JEE Main 2023 Jan 29 Shift 1 Question Paper with Solutions

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

General Instructions

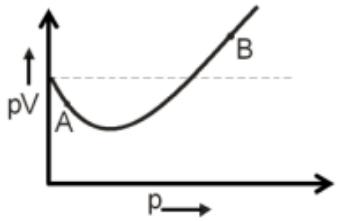
Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 90 questions, out of which 75 are to attempted. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. Each part (subject) has two sections.
   (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.
   (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer

Chemistry

Section-A

31. For 1 mol of gas, the plot of pV vs p is shown below. p is the pressure and V is the volume of the gas.



What is the value of compressibility factor at point A?

(1) 1

(2) 0.5

(3) 2

(4) 0

Correct Answer: (1) 1

Solution:

Step 1: Understanding compressibility factor.

The compressibility factor Z is defined as:

$$Z = \frac{pV_m}{RT}$$

where p is the pressure, V_m is the molar volume, R is the gas constant, and T is the temperature.

For an ideal gas, the compressibility factor Z is equal to 1. The value of Z deviates from 1 for real gases depending on the conditions.

Step 2: Analyzing the graph.

The given graph of pV vs p shows the behavior of the gas at different pressures. At point A, the gas behaves ideally because the graph is close to a straight line, indicating that $Z = 1$ at this point.

Step 3: Conclusion.

Since point A represents the behavior of the gas as an ideal gas, the compressibility factor at point A is $Z = 1$.

Quick Tip

For an ideal gas, the compressibility factor $Z = 1$. When the gas deviates from ideal behavior, $Z \neq 1$.

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32. The shortest wavelength of hydrogen atom in Lyman series is λ. The longest wavelength in Balmer series of He^+ is

(1) $\frac{5}{9}\lambda$

(2) $\frac{9\lambda}{5}$

(3) $\frac{36\lambda}{5}$

(4) $\frac{5\lambda}{9}$

Correct Answer: (2) $\frac{9\lambda}{5}$

Solution:

Step 1: Using the Rydberg formula for wavelengths.

The Rydberg formula for the wavelength of spectral lines is given by:

$$\frac{1}{\lambda} = R_Z \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

where R_Z is the Rydberg constant for the atom, n_1 and n_2 are the principal quantum numbers of the initial and final states, respectively.

Step 2: Shortest wavelength in the Lyman series for hydrogen.

For the shortest wavelength in the Lyman series of hydrogen, the transition occurs from $n = 2$ to $n = 1$. Using the Rydberg formula:

$$\frac{1}{\lambda_{\text{Lyman}}} = R_H \left(\frac{1}{1^2} - \frac{1}{2^2} \right) = R_H \left(1 - \frac{1}{4} \right) = \frac{3}{4} R_H$$

Thus, the shortest wavelength of the hydrogen atom in the Lyman series is $\lambda = \frac{4}{3R_H}$.

Step 3: Longest wavelength in the Balmer series of He^+.

For the longest wavelength in the Balmer series of He^+, the transition occurs from $n = 3$ to $n = 2$. Using the Rydberg formula:

$$\frac{1}{\lambda_{He^+}} = R_{He^+} \left(\frac{1}{2^2} - \frac{1}{3^2} \right) = R_{He^+} \left(\frac{1}{4} - \frac{1}{9} \right)$$

$$\frac{1}{\lambda_{He^+}} = R_{He^+} \left(\frac{5}{36} \right)$$

So, the wavelength is:

$$\lambda_{He^+} = \frac{36}{5R_{He^+}}$$

Since $R_{He^+} = 4R_H$ (due to the nuclear charge being 2 for He^+), we substitute:

$$\lambda_{He^+} = \frac{36}{5 \cdot 4R_H} = \frac{9\lambda}{5}$$

Step 4: Conclusion.

Thus, the longest wavelength in the Balmer series of He^+ is $\frac{9\lambda}{5}$.

Quick Tip

For spectral lines of hydrogen-like atoms, the Rydberg formula can be used to calculate wavelengths. The value of the Rydberg constant depends on the nuclear charge of the atom.

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33. Which of the following salt solutions would coagulate the colloid solution formed when $FeCl_3$ is added to NaOH solution, at the fastest rate?

(1) 10 mL of 0.2 mol $dm^{-}3$ $AlCl_3$

(2) 10 mL of 0.1 mol $dm^{-}3$ Na_2SO_4

(3) 10 mL of 0.1 mol $dm^{-}3$ $Ca_3(PO_4)_2$

(4) 10 mL of 0.15 mol $dm^{-}3$ $CaCl_2$

Correct Answer: (1) 10 mL of 0.2 mol $dm^{-}3$ $AlCl_3$

Solution:

Step 1: Understanding coagulation.

