H_5N_2{}^+$) reacts with warm water to form phenol (C_6H_5OH), not benzene. The diazonium group is replaced by a hydroxyl group.
4. **Benzoate with Sodalime and Heat:** This is decarboxylation. The benzoate loses CO_2 to form benzene.

Therefore, the reaction that does not produce benzene as a major product is the reaction of benzenediazonium ion with warm water.

Quick Tip

When dealing with reactions involving aromatic rings, look for reactions that either remove functional groups (like in soda lime reactions) or those that induce cyclization (like ethene cracking).

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61. Phosphoric acid ionizes in three steps with their ionization constant values K_1, K_2, and K_3, respectively, while K is the overall ionization constant. Which of the following statements are true?

(1) A and C only
(2) B, C and D only
(3) A, B and C only
(4) A and B only

Correct Answer: (3) A, B, and C only

Solution:
Phosphoric acid (H_3PO_4) ionizes stepwise as:
1. $H_3PO_4 \xrightarrow{K_1} H_2PO_4^- + H^+$ 2. $H_2PO_4^- \xrightarrow{K_2} HPO_4^{2-} + H^+$ 3. $HPO_4^{2-} \xrightarrow{K_3} PO_4^{3-} + H^+$
The overall ionization constant K is related to the individual constants by the equation:

$$K = K_1 \times K_2 \times K_3$$

Taking the logarithm of both sides:

$$\log K = \log K_1 + \log K_2 + \log K_3$$

Thus, Statement A is true.

- Statement B: H_3PO_4 (phosphoric acid) is indeed a stronger acid than $H_2PO_4^-$ (dihydrogen phosphate) and HPO_4^{2-} (hydrogen phosphate) because it is in its protonated form, and each successive deprotonation reduces the acid strength. Thus, Statement B is true.

- Statement C: As for the ionization constants, $K_1 > K_2 > K_3$, because the first proton is the easiest to lose, and subsequent deprotonations are progressively harder. Therefore, Statement C is true.

- Statement D: This is incorrect. The ratio $\frac{K_3}{K_2}$ does not have any standard relationship in the context of phosphoric acid's ionization. Therefore, Statement D is false.

Thus, the correct answer is A, B, and C only.

Quick Tip

For polyprotic acids like phosphoric acid, the ionization constants decrease as we move from the first proton dissociation to the third, reflecting the decreasing strength of successive deprotonations.

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62. Among the following, choose the ones with an equal number of atoms.

A. 212 g of Na_2CO_3 (s) [molar mass = 106 g]
B. 248 g of $NaNO_3$ (s) [molar mass = 62 g]
C. 240 g of NaOH (s) [molar mass = 40 g]
D. 12 g of H_2 (g) [molar mass = 2 g]
E. 220 g of CO_2 (g) [molar mass = 44 g]

Choose the correct answer from the options given below:

(1) A, B, and D only
(2) B, C, and D only
(3) B, D, and E only
(4) A, B, and C only

Correct Answer: (1) A, B, and D only

Solution:

A. 212 g of Na_2CO_3 (molar mass = 106 g/mol)

Moles = 212 g / 106 g/mol = 2 mol

Atoms per molecule = 2 (Na) + 1 (C) + 3 (O) = 6 atoms

Total "atoms" = 2 mol * 6 atoms/mol = 12

B. 248 g of Na_2O (molar mass = 62 g/mol)

Moles = 248 g / 62 g/mol = 4 mol

Atoms per molecule = 2 (Na) + 1 (O) = 3 atoms

Total "atoms" = 4 mol * 3 atoms/mol = 12

C. 240 g of NaOH (molar mass = 40 g/mol)

Moles = 240 g / 40 g/mol = 6 mol

Atoms per molecule = 1 (Na) + 1 (O) + 1 (H) = 3 atoms

Total "atoms" = 6 mol * 3 atoms/mol = 18

D. 12 g of H_2 (molar mass = 2 g/mol)

Moles = 12 g / 2 g/mol = 6 mol

Atoms per molecule = 2 (H) = 2 atoms

Total "atoms" = 6 mol * 2 atoms/mol = 12

E. 220 g of CO_2 (molar mass = 44 g/mol)

Moles = 220 g / 44 g/mol = 5 mol

Atoms per molecule = 1 (C) + 2 (O) = 3 atoms

Total "atoms" = 5 mol * 3 atoms/mol = 15

Now, we compare the total "atoms":
A = 12
B = 12
C = 18
D = 12
E = 15

A, B, and D have the same number of atoms (12).

Quick Tip

When comparing number of atoms in different compounds, first calculate the number of moles and then multiply by the number of atoms per mole.

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63. Given below are two statements:

Statement I: Like nitrogen that can form ammonia, arsenic can form arsine.
Statement II: Antimony cannot form antimony pentoxide.

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

(1) Both Statement I and Statement II are incorrect
(2) Statement I is correct but Statement II is incorrect
(3) Statement I is incorrect but Statement II is correct
(4) Both Statement I and Statement II are correct

Correct Answer: (2) Statement I is correct but Statement II is incorrect

Solution:

Statement I: Like nitrogen that can form ammonia, arsenic can form arsine.
This statement is **correct**. Arsenic, like nitrogen, can form arsine (AsH), which is analogous to ammonia (NH) in its chemical properties.

Statement II: Antimony cannot form antimony pentoxide.
This statement is **incorrect**. Antimony can form antimony pentoxide (SbO), which is a well-known compound of antimony in its highest oxidation state (+5).

Thus, the correct answer is (2) — Statement I is correct but Statement II is incorrect.

Quick Tip

Antimony (Sb) can form compounds like antimony pentoxide (SbO), and arsine (AsH) is analogous to ammonia (NH) in arsenic chemistry.

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64. Dalton's Atomic Theory could not explain which of the following?

(1) Law of constant proportion
(2) Law of multiple proportion
(3) Law of gaseous volume
(4) Law of conservation of mass

Correct Answer: (3) Law of gaseous volume

Solution:

Dalton's Atomic Theory was a significant step in the development of modern chemistry, but it had some limitations:

- Law of constant proportion: According to Dalton's theory, each compound is composed of atoms of different elements combined in fixed ratios. This is consistent with the law of constant proportion, which Dalton's theory could explain.

- Law of multiple proportion: Dalton's theory also explained the law of multiple proportions, where elements combine in simple, whole-number ratios to form different compounds.

- Law of gaseous volume: The law of gaseous volume (Gay-Lussac's Law) states that gases combine in simple whole-number ratios by volume when measured at the same temperature and pressure. Dalton's Atomic Theory could not explain this law because it assumed that the atoms of different elements were indivisible and had fixed volumes, but Gay-Lussac's law involves the behavior of gases, which require a more advanced understanding of molecular behavior.

- Law of conservation of mass: Dalton's theory also aligned with the law of conservation of mass, as it implied that the mass of reactants equals the mass of products, since atoms are neither created nor destroyed.

Thus, the correct answer is (3) Law of gaseous volume, as Dalton's Atomic Theory could not explain this phenomenon.

Quick Tip

Dalton's theory assumed fixed volumes for atoms, which made it incompatible with the behavior of gases, as shown in Gay-Lussac's Law. This required a molecular theory of gases.