Coagulation of colloidal particles occurs when ions from a solution neutralize the charge on the colloidal particles, causing them to aggregate. The rate of coagulation is influenced by the valency of the ions added. Higher valency ions are more effective in neutralizing the charge, leading to faster coagulation.

Step 2: Effect of salts on coagulation.

- For $AlCl_3$, the ion Al^{3+} has a valency of 3, which is highly effective in coagulating colloidal particles.

- For Na_2SO_4, the ion Na^{+} has a valency of 1, making it less effective than higher valency ions.

- For $Ca_3(PO_4)_2$, the ion Ca^{2+} has a valency of 2, which is more effective than Na^{+} but less effective than Al^{3+}.

- For $CaCl_2$, the ion Ca^{2+} also has a valency of 2.

Step 3: Conclusion.

Since the coagulation rate depends on the valency of the ions, the solution with Al^{3+} (from

$AlCl_3$) will coagulate the colloidal solution at the fastest rate. The correct option is (1).

Quick Tip

For coagulation of colloidal solutions: - Higher valency cations are more effective at neutralizing the charge of colloidal particles, leading to faster coagulation.

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34. The bond dissociation energy is highest for

(1) Cl_2

(2) I_2

(3) Br_2

(4) F_2

Correct Answer: (1) Cl_2

Solution:

Step 1: Understanding bond dissociation energy.

Bond dissociation energy is the energy required to break a bond in a molecule and separate the atoms involved. In general, as we move from fluorine to iodine in the halogens, the bond dissociation energy decreases due to increasing atomic size and the weakening of the bond.

Step 2: Trend in bond dissociation energy.

- For F_2, the bond dissociation energy is lower due to the small size of fluorine atoms, which leads to strong repulsion between the lone pairs of electrons on each fluorine atom.
- For Cl_2, the bond dissociation energy is higher because chlorine atoms are larger than fluorine atoms, reducing the lone pair repulsion and allowing a stronger bond to form.
- For Br_2 and I_2, the bond dissociation energies are lower than for Cl_2 due to their even larger atomic sizes and more diffuse electron clouds.

Step 3: Conclusion.

Therefore, the bond dissociation energy is highest for Cl_2, making option (1) the correct answer.

Quick Tip

Bond dissociation energy generally decreases down the group in the halogens due to increasing atomic size and weaker bonds. The exception is F_2 due to lone pair repulsion.

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35. The reaction representing the Mond process for metal refining is

(1) Ni + 4CO $\xrightarrow{\Delta}$ $Ni(CO)_4$

(2) 2K $[Au(CN)_2]$ + Zn $\xrightarrow{\Delta}$ K_2 $[Zn(CN)_4]$ + 2 Au

(3) Zr + I_2 $\xrightarrow{\Delta}$ ZrI_4

(4) ZnO + C $\xrightarrow{\Delta}$ Zn + CO

Correct Answer: (1) Ni + 4CO $\xrightarrow{\Delta}$ $Ni(CO)_4$

Solution:

Step 1: Understanding the Mond process.

The Mond process is a method of refining nickel. It involves the formation of a volatile nickel carbonyl complex by reacting nickel with carbon monoxide at moderate temperatures (around 50°C to 60°C).

$$Ni + 4CO \xrightarrow{\Delta} Ni(CO)_4$$

Nickel forms nickel tetracarbonyl, which is a gaseous compound. This gaseous compound can then be decomposed to yield pure nickel.

Step 2: Reviewing the options.

- Option (1) represents the Mond process for nickel refining, where nickel reacts with carbon monoxide to form nickel carbonyl.
- Option (2) is related to the cyanide process for gold refining.
- Option (3) represents the preparation of zirconium iodide.
- Option (4) is the reduction of zinc oxide to zinc using carbon.

Step 3: Conclusion.

Thus, the correct reaction representing the Mond process for metal refining is option (1).

Quick Tip

The Mond process is specifically used for refining nickel, where nickel reacts with carbon monoxide to form a volatile nickel carbonyl complex.

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36. Which of the given compounds can enhance the efficiency of hydrogen storage tank?

(1) Li/P_4

(2) SiH_4

(3) $NaNi_5$

(4) Di-isobutylaluminium hydride

Correct Answer: (3) $NaNi_5$

Solution:

Step 1: Understanding hydrogen storage.

Hydrogen storage materials are compounds that can absorb and release hydrogen efficiently for use in hydrogen fuel cells or other energy storage systems. The efficiency of a hydrogen storage tank is influenced by the material's ability to absorb and desorb hydrogen at reasonable temperatures and pressures.