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65. The correct order of decreasing basic strength of the given amines is:

(1) N-ethylmethanamine > ethanamine > benzenamine > N-methylaniline
(2) N-ethylmethanamine > ethanamine > N-methylaniline > benzenamine
(3) N-methylaniline > ethanamine > benzenamine > N-ethylmethanamine
(4) N-methylaniline > N-ethylmethanamine > benzenamine > ethanamine

Correct Answer: (2) N-ethylmethanamine > ethanamine ¿ N-methylaniline ¿ benzenamine

Solution:
Basic strength of amines depends on the availability of the nitrogen lone pair for protonation. The basicity of amines can be influenced by electron-donating and electron-withdrawing groups attached to the nitrogen. The general trend is:

- Alkyl groups (like ethyl and methyl) donate electrons to the nitrogen, increasing its basicity.
- A benzene ring (as in benzenamine) is electron-withdrawing due to resonance, which decreases the basicity of the nitrogen.

Let's analyze the amines in the options:
- N-ethylmethanamine (ethylamine): The ethyl group is electron-donating, making the nitrogen more basic than ethanamine.
- Ethanamine (ethylamine): The amine group is attached to an ethyl group, giving it good electron-donating effects, but the effect is weaker than in N-ethylmethanamine.
- N-methylaniline: The methyl group is electron-donating, but the aromatic ring in benzenamine withdraws electron density through resonance, making N-methylaniline less basic than ethanamine.
- Benzenamine (aniline): The aromatic ring has a strong electron-withdrawing effect on the nitrogen, making this the least basic of all the options.

Thus, the correct order of basicity is N-ethylmethanamine > ethanamine > N-methylaniline > benzenamine.

Quick Tip

When evaluating the basicity of amines, remember that alkyl groups increase basicity by donating electron density, while aromatic rings decrease basicity by withdrawing electron density.

---

66. Which of the following statements are true?

A. Unlike Ga that has a very high melting point, Cs has a very low melting point.
B. On Pauling scale, the electronegativity values of N and C are not the same.
C. Ar, K^+, Cl^-, Ca^{2+} and S^{2-} are all isoelectronic species.
D. The correct order of the first ionization enthalpies of Na, Mg, Al, and Si is Si > Al > Mg > Na.
E. The atomic radius of Cs is greater than that of Li and Rb.

Choose the correct answer from the options given below:

(1) C and E only
(2) C and D only
(3) A, C, and E only
(4) A, B, and E only

Correct Answer: (3) A, C, and E only

Solution:

Let's evaluate each statement:

- Statement A: Cs has a very low melting point compared to Ga. This statement is **true**, as cesium (Cs) is an alkali metal and has a much lower melting point compared to gallium (Ga).

- Statement B: On the Pauling scale, the electronegativity values of N and C are actually different. Nitrogen (N) has a higher electronegativity (3.04) than carbon (C) (2.55). This statement is **true**.

- Statement C: Ar, K^+, Cl^-, Ca^{2+}, and S^{2-} all have the same electron configuration (18 electrons), so they are isoelectronic species. This statement is **true**.

- Statement D: The correct order of the first ionization enthalpies is Si ¿ Al ¿ Mg ¿ Na. This is incorrect because magnesium (Mg) has a higher ionization enthalpy than aluminum (Al). The correct order should be Si ¿ Mg ¿ Al ¿ Na. Thus, this statement is **false**.

- Statement E: The atomic radius of Cs (cesium) is greater than that of Li (lithium) and Rb (rubidium). This statement is **true**, as atomic size increases down the group in the periodic table.

Thus, the correct answer is (3) A, C, and E only.

Quick Tip

Isoelectronic species have the same number of electrons, but not necessarily the same number of protons. Always check the electron configurations and atomic sizes carefully when analyzing such questions.

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67. Match List I with List II:

List I (Compound) **List II (Geometry)**

A. XeO_3		**I.** sp^3 linear
B. XeF_2		**II.** sp^3 pyramidal
C. $XeOF_4$		**III.** sp^{3d} distorted octahedral
D. XeF_6		**IV.** sp$^{3d^2}$ square pyramidal

Choose the correct answer from the options given below:

(1) A-I, B-IV, C-III, D-II
(2) A-IV, B-II, C-III, D-I
(3) A-IV, B-I, C-II, D-III
(4) A-II, B-I, C-IV, D-III

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

Solution:
To determine the correct geometry, we need to determine the number of electron pairs (bonding

and lone pairs) around the central Xenon atom for each molecule.

A. XeO_3

- Xe has 8 valence electrons. Each O contributes 2 electrons for bonding. So Xe will have 3 double bonds with the 3 O atoms, leaving one lone pair. 3 bond pairs + 1 lone pair = 4 electron pairs around Xe.
- This gives sp^3 hybridization. Because of the presence of a lone pair, the geometry is pyramidal.

B. XeF_2

- Xe has 8 valence electrons. Each F contributes 1 electron for bonding. So Xe will have 2 single bonds with the 2 F atoms, leaving three lone pairs. 2 bond pairs + 3 lone pairs = 5 electron pairs around Xe.
- This gives sp^3d hybridization. The three lone pairs are arranged equatorially to minimize repulsion, resulting in a linear geometry.

C. $XeOF_4$

- Xe has 8 valence electrons. Each F contributes 1 electron for bonding, O contributes 2 electron bonding. So Xe will have 4 single bonds with the 4 F atoms, and 1 double bond with the 1 O atom, leaving one lone pair. 5 bond pairs + 1 lone pair = 6 electron pairs around Xe.
- This gives sp^3d^2 hybridization. With one lone pair it makes Square pyramidal.

D. XeF_6

- Xe has 8 valence electrons. Each F contributes 1 electron for bonding. So Xe will have 6 single bonds with the 6 F atoms, leaving one lone pair. 6 bond pairs + 1 lone pair = 7 electron pairs around Xe.
- Due to steric congestion, the molecule does not exhibit octahedral geometry. Based on the VSEPR model, The molecule is predicted to have a distorted octahedral geometry. The central Xe atom has seven electron pairs around it (6 bonds and 1 lone pair), which cause its geometry to be distorted octahedral.

Matching the compounds to their geometries:

A (XeO_3) - II (sp^3 pyramidal)
B (XeF_2) - I (sp^3d linear)
C ($XeOF_4$) - IV (sp^3d^2 square pyramidal)
D (XeF_6) - III (sp^3d distorted octahedral)

The correct answer is (4) A-II, B-I, C-IV, D-III

Quick Tip

Remember that the hybridization and geometry of a molecule are largely determined by the number of bonding and lone pairs on the central atom. For compounds with xenon, the hybridization can often be sp^3, sp^{3d}, or sp^{3d^2} depending on the number of bonds and lone pairs.

68. The standard heat of formation, in kcal/mol, of Ba^{2+} is:

Given: Standard heat of formation of SO^{2}(aq) = -216 kcal/mol, standard heat of crystallization of BaSO(s) = -4.5 kcal/mol, standard heat of formation of BaSO(s) = -349 kcal/mol.

(1) 133.0
(2) 133.0 + 133.0
(3) 220.5
(4) -128.5

Correct Answer: (4) -128.5

Solution:

We are given the following information:

$\Delta H_f^\circ(\mathrm{SO}_4^{2-}(aq)) = -216$ kcal/mol
$\Delta H_{\text{crystallization}}(\mathrm{BaSO}_4(s)) = -4.5$ kcal/mol
$\Delta H_f^\circ(\mathrm{BaSO}_4(s)) = -349$ kcal/mol

We need to find $\Delta H_f^\circ(\mathrm{Ba}^{2+}(aq))$.