Step 2: Reviewing the options.

- Option (1): Li/P_4 (Lithium-phosphorus compounds) are used in some energy applications, but they are not particularly known for enhancing hydrogen storage efficiency.
- Option (2): SiH_4 (Silane) is used in semiconductor applications and is not commonly used for hydrogen storage enhancement.
- Option (3): $NaNi_5$ (Sodium nickel hydride) is a well-known material used in hydrogen storage systems. It has the ability to absorb and release hydrogen at moderate pressures and temperatures, making it an efficient material for enhancing hydrogen storage efficiency.
- Option (4): Di-isobutylaluminium hydride is an organoaluminum compound used in organic synthesis and not for hydrogen storage enhancement.

Step 3: Conclusion.

Thus, the correct compound that enhances the efficiency of hydrogen storage tanks is $NaNi_5$,

making option (3) the correct answer.

Quick Tip

When selecting materials for hydrogen storage: - Consider compounds that can efficiently absorb and release hydrogen at moderate pressures and temperatures. - Metal hydrides like $NaNi_5$ are commonly used for hydrogen storage due to their high hydrogen absorption capacity.

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37. The correct order of hydration enthalpies is

(A) K^+

(B) Rb^+

(C) Mg^{2+}

(D) Cs^+

(E) Ca^{2+}

Choose the correct answer from the options given below:

(1) C > A > E > B > D

(2) E > C > A > B > D

(3) C > E > A > D > B

(4) C > E > A > B > D

Correct Answer: (4) C > E > A > B > D

Solution:

Step 1: Understanding hydration enthalpy.

Hydration enthalpy refers to the energy released when an ion is surrounded by water molecules, forming a hydration shell. The magnitude of hydration enthalpy depends on the charge and size of the ion. Smaller ions with higher charges tend to have higher hydration enthalpies due to stronger interactions with water molecules.

Step 2: Analyzing the given ions.

- Cs^+ (Option C): Cs^+ has the largest ionic radius among the given ions, so its hydration enthalpy is the least.

- Ca^2+ (Option E): Ca^2+ is smaller than Cs^+ and has a higher charge, leading to a larger hydration enthalpy than Cs^+.
- K^+ (Option A): K^+ is smaller than Cs^+ but larger than Ca^2+, so its hydration enthalpy is between that of Cs^+ and Ca^2+.
- Rb^+ (Option B): Rb^+ is similar in size to K^+, but with a slightly lower hydration enthalpy.
- Mg^2+ (Option D): Mg^2+ is the smallest ion with the highest charge, so its hydration enthalpy is the highest.

Step 3: Conclusion.

Thus, the correct order of hydration enthalpies is $C > E > A > B > D$, making option (4) the correct answer.

Quick Tip

For hydration enthalpy, the smaller the ion and the higher the charge, the greater the enthalpy. This is because the ion's electric field interacts more strongly with the water molecules.

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38. The magnetic behaviour of Li_2O, Na_2O_2 and KO_2, respectively, are

(1) diamagnetic, paramagnetic and diamagnetic

(2) paramagnetic, paramagnetic and diamagnetic

(3) paramagnetic, diamagnetic and paramagnetic

(4) diamagnetic, diamagnetic and paramagnetic

Correct Answer: (4) diamagnetic, diamagnetic and paramagnetic

Solution:

Step 1: Understanding magnetic behavior.

- Diamagnetic substances are those that do not have any unpaired electrons. They are repelled by a magnetic field.
- Paramagnetic substances contain unpaired electrons and are attracted to a magnetic field.

Step 2: Analyzing the magnetic behavior of each compound.

- Li_2O (Lithium oxide): Lithium oxide has no unpaired electrons in its bonding, making it

diamagnetic.

- Na_2O_2 (Sodium peroxide): Sodium peroxide has unpaired electrons due to the presence of O_2^{2-} (peroxide ion), making it diamagnetic as the peroxide ion has paired electrons but still shows repulsion in a magnetic field.

- KO_2 (Potassium superoxide): Potassium superoxide has unpaired electrons in the O_2^- ion, which makes it paramagnetic.

Step 3: Conclusion.

Thus, the magnetic behavior of Li_2O, Na_2O_2 and KO_2 is diamagnetic, diamagnetic and paramagnetic, respectively, making option (4) the correct answer.

Quick Tip

To determine the magnetic behavior of compounds, look for the presence of unpaired electrons. Diamagnetic substances have no unpaired electrons, while paramagnetic substances have at least one unpaired electron.

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39. "A" obtained by Ostwald's method involving air oxidation of NH_3, upon further air oxidation produces "B". "B" on hydration forms an oxoacid of Nitrogen along with evolution of "A". The oxoacid also produces "A" and gives positive brown ring test.