The formation reaction for $BaSO_4$(s) is:

Ba^{2+}(aq) + $SO_4{}^{2-}$(aq) → $BaSO_4$(s)
Using Hess's Law, we can write:

$$\Delta H_f^\circ(\mathrm{BaSO}_4(s)) = \Delta H_f^\circ(\mathrm{Ba}^{2+}(aq)) + \Delta H_f^\circ(\mathrm{SO}_4^{2-}(aq)) + \Delta H_{\text{crystallization}}(\mathrm{BaSO}_4(s))$$

Rearranging to solve for $\Delta H_f^\circ(\mathrm{Ba}^{2+}(aq))$:

$$\Delta H_f^\circ(\mathrm{Ba}^{2+}(aq)) = \Delta H_f^\circ(\mathrm{BaSO}_4(s)) - \Delta H_f^\circ(\mathrm{SO}_4^{2-}(aq)) - \Delta H_{\text{crystallization}}(\mathrm{BaSO}_4(s))$$

Substituting the given values:

$$\Delta H_f^\circ(\mathrm{Ba}^{2+}(aq)) = -349 - (-216) - (-4.5) = -349 + 216 + 4.5 = -128.5 \text{ kcal/mol}$$

Therefore, the standard heat of formation of Ba^{2+} is -128.5 kcal/mol.
The correct answer is (4).

Quick Tip

Always apply Hess's Law when you have multiple reactions and want to find the heat of formation of an intermediate species.

69. Among the given compounds I-III, the correct order of bond dissociation energy of the C-H bond marked with is:

(1) I $>$ II $>$ III
(2) III $>$ II $>$ I
(3) II $>$ I $>$ III
(4) I $>$ III $>$ II

Correct Answer: (3) II $>$ I $>$ III

Solution:

Bond dissociation energy is the energy required to break a bond, and it depends on the stability of the bond. In the case of C-H bonds, the following factors affect their bond dissociation energy:

- Aromatic C-H bond (I): The C-H bond in an aromatic compound is stabilized by resonance and the delocalization of electrons in the aromatic ring. This results in a relatively high bond dissociation energy.

- Aliphatic C-H bond (II): The C-H bond in a typical aliphatic compound (like an alkane) is weaker compared to the C-H bond in an aromatic system because there is no such resonance stabilization. Thus, the bond dissociation energy will be moderate.

- C-H bond in a cyclopropane-like structure (III): The C-H bond in a strained structure like cyclopropane is weaker due to the angle strain, making it easier to break. Hence, this bond has the lowest bond dissociation energy.

Thus, the correct order of bond dissociation energy is II $>$ I $>$ III.

Quick Tip

Resonance stabilization (like in aromatic compounds) usually increases the bond dissociation energy, while strain (like in cyclopropanes) decreases it.

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70. Predict the major product P in the following sequence of reactions:

(i) HBr, benzoyl peroxide
(ii) KCN
(iii) Na(Hg), C_2H_5OH

(1) C_6H_5 — CH_2 — CH_3
(2) C_6H_5 — CH_2 — NH_2
(3) C_6H_5 — CH_2 — CN
(4) C_6H_5 — NH_2

Correct Answer: (3) $C_6H_5 — CH_2 — CN$

Solution:

The sequence of reactions involves the following steps:

1. Step (i) HBr, benzoyl peroxide: This is a free radical halogenation reaction, where the alkyl group on the benzene ring undergoes bromination at the benzylic position due to the formation of free radicals, resulting in the product $C_6H_5 — CH_2Br$ (benzyl bromide).

2. Step (ii) KCN: The next step is the nucleophilic substitution of the bromine atom by the cyanide ion (CN^-), leading to the formation of $C_6H_5 — CH_2 — CN$ (benzyl cyanide).

3. Step (iii) Na(Hg), C_2H_5OH: This is a reduction reaction (Clemmensen reduction), which typically reduces a carbonyl group (in this case, the nitrile group) to a methylene group ($–CH_2$). However, since there is no carbonyl group here, this reaction doesn't affect the cyanide group. Hence, the major product remains as $C_6H_5 — CH_2 — CN$.

Thus, the major product is $C_6H_5 — CH_2 — CN$, and the correct answer is (3).

Quick Tip

In the presence of KCN, alkyl halides undergo nucleophilic substitution to form nitriles, which is a common reaction. The subsequent step does not affect the nitrile in this case.

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71. Match List I with List II:

List I (Process)		**List II (Catalyst)**
A. Haber process		**I.** Fe catalyst
B. Wacker oxidation		**II.** $PdCl_2$
C. Wilkinson catalyst		**III.** $[(C_6H_5)_3RhCl]$
D. Ziegler catalyst		**IV.** $TiCl_4$ with $Al(C_2H_5)_3$

Choose the correct answer from the options given below:

(1) A-II, B-III, C-I, D-IV
(2) A-I, B-II, C-III, D-IV
(3) A-I, B-IV, C-III, D-II
(4) A-I, B-II, C-IV, D-III

Correct Answer: (2) A-I, B-II, C-III, D-IV

Solution:
Let's match the processes with their respective catalysts:
- A. Haber process: This is the process for the industrial synthesis of ammonia (N + 3H →

2NH), and the catalyst used is Fe (iron). Thus, A-I.

- B. Wacker oxidation: This process involves the oxidation of alkenes to carbonyl compounds (like aldehydes or ketones), and the catalyst used is PdCl (palladium chloride). Thus, B-II.

- C. Wilkinson catalyst: This catalyst is used in the hydrogenation of alkenes, and its composition is [(CH)RhCl] (tris(triphenylphosphine) rhodium chloride). Thus, C-III.

- D. Ziegler catalyst: This is used in the polymerization of alkenes, and the catalyst used is TiCl with Al(CH) (titanium tetrachloride and triethylaluminum). Thus, D-IV.

Thus, the correct answer is (2) A-I, B-II, C-III, D-IV.

Quick Tip

The Haber process uses iron as a catalyst, Wacker oxidation uses palladium, Wilkinson's catalyst is rhodium-based, and Ziegler catalyst is a combination of titanium and aluminum compounds.