(1) NO_2, N_2O_5

(2) NO_2, N_2O_4

(3) NO, NO_2

(4) N_2O_3, NO_2

Correct Answer: (3) NO, NO_2

Solution:

Step 1: Identifying the compounds.

- In Ostwald's method, ammonia (NH_3) is oxidized by air to form nitrogen oxides.

- The compound "A" is formed by the air oxidation of NH_3. The oxidation of ammonia initially produces NO (Nitric oxide), which is a colorless gas. Thus, "A" is NO.

- Further oxidation of NO forms "B", which is NO_2 (Nitrogen dioxide), a brown gas.

- On hydration, NO_2 forms nitric acid (HNO_3), and the reaction also releases NO. This indicates that the oxoacid formed is nitric acid, and it also produces NO, which matches the information provided.

Step 2: Brown ring test.

The brown ring test is a characteristic test for nitrate ions (NO_3^-) in solution. It involves the formation of a brown ring when iron(II) sulfate is added to nitric acid (HNO_3), confirming the presence of NO_3^-.

Step 3: Conclusion.

Thus, the correct pair of compounds is NO and NO_2, corresponding to option (3).

Quick Tip

- The brown ring test is used to detect the presence of nitrate ions in a solution, confirming the formation of nitric acid (HNO_3). - The reaction involves oxidation of ammonia to produce NO, which further oxidizes to NO_2.

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40. The standard electrode potential (M^3+/M^2+) for V, Cr, Mn, & Co are -0.26 V, -0.41 V, +1.57 V, and +1.97 V, respectively. The metal ions which can liberate H_2 from a dilute acid are

(1) V^2+ and Mn^2+

(2) Cr^2+ and Co^2+

(3) V^2+ and Cr^2+

(4) Mn^2+ and Co^2+

Correct Answer: (3) V^2+ and Cr^2+

Solution:

Step 1: Understanding the concept of electrode potential.

The standard electrode potential indicates the tendency of a species to gain electrons and get reduced. A more positive electrode potential means that the species is more readily reduced, while a more negative electrode potential indicates that the species is more readily oxidized. For a metal ion to liberate H_2 from a dilute acid, it must be able to reduce H^+ ions (i.e., the

metal ion must have a lower reduction potential than H^+/H_2, which has a standard potential of 0 V).

Step 2: Analyzing the given electrode potentials.

The electrode potentials are given for the following metal ions:

- V^{3+}/V^{2+} : -0.26 V
- Cr^{3+}/Cr^{2+} : -0.41 V
- Mn^{3+}/Mn^{2+} : +1.57 V
- Co^{3+}/Co^{2+} : +1.97 V

Since the more negative the electrode potential, the greater the tendency of the ion to donate electrons, V^{2+} and Cr^{2+} are the ions that will be able to reduce H^+ ions and liberate H_2 from a dilute acid, as their reduction potentials are negative.

Step 3: Conclusion.

Thus, the correct answer is (3) V^{2+} and Cr^{2+}.

Quick Tip

To liberate H_2 from a dilute acid, the metal ion must be able to reduce H^+. This occurs when the metal has a more negative electrode potential than 0 V.

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41. Correct statement about smog is

(1) NO_2 is present in classical smog

(2) Both NO_2 and SO_2 are present in classical smog

(3) Photochemical smog has high concentration of oxidizing agents

(4) Classical smog also has high concentration of oxidizing agents

Correct Answer: (3) Photochemical smog has high concentration of oxidizing agents

Solution:

Step 1: Understanding the types of smog.

Smog is classified into two main types:

- Classical smog: It is also called ”London-type smog” and is characterized by the presence of SO_2 (sulfur dioxide) and particulate matter. It typically occurs in cool, humid

environments.

- Photochemical smog: It is also called ”Los Angeles-type smog” and occurs in sunny, warm environments. It is characterized by the presence of NO_2 (nitrogen dioxide) and oxidizing agents like ozone (O_3).

Step 2: Analyzing the options.

- Option (1): NO_2 is not present in classical smog. Classical smog is primarily composed of SO_2 and particulate matter.

- Option (2): Both NO_2 and SO_2 are not present in classical smog. This combination is more characteristic of photochemical smog.

- Option (3): Photochemical smog has a high concentration of oxidizing agents such as ozone (O_3), making this the correct statement.

- Option (4): Classical smog does not have a high concentration of oxidizing agents, which makes this statement incorrect.

Step 3: Conclusion.

Thus, the correct statement is that photochemical smog has a high concentration of oxidizing agents, which is option (3).

Quick Tip

In photochemical smog, ozone and other oxidizing agents play a significant role in the reactions, whereas classical smog is dominated by sulfur dioxide and particulate matter.

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42. Chiral complex from the following is: Here en = ethylene diamine

(1) cis – $[PtCl_2\ (en)]_2^{\ 2+}$

(2) trans – $[PtCl_2(en)]_2^{\ 2+}$

(3) cis – $[PtCl_2(NH_3)_2]$

(4) trans – $[Co(NH_3)_4Cl_2]^+$

Correct Answer: (1) cis – $[PtCl_2\ (en)]_2^{\ 2+}$

Solution:

Step 1: Understanding chirality in complexes.

Chirality in coordination complexes occurs when the complex does not have any elements of symmetry, such as a plane of symmetry or a center of inversion. A chiral complex can exist in two non-superimposable mirror image forms, known as enantiomers. The arrangement of ligands around the metal center determines whether the complex is chiral.

Step 2: Analyzing the given options.

- Option (1): cis – $[PtCl_2\ (en)]_2^{2+}$ – In this complex, the two ethylene diamine (en) ligands are arranged in a cis configuration, which results in the complex being chiral. The platinum center has a non-symmetric arrangement of ligands, leading to chirality.
- Option (2): trans – $[PtCl_2(en)]_2^{2+}$ – In this complex, the ethylene diamine ligands are arranged in a trans configuration. This symmetry causes the complex to be achiral.
- Option (3): cis – $[PtCl_2(NH_3)_2]$ – This complex is achiral because it has a symmetric arrangement of ammonia ligands.
- Option (4): trans – $[Co(NH_3)_4Cl_2]^+$ – This complex is also achiral because it has a symmetric arrangement of ligands.

Step 3: Conclusion.

The correct answer is Option (1) because the cis arrangement of the ethylene diamine ligands around the platinum ion results in a chiral complex.

Quick Tip

A complex can be chiral when the ligands are arranged asymmetrically around the central metal ion. The presence of symmetry elements like a mirror plane or a center of symmetry makes the complex achiral.

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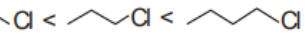
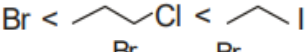
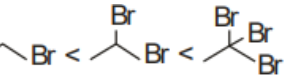
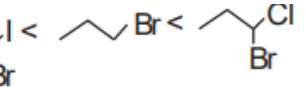
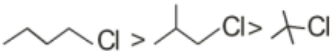
43. Identify the correct order for the given property for the following compounds:

(A) 

(B) 

(C) 

(D) 

(E) Boiling Point: 

Choose the correct answer from the options given below:

(1) (B), (C) and (D) only

(2) (A), (C) and (E) only

(3) (A), (B) and (D) only

(4) (A), (B) and (E) only

Correct Answer: (2) (A), (C) and (E) only

Solution:

Step 1: Understanding the boiling point trends.

- The boiling point of compounds increases with molecular size and intermolecular forces. For halogens, the boiling point increases with the number of atoms in the molecule and the size of the molecules.

- In (A), the boiling point increases as Cl ¡ Cl_2 ¡ Cl_3 due to the increase in molecular weight and intermolecular forces.

- In (C), the boiling point increases as Br ¡ Br_2 ¡ Br_3, following the same reasoning as for (A).

- In (E), Cl has the highest boiling point, followed by Cl_2 and Cl_3.

Step 2: Understanding the density trends.

- The density of halogens increases with atomic size and mass. Heavier atoms have higher densities.

- In (B), the density increases as Br ¡ Cl_2 ¡ I.

- In (D), the density increases as Br ¡ Br_2 ¡ Br_3.

Step 3: Conclusion.

The correct answer, combining the correct trends in boiling point and density, is option (2) because:

- (A), (C), and (E) are correct for boiling point trends.

- (B) and (D) are correct for density trends.

Quick Tip

For halogens, the boiling point increases with molecular size, while density increases with atomic mass. The correct order can be predicted by these general trends.

44. The increasing order of pK_a for the following phenols is

(1) 2, 4-Dinitrophenol

(2) 4-Nitrophenol

(3) 2, 4, 5-Trimethylphenol

(4) Phenol

(5) 3-Chlorophenol

Correct Answer: (2) 4-Nitrophenol

Solution:

Step 1: Understanding pK_a and its relation to acidity.

The pK_a value is inversely related to acidity: a lower pK_a indicates a stronger acid. Substituents on the phenol ring can affect the acidity by either stabilizing or destabilizing the negative charge on the oxygen atom of the phenoxide ion.