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72. Energy and radius of first Bohr orbit of He$^+$ and Li^2+ are:

Given: $R_H = 2.18 \times 10^{-18}\,\text{J}, a_0 = 52.9\,\text{pm}$
(1) $E_n(\text{Li}^{2+}) = -8.72 \times 10^{-18}\,\text{J}, r_n(\text{Li}^{2+}) = 26.4\,\text{pm}, E_n(\text{He}^+) = -19.62 \times 10^{-18}\,\text{J}, r_n(\text{He}^+) = 9.6\,\text{pm}$
(2) $E_n(\text{Li}^{2+}) = -19.62 \times 10^{-16}\,\text{J}, r_n(\text{Li}^{2+}) = 17.6\,\text{pm}, E_n(\text{He}^+) = -8.72 \times 10^{-16}\,\text{J}, r_n(\text{He}^+) = 26.4\,\text{pm}$
(3) $E_n(\text{Li}^{2+}) = -8.72 \times 10^{-16}\,\text{J}, r_n(\text{Li}^{2+}) = 17.6\,\text{pm}, E_n(\text{He}^+) = -19.62 \times 10^{-16}\,\text{J}, r_n(\text{He}^+) = 26.4\,\text{pm}$
(4) $E_n(\text{Li}^{2+}) = -19.62 \times 10^{-18}\,\text{J}, r_n(\text{Li}^{2+}) = 17.5\,\text{pm}, E_n(\text{He}^+) = -8.72 \times 10^{-18}\,\text{J}, r_n(\text{He}^+) = 26.4\,\text{pm}$

Correct Answer: (1) $E_n(\text{Li}^{2+}) = -8.72 \times 10^{-18}\,\text{J}, r_n(\text{Li}^{2+}) = 26.4\,\text{pm}, E_n(\text{He}^+) = -19.62 \times 10^{-18}\,\text{J}, r_n(\text{He}^+) = 9.6\,\text{pm}$

Solution:

The energy and radius of the first Bohr orbit are given by the following formulas:

1. The energy of the nth orbit for a hydrogen-like atom:

$$E_n = -\frac{R_H}{n^2} Z^2$$

Where Z is the atomic number of the ion.
2. The radius of the nth orbit:

$$r_n = \frac{a_0}{Z} \cdot n$$

For Li^2+ (Z = 3) and He$^+$ (Z = 2), we calculate for $n = 1$ (the first Bohr orbit).

- For Li^2+ (Z = 3):

$$E_n(\mathrm{Li}^{2+}) = -\frac{2.18 \times 10^{-18}}{1^2} \cdot 3^2 = -8.72 \times 10^{-18}\,\mathrm{J}$$

$$r_n(\mathrm{Li}^{2+}) = \frac{52.9\,\mathrm{pm}}{3} = 17.6\,\mathrm{pm}$$

- For He$^+$ (Z = 2):

$$E_n(\mathrm{He}^{+}) = -\frac{2.18 \times 10^{-18}}{1^2} \cdot 2^2 = -19.62 \times 10^{-18}\,\mathrm{J}$$

$$r_n(\mathrm{He}^{+}) = \frac{52.9\,\mathrm{pm}}{2} = 26.4\,\mathrm{pm}$$

Thus, the correct values are:

- $E_n(\mathrm{Li}^{2+}) = -8.72 \times 10^{-18}\,\mathrm{J}, r_n(\mathrm{Li}^{2+}) = 17.6\,\mathrm{pm}$ - $E_n(\mathrm{He}^{+}) = -19.62 \times 10^{-18}\,\mathrm{J}, r_n(\mathrm{He}^{+}) = 26.4\,\mathrm{pm}$

Therefore, the correct answer is (1).

Quick Tip

For hydrogen-like ions, the energy and radius of the first Bohr orbit depend on the atomic number Z. The energy is proportional to Z^2, and the radius is inversely proportional to Z.

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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): I$^-$ undergoes SN$_2$ reaction faster than Cl$^-$.
Reason (R): Iodine is a better leaving group because of its large size.

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

(1) Both A and R are true but R is not the correct explanation of A.
(2) A is true but R is false.
(3) A is false but R is true.
(4) Both A and R are true and R is the correct explanation of A.

Correct Answer: (4) Both A and R are true and R is the correct explanation of A.

Solution:

- Assertion (A): It is true that I$^-$ undergoes SN$_2$ reactions faster than Cl$^-$. This is because I$^-$ is a larger ion with a more diffuse electron cloud compared to Cl$^-$, making it a better nucleophile and more willing to leave in an SN$_2$ mechanism.

- Reason (R): Iodine is indeed a better leaving group than chlorine due to its larger size and better ability to stabilize the negative charge once it departs from the carbon atom. The larger atomic size allows iodine to better accommodate the electron density, which is why it is a better leaving group.

Thus, both the assertion and the reason are true, and the reason correctly explains the assertion.

Therefore, the correct answer is (4) Both A and R are true and R is the correct explanation of A.

Quick Tip

In SN_2 reactions, the leaving group ability increases with the size of the atom, as larger atoms can stabilize the negative charge better after departure. This is why I^- is a better leaving group than Cl^-.

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74. If the half-life ($t_{1/2}$) for a first-order reaction is 1 minute, then the time required for 99.9% completion of the reaction is closest to:

(1) 4 minutes
(2) 5 minutes
(3) 10 minutes
(4) 2 minutes

Correct Answer: (3) 10 minutes

Solution:

For a first-order reaction, the relationship between the concentration and time is given by:

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

Where: - $[A]_0$ is the initial concentration, - $[A]$ is the concentration at time t, - k is the rate constant, - t is the time elapsed.
For a first-order reaction, the half-life $t_{1/2}$ is related to the rate constant k by the equation:

$$t_{1/2} = \frac{0.693}{k}$$

Given that $t_{1/2} = 1$ minute, we can solve for k:

$$k = \frac{0.693}{1} = 0.693\,\text{min}^{-1}$$

To find the time for 99.9% completion, we know that 99.9% completion corresponds to 0.1% remaining, or $[A] = 0.001[A]_0$.
Substitute into the first-order equation:

$$\ln\left(\frac{1}{0.001}\right) = kt$$

$$\ln(1000) = 0.693 \times t$$

$$6.907 = 0.693 \times t$$

$$t = \frac{6.907}{0.693} \approx 10\,\text{minutes}$$

Thus, the time required for 99.9% completion is 10 minutes.

Quick Tip

For a first-order reaction, the time for 99.9% completion can be calculated using the formula:

$$t = \frac{\ln(1/0.001)}{k}$$

Where k is determined from the half-life of the reaction.

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75. Which of the following aqueous solutions will exhibit the highest boiling point?

(1) 0.01M KNO
(2) 0.01M HSO
(3) 0.01M CHO
(4) 0.01M Urea

Correct Answer: (2) 0.01M HSO

Solution:

The boiling point elevation is directly proportional to the molality of the solution and the van 't Hoff factor i, which accounts for the number of particles the solute dissociates into.

- KNO dissociates into 2 ions (K^+ and NO^-), so $i = 2$.
- HSO dissociates into 3 ions (H^+, HSO^-, and SO^2), so $i = 3$.
- CHO (glucose) does not dissociate, so $i = 1$.
- Urea also does not dissociate into ions, so $i = 1$.

Since the boiling point elevation is proportional to i, the solution with the highest van 't Hoff factor will have the highest boiling point. Therefore, HSO (which dissociates into 3 ions) will exhibit the highest boiling point.

Thus, the correct answer is (2) 0.01M HSO.

Quick Tip

For colligative properties like boiling point elevation, the more particles a solute dissociates into, the greater the effect on the boiling point.