- Electron-withdrawing groups (like nitro, chlorine) stabilize the negative charge on the oxygen, increasing acidity (lower pK_a).

- Electron-donating groups (like methyl) destabilize the negative charge, decreasing acidity (higher pK_a).

Step 2: Analyzing the given phenols.

- (1) 2, 4-Dinitrophenol: The nitro groups at positions 2 and 4 are strong electron-withdrawing groups, significantly increasing the acidity of the phenol, leading to a low pK_a.

- (2) 4-Nitrophenol: The nitro group at position 4 is electron-withdrawing, but less so than the two nitro groups in 2, 4-dinitrophenol. This leads to a higher pK_a compared to 2, 4-dinitrophenol.

- (3) 2, 4, 5-Trimethylphenol: The methyl groups are electron-donating, which will make this phenol less acidic, leading to a higher pK_a compared to nitro-substituted phenols.

- (4) Phenol: Phenol itself has a moderate pK_a, with no additional electron-withdrawing or electron-donating substituents.

- (5) 3-Chlorophenol: Chlorine is slightly electron-withdrawing through induction but is less effective than nitro groups in lowering pK_a.

Step 3: Conclusion.

The correct increasing order of pK_a (from lowest to highest) is:

2, 4-Dinitrophenol $<$ 4-Nitrophenol $<$ Phenol $<$ 3-Chlorophenol $<$ 2, 4, 5-Trimethylphenol

Thus, the correct answer is option (2) 4-Nitrophenol.

Quick Tip

In general: - Electron-withdrawing groups (e.g., nitro, halogens) lower pK_a and increase acidity. - Electron-donating groups (e.g., methyl) raise pK_a and decrease acidity.

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45. Match List I with List II.

List-I (Reaction)	List-II (Reagents)
(A) Hoffmann Degradation	(I) Conc. KOH, Δ
(B) Clemenson reduction	(II) $CHCl_3$, $NaOH/H_3O^+$
(C) Cannizzaro reaction	(III) Br_2, NaOH
(D) Reimer-Tiemann reaction	(IV) Zn-Hg/HCl

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

Solution:

Step 1: Understanding the reactions and reagents.

- Hoffmann Degradation (A): This reaction involves the degradation of amides to amines using conc. KOH and heating ().

- Clemenson Reduction (B): This reduction of aldehydes or ketones to hydrocarbons occurs using Zn-Hg/HCl (Clemmensen reduction).

- Cannizzaro Reaction (C): This reaction is the base-induced disproportionation of aldehydes without hydrogen atoms on the -carbon, where Br_2, NaOH is used.

- Reimer-Tiemann Reaction (D): The Reimer-Tiemann reaction involves the formylation of phenols using $CHCl_3$, $NaOH/H_3O^+$.

Step 2: Matching the reactions and reagents.

- (A) Hoffmann Degradation matches with (III) Conc. KOH, .

- (B) Clemenson Reduction matches with (IV) Zn-Hg/HCl.

- (C) Cannizzaro Reaction matches with (I) Br_2, NaOH.

- (D) Reimer-Tiemann Reaction matches with (II) $CHCl_3$, $NaOH/H_3O^+$.

Step 3: Conclusion.

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

Quick Tip

In organic chemistry reactions, identifying the correct reagents for each type of reaction is key. For example: - The Hoffmann degradation involves heating with KOH, which eliminates the acyl group. - The Clemmensen reduction uses zinc amalgam and hydrochloric acid to reduce carbonyl compounds to hydrocarbons.

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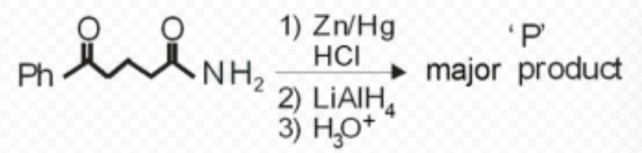
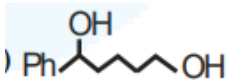
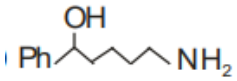
46. The major product 'P' for the following sequence of reactions is:



(1)

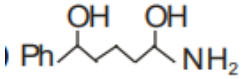


(2)



(3)

(4)



Correct Answer: (3) Ph - NH_2

Solution:

Step 1: Understanding the reactions.

- First reaction (Zn/Hg, HCl): This reaction is known as the Clemmensen reduction, which

reduces the carbonyl group (C=O) to a methylene group (-CH_2) while keeping the rest of the structure intact. In this case, the carbonyl group in the molecule is reduced to a methylene group.

- Second reaction ($LiAlH_4$): Lithium aluminum hydride is a powerful reducing agent that reduces any remaining carbonyl groups (like in aldehydes or ketones) to alcohols. However, since there is no carbonyl group left after the Clemmensen reduction, this step will not affect the structure.