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76. Higher yield of NO in the reaction
N_2 (g) + O_2 (g) → 2NO (g)
can be obtained at [ΔH **of the reaction = +180.7 kJ mol**$^{-1}$]

A. higher temperature
B. lower temperature
C. higher concentration of N_2
D. higher concentration of O_2

Choose the correct answer from the options given below:

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

Correct Answer: (3) A, C, D only

Solution:

For the reaction given:

$$\mathrm{N_2}(g) + \mathrm{O_2}(g) \rightarrow 2\mathrm{NO}(g)$$

The reaction has a positive ΔH, meaning it is endothermic. According to Le Chatelier's Principle:
- A. Higher temperature: Since the reaction is endothermic, increasing the temperature will shift the equilibrium to the right, promoting the formation of NO. Thus, higher temperature will favor the production of NO. This statement is true.
- B. Lower temperature: Lowering the temperature would shift the equilibrium to the left, favoring the reactants. Thus, lower temperature would not increase the yield of NO. This statement is false.
- C. Higher concentration of N_2: Increasing the concentration of one of the reactants (in this case, N_2) will shift the equilibrium to the right to produce more products. This statement is true.
- D. Higher concentration of O_2: Similarly, increasing the concentration of O_2 will shift the equilibrium to the right, increasing the yield of NO. This statement is true.

Thus, the correct answer is (3) A, C, D only.

Quick Tip

For endothermic reactions, higher temperatures and increased concentrations of reactants will favor the formation of products, according to Le Chatelier's principle.

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77. Match List I with List II:

List I (Ion) **List II (Group Number in Cation Analysis)**

A. Co^{2}+		**I.** Group-I
B. Mg^{2}+		**II.** Group-III
C. Pb^{2}+		**III.** Group-IV
D. Al^{3}+		**IV.** Group-VI

Choose the correct answer from the options given below:

(1) A-III, B-IV, C-II, D-I
(2) A-III, B-II, C-IV, D-I
(3) A-III, B-IV, C-I, D-II
(4) A-III, B-IV, C-II, D-I

Correct Answer: (2) A-III, B-II, C-IV, D-I

Solution:

In cation analysis, the ions are grouped based on their behavior with specific reagents:
- A. Co^{2}+ (Cobalt): This ion is typically found in Group-III in cation analysis. So, A-III.

- B. Mg^{2}+ (Magnesium): This ion is found in Group-II as it does not form precipitates with most reagents used for Group-I and Group-III cations. So, B-II.

- C. Pb^{2}+ (Lead): This ion is typically found in Group-IV of cation analysis, as it forms precipitates with specific reagents used in this group. So, C-IV.

- D. Al^{3}+ (Aluminum): This ion is found in Group-I. It is typically analyzed in Group-I due to its distinct behavior in reactions with different reagents. So, D-I.

Thus, the correct matching is (2) A-III, B-II, C-IV, D-I.

Quick Tip

In qualitative analysis, cations are grouped based on their reactions with various reagents. Groups are determined by the solubility of the formed precipitates and their subsequent reactions.

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78. The ratio of the wavelengths of the light absorbed by a Hydrogen atom when it undergoes n = 2 → n = 3 and n = 4 → n = 6 transitions, respectively, is:

(1) 1 : 9
(2) 1 : 36
(3) 1 : 4
(4) 1 : 25

Correct Answer: (3) 1 : 4

Solution:

The wavelength (λ) of light absorbed or emitted during a transition in a hydrogen atom can be related to the energy difference between the two states by the equation:

$$\Delta E = \frac{R_H}{n_1^2} - \frac{R_H}{n_2^2}$$

where R_H is the Rydberg constant, n_1 and n_2 are the principal quantum numbers of the initial and final orbits, respectively.
The energy and wavelength are inversely related:

$$E = \frac{hc}{\lambda}$$

where h is Planck's constant and c is the speed of light.
Thus, the ratio of the wavelengths is the inverse of the ratio of the energies. Therefore, we calculate the energy differences for the two transitions:
1. For the n = 2 → n = 3 transition:

$$\Delta E_1 = \frac{R_H}{2^2} - \frac{R_H}{3^2} = R_H\left(\frac{1}{4} - \frac{1}{9}\right) = R_H \times \frac{5}{36}$$

2. For the n = 4 → n = 6 transition:

$$\Delta E_2 = \frac{R_H}{4^2} - \frac{R_H}{6^2} = R_H\left(\frac{1}{16} - \frac{1}{36}\right) = R_H \times \frac{5}{144}$$

Now, the ratio of the wavelengths (λ_1/λ_2) is the inverse of the ratio of the energy differences:

$$\frac{\lambda_1}{\lambda_2} = \frac{\Delta E_2}{\Delta E_1} = \frac{\frac{5}{144}}{\frac{5}{36}} = \frac{36}{144} = \frac{1}{4}$$

Thus, the ratio of the wavelengths is 1 : 16.
Therefore, the correct answer is (3) 1 : 4.

Quick Tip

For hydrogen atom transitions, the wavelength is inversely proportional to the energy difference, which can be calculated using the Rydberg formula. The energy difference determines the wavelength of light absorbed or emitted.

79. The correct order of the wavelength of light absorbed by the following complexes is:

A. $[Co(NH_3)_6]^{3+}$
B. $[Co(CN)_6]^{3-}$
C. $[Cu(H_2O)_4]^{2+}$
D. $[Ti(H_2O)_6]^{3+}$

Choose the correct answer from the options given below:

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

Correct Answer: (3) C < A < D < B

Solution:

The order of absorption of light (wavelength) is determined by the ligand field strength, where stronger field ligands tend to absorb light at shorter wavelengths, while weaker field ligands absorb light at longer wavelengths.

1. A. $[Co(NH_3)_6]^{3+}$: Ammonia (NH) is a moderate field ligand. Thus, this complex absorbs light at a medium wavelength.

2. B. $[Co(CN)_6]^{3-}$: Cyanide (CN) is a strong field ligand, leading to a large splitting of d-orbitals and absorption of light at a shorter wavelength (higher energy).

3. C. $[Cu(H_2O)_4]^{2+}$: Water (HO) is a weak field ligand, resulting in small d-orbital splitting and absorption at longer wavelengths (lower energy).

4. D. $[Ti(H_2O)_6]^{3+}$: Titanium in the +3 oxidation state (with water ligands) is a relatively weak field complex, leading to light absorption at longer wavelengths compared to ammonia and cyanide complexes.

Thus, the correct order of the wavelength of light absorbed is:

$$C < A < D < B$$

Therefore, the correct answer is (3) C < A < D < B.

Quick Tip

The wavelength of light absorbed by a complex is inversely proportional to the ligand field strength. Strong field ligands (e.g., CN) cause larger d-orbital splitting and absorb light at shorter wavelengths.

80. Identify the correct orders against the property mentioned:

A. $H_2O > NH_3 > CHCl_3$ - dipole moment
B. $XeF_4 > XeO_3 > XeF_2$ - number of lone pairs on central atom
C. O–H > C–H > N–O - bond length
D. N_2 ¿ O_2 ¿ H_2 - bond enthalpy

Choose the correct answer from the options given below:

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

Correct Answer: (3) B, C only

Solution:

Let's evaluate each property and its respective order:
- A. $H_2O > NH_3 > CHCl_3$ (Dipole Moment): - Water (H_2O) has the highest dipole moment due to its bent structure and high electronegativity difference between oxygen and hydrogen.

- Ammonia (NH_3) also has a dipole moment, but it is less than water due to the smaller electronegativity difference and less angular geometry.

- $CHCl_3$ has the least dipole moment because the presence of chlorine atoms leads to a more symmetrical distribution of charge despite having polar bonds. Therefore, A is correct.