- Third reaction (H_3O^+): This step adds water, resulting in the protonation of any anionic sites, but does not affect the already reduced structure.

Step 2: Identifying the product.

- The starting compound is a ketone (with a -CO group). The Clemmensen reduction reduces the -CO group to -CH_2. After the subsequent treatment with $LiAlH_4$, no further reduction happens as there is no carbonyl group left. Finally, protonation by H_3O^+ does not alter the product.

Thus, the product is a primary amine (Ph - NH_2).

Step 3: Conclusion.

The major product is Ph - NH_2, making option (3) the correct answer.

Quick Tip

The Clemmensen reduction is commonly used to reduce carbonyl groups (e.g., in ketones or aldehydes) to methylene groups (-CH_2). This reaction is often followed by reduction using $LiAlH_4$ to achieve complete conversion.

---

47. During the borax bead test with $CuSO_4$, a blue-green colour of the bead was observed in an oxidising flame due to the formation of

(1) Cu_3B_2

(2) Cu

(3) $Cu(BO_2)_2$

(4) CuO

Correct Answer: (3) $Cu(BO_2)_2$

Solution:

Step 1: Understanding the Borax Bead Test.

The borax bead test is a qualitative analysis technique used to identify metal ions based on the colour change of the borax bead. In an oxidising flame, the metal ion reacts with borax (sodium borate) to form a coloured compound, which helps to identify the metal.

- In the case of copper ions (Cu^2+), a blue-green colour is formed due to the formation of copper(II) borate ($Cu(BO_2)_2$) when copper ions react with borax in the presence of an oxidising flame.

Step 2: Identifying the product.

- Cu_3B_2 is not formed in this test. It is associated with other reactions but not the borax bead test.

- Cu refers to copper metal, which is not formed in the borax bead test.

- $Cu(BO_2)_2$ is the correct product. Copper(II) borate is responsible for the characteristic blue-green colour in the borax bead test when copper is tested.

- CuO (copper(II) oxide) does not give the blue-green colour observed in the test.

Step 3: Conclusion.

Thus, the correct answer is $Cu(BO_2)_2$, which corresponds to option (3).

Quick Tip

The borax bead test uses the formation of coloured metal borates to identify metal ions. For copper, the test results in a blue-green colour due to the formation of copper(II) borate ($Cu(BO_2)_2$).

---

48. Match List I with List II.

List I (Antimicrobials)	List II (Names)
(A) Narrow Spectrum Antibiotic	(I) Furacin
(B) Antiseptic	(II) Sulphur dioxide
(C) Disinfectants	(III) Penicillin-G
(D) Broad Spectrum Antibiotic	(IV) Chloramphenicol

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

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

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

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

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

Solution:

Step 1: Understanding the antimicrobial classifications.

- Narrow Spectrum Antibiotic (A): A narrow-spectrum antibiotic acts against a limited range of microorganisms. Penicillin-G is an example of a narrow-spectrum antibiotic.
- Antiseptic (B): Antiseptics are used to reduce the possibility of infection by inhibiting the growth of microorganisms on living tissue. Sulphur dioxide is used as an antiseptic, often in food preservation.
- Disinfectants (C): Disinfectants are chemicals used to kill or inhibit microorganisms on non-living objects. Chloramphenicol is commonly used as a disinfectant, particularly in industrial settings.
- Broad Spectrum Antibiotic (D): Broad-spectrum antibiotics act against a wide range of bacteria. Furacin is an example of a broad-spectrum antibiotic.

Step 2: Matching the antimicrobials with their names.

- (A) Narrow Spectrum Antibiotic matches with (III) Penicillin-G.
- (B) Antiseptic matches with (II) Sulphur dioxide.
- (C) Disinfectants matches with (IV) Chloramphenicol.
- (D) Broad Spectrum Antibiotic matches with (I) Furacin.

Step 3: Conclusion.

Thus, the correct matching is: (A) – III, (B) – II, (C) – IV, (D) – I, which corresponds to option (1).

Quick Tip

- Narrow-spectrum antibiotics like Penicillin-G are effective against specific types of bacteria, while broad-spectrum antibiotics like Furacin target a wide range of bacteria.
- Antiseptics like Sulphur dioxide and disinfectants like Chloramphenicol play crucial roles in controlling microorganisms in different environments.

---

49. Number of cyclic tripeptides formed with 2 amino acids A and B is:

(1) 2

(2) 3

(3) 5

(4) 4

Correct Answer: (4) 4

Solution:

Step 1: Understanding cyclic tripeptides.