- B. XeF_4 ¿ XeO_3 ¿ XeF_2 (Number of Lone Pairs on Central Atom):
- XeF_4 has the largest number of lone pairs on the central xenon atom (2 lone pairs).
- XeO_3 has 1 lone pair.
- XeF_2 has no lone pairs on the central atom. Therefore, B is correct.

- C. O–H > C–H > N–O (Bond Length):
- The O–H bond is the shortest, followed by the C–H bond, and the N–O bond is the longest due to the different sizes of the atoms and the bond strengths. Therefore, C is correct.

- D. $N_2 > O_2 > H_2$ (Bond Enthalpy):
- Nitrogen (N_2) has the highest bond enthalpy due to the strong triple bond between nitrogen atoms.
- Oxygen (O_2) has a lower bond enthalpy than nitrogen due to the presence of a double bond.
- Hydrogen (H_2) has the lowest bond enthalpy due to the single bond between hydrogen atoms. Therefore, D is incorrect because bond enthalpy decreases as we move from N_2 to H_2.

Thus, the correct answer is (3) B, C only.

Quick Tip

The dipole moment increases with the difference in electronegativity and the molecular geometry. Lone pairs on the central atom increase as we go from simpler molecules like XeF_2 to more complex ones like XeF_4.

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81. Match List I with List II:

List I (Mixture) **List II (Method of Separation)**

A. $CHCl_3 + C_6H_5NH_2$		**I.** Distillation under reduced pressure
B. Crude oil + petroleum industry		**II.** Steam distillation
C. Glycerol from spent-lye		**III.** Fractional distillation
D. Aniline + water		**IV.** Simple distillation

Choose the correct answer from the options given below:

(1) A-IV, B-III, C-II, D-I
(2) A-III, B-IV, C-I, D-II
(3) A-III, B-IV, C-II, D-I
(4) A-IV, B-II, C-I, D-II

Correct Answer: (3) A-III, B-IV, C-II, D-I

Solution:

Let's evaluate each mixture and its appropriate method of separation:
- A. $CHCl_3 + C_6H_5NH_2$ (Chloroform and Aniline): Chloroform and aniline can be separated by fractional distillation, as they have different boiling points. Thus, A-III.
- B. Crude oil + petroleum industry: The components in crude oil can be separated by simple distillation based on their boiling points. This is a typical method used in the petroleum industry. Thus, B-IV.
- C. Glycerol from spent-lye: Glycerol can be separated from spent-lye by steam distillation, a method used to separate water-soluble organic compounds. Thus, C-II.
- D. Aniline + water: Aniline and water can be separated by distillation under reduced pressure, as aniline has a much higher boiling point than water. This method helps in separating components with large differences in boiling points. Thus, D-I.

Thus, the correct answer is (3) A-III, B-IV, C-II, D-I.

Quick Tip

The separation method depends on the boiling points and other properties of the mixtures. For separating organic liquids with significant boiling point differences, fractional or simple distillation is typically used. For mixtures where both components are water-soluble, steam distillation is a good method.

---

82. If the rate constant of a reaction is 0.03 s^{-1}, how much time does it take for a 7.2 mol L^{-1} concentration of the reactant to get reduced to 0.9 mol L^{-1}? (Given: log 2 = 0.301)

(1) 23.1 s
(2) 210 s
(3) 21.0 s
(4) 69.3 s

Correct Answer: (4) 69.3 s

Solution:

Since the units of the rate constant are s^{-1}, this indicates that the reaction is first-order. For a first-order reaction, the integrated rate law is:

$$\ln \frac{[A]_t}{[A]_0} = -kt$$

Where: $[A]_t$ is the concentration of reactant at time t = 0.9 mol L^{-1}
$[A]_0$ is the initial concentration of reactant = 7.2 mol L^{-1}
k is the rate constant = 0.03 s^{-1}
t is the time

Substituting the values:

$$\ln \frac{0.9}{7.2} = -0.03t$$

$$\ln \frac{1}{8} = -0.03t$$

$$\ln 1 - \ln 8 = -0.03t$$

$$0 - \ln 2^3 = -0.03t$$

$$-3 \ln 2 = -0.03t$$

$$t = \frac{3 \ln 2}{0.03}$$

Given that log 2 = 0.301, we can convert to natural logarithm:

$$\ln 2 = 2.303 \times \log 2 = 2.303 \times 0.301 \approx 0.693$$

Substituting the value of $\ln 2$:

$$t = \frac{3 \times 0.693}{0.03} = \frac{2.079}{0.03} = 69.3 \text{ s}$$

The time required is approximately 69.3 s. The correct answer is (4).

Quick Tip

For a first-order reaction, the relationship between concentration and time is logarithmic. Always ensure to use the integrated rate law for calculations involving concentration changes over time.

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83. Which among the following electronic configurations belong to main group elements?

A. [Ne]$3s^1$
B. [Ar]$3d^3 4s^2$
C. [Kr]$4d^5 3s^2 5p^5$
D. [Ar]$3d^1 04s^1$
E. [Rn]$5f^7 6d^2 7s^2$

Choose the correct answer from the options given below:

(1) A and C only
(2) D and E only
(3) A, C, and D only
(4) B and E only

Correct Answer: (3) A, C, and D only

Solution:

To determine which electronic configurations belong to main group elements, we need to examine the positions of these elements in the periodic table. Main group elements are those found in the s- and p-blocks.
- A. [Ne]$3s^1$: This configuration corresponds to an element in the alkali metal group (main group element). Thus, A is correct.
- B. [Ar]$3d^3 4s^2$: This configuration corresponds to an element in the d-block (transition metal), not a main group element. Thus, B is incorrect.
- C. [Kr]$4d^5 3s^2 5p^5$: This configuration corresponds to an element in the p-block (halogen). Thus, C is correct.
- D. [Ar]$3d^1 04s^1$: This configuration corresponds to an element in the d-block (transition metal), but it involves the 4s orbital, which is characteristic of main group elements. Thus, D is correct.
- E. [Rn]$5f^7 6d^2 7s^2$: This configuration corresponds to an element in the f-block (lanthanide series), not a main group element. Thus, E is incorrect.
Thus, the correct answer is (3) A, C, and D only.

Quick Tip

Main group elements are found in the s- and p-blocks of the periodic table. Transition metals and lanthanides belong to the d- and f-blocks.

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84. Match List I with List II:

List I (Example) **List II (Type of Solution)**

A. Humidity		**I.** Solid in solid
B. Alloys		**II.** Liquid in gas
C. Amalgams		**III.** Solid in gas
D. Smoke		**IV.** Liquid in solid

Choose the correct answer from the options given below:

(1) A-II, B-I, C-IV, D-III
(2) A-III, B-I, C-IV, D-II
(3) A-III, B-II, C-I, D-IV
(4) A-II, B-IV, C-I, D-III

Correct Answer: (1) A-II, B-I, C-IV, D-III

Solution:

Let's evaluate each example and match it with the correct type of solution:
- A. Humidity: Humidity refers to water vapor in the air, which is a liquid in gas solution. Thus, A-II.
- B. Alloys: Alloys are mixtures of metals (solid in solid), such as brass or steel. Thus, B-I.
- C. Amalgams: Amalgams are alloys of metals with mercury, where mercury is the liquid in a solid matrix. Thus, C-IV.
- D. Smoke: Smoke is a solid in gas solution, consisting of solid particles dispersed in gas. Thus, D-III.

Therefore, the correct matching is (1) A-II, B-I, C-IV, D-III.

Quick Tip

In solutions, the phase of the solute and solvent determine the type of solution: - Solid in solid: Alloys. - Liquid in gas: Humidity. - Solid in gas: Smoke. - Liquid in solid: Amalgams.

---

85. 5 moles of liquid X and 10 moles of liquid Y make a solution having a vapor pressure of 70 torr. The vapor pressures of pure X and Y are 63 torr and 78 torr, respectively. Which of the following is true regarding the described solution?

(1) The solution shows negative deviation.
(2) The solution is ideal.
(3) The solution has volume greater than the sum of individual volumes.
(4) The solution shows positive deviation.

Correct Answer: (1) The solution shows negative deviation.

Solution:

The vapor pressure of an ideal solution can be predicted using Raoult's law, which states:

$$P_{\text{solution}} = X_X P_X^0 + X_Y P_Y^0$$

Where: - P_{solution} is the vapor pressure of the solution, - X_X and X_Y are the mole fractions of X and Y, respectively, - P_X^0 and P_Y^0 are the vapor pressures of pure X and Y, respectively.
Given: - Moles of X = 5, Moles of Y = 10, - $P_X^0 = 63\,\text{torr}, P_Y^0 = 78\,\text{torr}$, - Total moles = $5 + 10 = 15$.
The mole fractions are:

$$X_X = \frac{5}{15} = \frac{1}{3}, \quad X_Y = \frac{10}{15} = \frac{2}{3}$$

Now, applying Raoult's law:

$$P_{\text{solution}} = \left(\frac{1}{3}\right)(63) + \left(\frac{2}{3}\right)(78)$$

$$P_{\text{solution}} = 21 + 52 = 73\,\text{torr}$$

The given vapor pressure is 70 torr, which is lower than the calculated vapor pressure of 73 torr. This means the solution exhibits negative deviation from Raoult's law.
Thus, the solution shows negative deviation.
Therefore, the correct answer is (1) The solution shows negative deviation.

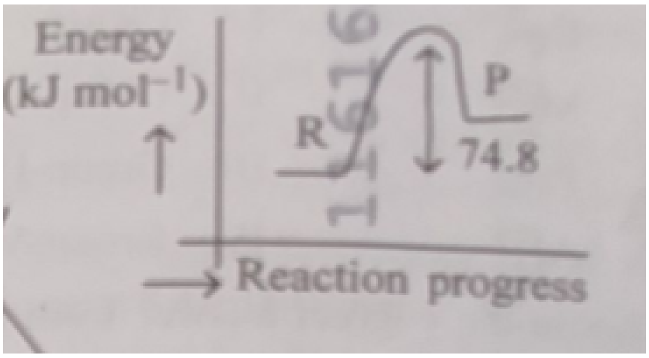
Quick Tip

A solution exhibits negative deviation when its vapor pressure is lower than expected based on Raoult's law. This occurs when the intermolecular forces between the components of the solution are stronger than between the components and the solvent.

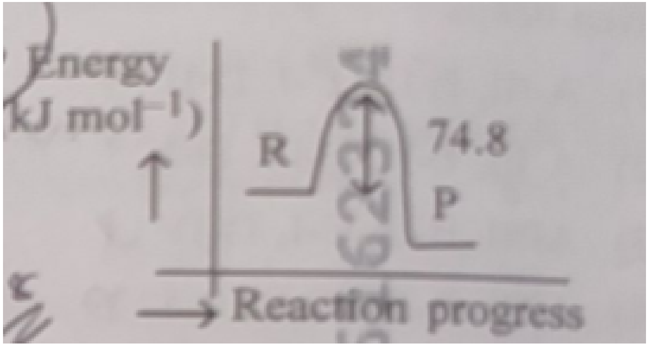
---

86. $C(s) + 2H_2(g) \rightarrow CH_4(g)$; $\Delta H = -74.8\,\text{kJ mol}^{-1}$
Which of the following diagrams gives an accurate representation of the above reaction?

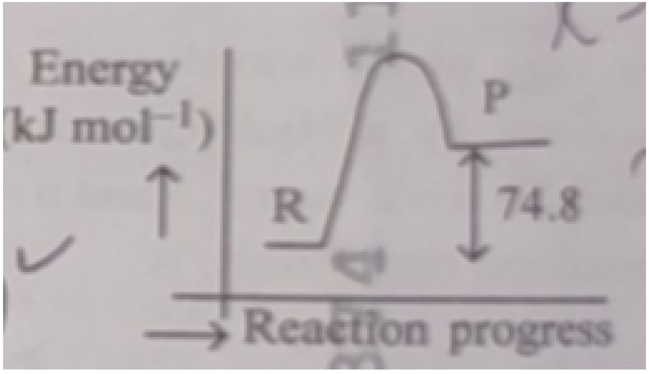
(1)


Energy
(kJ mol⁻¹)
R
P
74.8
Reaction progress

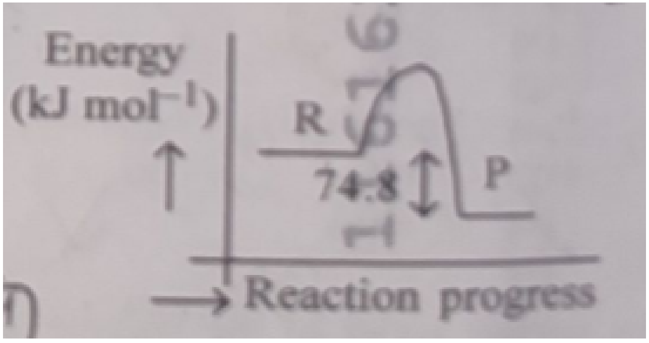
(2)

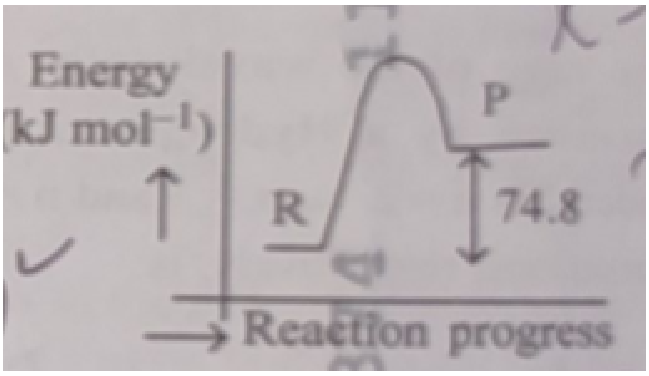

Energy
(kJ mol⁻¹)
R
74.8
P
Reaction progress

(3)


Energy
(kJ mol⁻¹)
P
R
74.8
Reaction progress

(4)


Energy
(kJ mol⁻¹)
R
74.8
P
Reaction progress

Correct Answer: (3) 

Solution:

Given the reaction:

$$C(s) + 2H_2(g) \rightarrow CH_4(g) \quad (\Delta H = -74.8\,\text{kJ mol}^{-1})$$

The negative value of ΔH indicates that the reaction is exothermic. In an exothermic reaction, the energy of the products is lower than that of the reactants. This is represented in the energy profile diagram by a downward curve from reactants to products, with a peak corresponding to the activation energy (the energy required to reach the transition state).

- The correct diagram will show: - Reactants at a higher energy level than the products. - A peak at the transition state with an energy difference (activation energy). - The energy difference between the reactants and products corresponds to the given $\Delta H = -74.8\,\text{kJ mol}^{-1}$.

Thus, diagram (3) correctly represents the energy profile for this exothermic reaction, with the products at a lower energy than the reactants and a transition state with a well-defined peak.

Therefore, the correct answer is (3).

Quick Tip

For exothermic reactions, the products are lower in energy than the reactants, and the enthalpy change (ΔH) is negative. The energy profile typically shows a downward slope from reactants to products.

---

87. Which one of the following compounds does not decolorize bromine water?

(1) Phenol
(2) CH_2CH_2
(3) NH_2
(4) Cyclohexane

Correct Answer: (4) Cyclohexane

Solution:

Let's analyze each compound:
(1) Phenol:

- Phenol contains an electron donating group (OH) attached to a benzene ring, activates the ring toward electrophilic substitution. Phenol readily undergoes electrophilic substitution reactions with bromine, leading to decolourisation.

(2) Styrene:

- Styrene contains a vinyl group ($CH{=}CH_2$) attached to a benzene ring. The alkene part of styrene will readily react with bromine water by addition reaction.

(3) Aniline:

- Aniline also contains an activating amine group (NH_2) attached to a benzene ring. It readily undergoes electrophilic substitution reactions with bromine, leading to decolourisation.

(4) Cyclohexane:

- Cyclohexane is a saturated cyclic alkane. It lacks double or triple bonds and isn't readily susceptible to electrophilic attack (it would require much higher temperatures and/or UV light to react). So Cyclohexane does not decolourise bromine water under normal conditions.

Therefore, cyclohexane does not decolourise bromine water.
The compound that does not decolourise bromine water is (4) Cyclohexane.

Quick Tip

Bromine water is decolorized by compounds with unsaturation or electron-rich groups that can react with bromine, such as alkenes, alkynes, and activated aromatic compounds.

---

88. Consider the following compounds:
K_2O_2, H_2O_2, and H_2SO_4
The oxidation states of the underlined elements in them are, respectively:

(1) +2, -2, and +6
(2) +1, -2, and +4
(3) +4, -4, and +6
(4) +1, -1, and +6

Correct Answer: (1) +2, -2, and +6

Solution:

Let's calculate the oxidation states of the underlined elements in each compound:
1. K_2O_2:
- The oxidation state of oxygen in peroxides is always -1. - To balance the charges, the oxidation

state of potassium (K) in K_2O_2 is +1.
- Thus, the oxidation states of the elements are K = +1 and O = -1. The underlined element here is K, and its oxidation state is +1.

2. H_2O_2: - The oxidation state of hydrogen (H) is +1.
- The oxidation state of oxygen (O) in peroxides is -1.
- Thus, the oxidation states of the elements in H_2O_2 are H = +1 and O = -1. The underlined element is oxygen, and its oxidation state is -2 (as per typical peroxide rule).

3. H_2SO_4:
- The oxidation state of hydrogen (H) is +1.
- The oxidation state of oxygen (O) is -2.
- In H_2SO_4, sulfur (S) has an oxidation state of +6, as the sum of oxidation states of hydrogen ($2 \times +1$) and oxygen (4×-2) must balance the compound. Therefore, S = +6.

Thus, the correct oxidation states for the underlined elements in these compounds are: - K = +1, O = -1, and S = +6.
The correct answer is (1) +2, -2, and +6.

Quick Tip

In peroxides, the oxidation state of oxygen is -1. In sulfuric acid, sulfur has an oxidation state of +6, and hydrogen generally has an oxidation state of +1.

---

89. Given below are two statements:

Statement I: Benzendiazonium salt is prepared by the reaction of aniline with nitrous acid at 273-278 K. It decomposes easily in the dry state.
Statement II: Insertion of iodine into the benzene ring is difficult and hence iodobenzene is prepared through the reaction of benzendiazonium salt with KI.

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

(1) Both Statement I and Statement II are incorrect.
(2) Statement I is correct but Statement II is incorrect.
(3) Statement I is incorrect but Statement II is correct.
(4) Both Statement I and Statement II are correct.

Correct Answer: (3) Statement I is incorrect but Statement II is correct.

Solution:

- Statement I: The preparation of benzene diazonium salt involves the reaction of aniline with nitrous acid (generated in situ from sodium nitrite and hydrochloric acid). This reaction occurs at temperatures between 0-5°C, not 273-278 K (which corresponds to much higher temperatures, typically above room temperature). Hence, Statement I is incorrect.

- Statement II: The insertion of iodine into the benzene ring is indeed difficult as iodine does not react readily under normal conditions with the benzene ring. However, iodobenzene can be prepared effectively by reacting benzene diazonium salt with KI (Potassium iodide), which leads to the formation of iodobenzene. This is a typical reaction, known as the Sandmeyer reaction. Therefore, Statement II is correct.

Thus, the correct answer is (3) Statement I is incorrect but Statement II is correct.

Quick Tip

The Sandmeyer reaction is a key method for introducing halogen atoms (like iodine) into the aromatic ring. It involves using a diazonium salt and the corresponding halide ion (KI for iodine).

---

90. Which of the following are paramagnetic?

A. $[\text{NiCl}_4]^{2-}$
B. Ni(CO)_4
C. $[\text{Ni(CN)}_4]^{2-}$
D. $[\text{Ni(H}_2\text{O)}_6]^{2+}$
E. $\text{Ni(PPh}_3)_4$

Choose the correct answer from the options given below:

(1) B and E only
(2) A and D only
(3) A, D, and E only
(4) A and C only

Correct Answer: (3) A, D, and E only

Solution:

To determine paramagnetism, we must check if the complex has unpaired electrons. A paramagnetic substance has unpaired electrons, while a diamagnetic substance has all electrons paired.

1. $[\text{NiCl}_4]^{2-}$: Ni^2+ has an electronic configuration of [Ar] 3d^8. In a tetrahedral field like in this complex, the Ni^2+ ion has unpaired electrons, and thus $[\text{NiCl}_4]^{2-}$ is paramagnetic.

2. Ni(CO)_4: CO is a strong field ligand that causes pairing of the electrons in Ni, leading to a diamagnetic complex. Hence, Ni(CO)_4 is diamagnetic.

3. $[\text{Ni(CN)}_4]^{2-}$: CN^- is a very strong field ligand, and it causes pairing of electrons in Ni^2+. Therefore, $[\text{Ni(CN)}_4]^{2-}$ is diamagnetic.

4. $[Ni(H_2O)_6]^{2+}$: Water is a weak field ligand, and $Ni^{2}+$ (d^8) has unpaired electrons in a weak field ligand environment, making $[Ni(H_2O)_6]^{2+}$ paramagnetic.

5. $Ni(PPh_3)_4$: PPh_3 is a weak field ligand, and $Ni^{2}+$ in this environment will have unpaired electrons, making $Ni(PPh_3)_4$ paramagnetic.

Thus, the correct answer is (3) A, D and E only.

Quick Tip

Paramagnetism is caused by the presence of unpaired electrons. Strong field ligands (such as CO, CN^-) cause pairing of electrons and lead to diamagnetism, while weak field ligands (such as water and PPh_3) do not cause electron pairing, leading to paramagnetism.