A cyclic tripeptide consists of three amino acid residues where the peptide bonds form a ring structure. With two amino acids (A and B), we can form cyclic tripeptides by arranging them in various sequences.

Step 2: Number of possible cyclic tripeptides.

- We need to form cyclic tripeptides using amino acids A and B.
- The total number of sequences we can arrange three amino acids with repetition of two types (A and B) is $2^3 = 8$ sequences.
- However, since it is a cyclic peptide, rotations of the same sequence around the ring are considered identical. Therefore, we must account for these redundancies.

There are 4 unique cyclic tripeptides that can be formed:

1. AAAB
2. AABB
3. ABAB
4. BAB

Step 3: Conclusion.

Thus, the number of cyclic tripeptides formed is 4, making option (4) the correct answer.

Quick Tip

When dealing with cyclic peptides, remember that the number of unique structures is reduced due to symmetry (rotations of the same sequence are considered equivalent).

---

50. Compound that will give positive Lassaigne's test for both nitrogen and halogen is

(1) $N_2H_4.HCl$

(2) CH_3NH_2, HCl

(3) NH_4Cl

(4) $NH_2OH.HCl$

Correct Answer: (2) CH_3NH_2, HCl

Solution:

Step 1: Understanding Lassaigne's test.

Lassaigne's test is used to detect the presence of nitrogen, sulfur, and halogens in organic compounds. For nitrogen detection, the compound is heated with sodium, and for halogens, a similar test is carried out. A positive test for nitrogen gives a blue color in the test, and for halogen, it gives a white precipitate of silver halide.

Step 2: Identifying the compound that will give a positive test for both nitrogen and halogen.

- (1) $N_2H_4.HCl$ (Hydrazine hydrochloride): This compound contains nitrogen, but it does not have a halogen to give a positive test for both.

- (2) CH_3NH_2, HCl (Methylamine hydrochloride): This compound contains both nitrogen (amine group) and chlorine (as HCl), so it will give a positive test for both nitrogen and halogen.

- (3) NH_4Cl (Ammonium chloride): This compound contains nitrogen, but it does not contain any halogen atoms that would give a positive halogen test.

- (4) $NH_2OH.HCl$ (Hydroxylamine hydrochloride): This compound contains nitrogen but

does not contain a halogen to give a positive test for halogens.

Step 3: Conclusion.

Thus, the correct compound that gives positive Lassaigne's test for both nitrogen and halogen is CH_3NH_2, HCl, making option (2) the correct answer.

Quick Tip

For Lassaigne's test: - A blue color in the test confirms the presence of nitrogen. - A white precipitate with silver nitrate confirms the presence of halogens.

Section-B

51. Millimoles of calcium hydroxide required to produce 100 mL of the aqueous solution of pH 12 is $x \times 10^{-1}$. The value of x is ———(Nearest integer). Assume complete dissociation.

Solution:

The pH of a solution is related to the concentration of hydrogen ions $[H^+]$ in the solution:

$$\text{pH} = -\log[H^+]$$

For a solution with pH 12, the concentration of hydrogen ions is:

$$[H^+] = 10^{-\text{pH}} = 10^{-12}$$

Since the solution is basic (pH ¿ 7), the concentration of hydroxide ions $[OH^-]$ can be calculated using the relationship between $[H^+]$ and $[OH^-]$ in water:

$$[H^+][OH^-] = 10^{-14} \quad \text{(Kw)}$$

Thus:

$$[OH^-] = \frac{10^{-14}}{[H^+]} = \frac{10^{-14}}{10^{-12}} = 10^{-2}\,\text{mol/L}$$

Calcium hydroxide, $Ca(OH)_2$, dissociates completely into Ca^{2+} and 2 OH^- ions:

$$Ca(OH)_2 \rightarrow Ca^{2+} + 2\,OH^-$$

Thus, the concentration of OH^- ions from calcium hydroxide is twice the concentration of $Ca(OH)_2$:

$$[OH^-] = 2 \times [Ca(OH)_2]$$

From the calculated concentration of OH^- (10^{-2} mol/L), the concentration of $Ca(OH)_2$ is:

$$[Ca(OH)_2] = \frac{10^{-2}}{2} = 5 \times 10^{-3} \text{ mol/L}$$

The number of moles of $Ca(OH)_2$ required for 100 mL (0.1 L) of solution is:

$$\text{Moles of } Ca(OH)_2 = [Ca(OH)_2] \times \text{Volume} = 5 \times 10^{-3} \text{ mol/L} \times 0.1 \text{ L} = 5 \times 10^{-4} \text{ mol}$$

Finally, converting moles to millimoles (1 mol = 1000 mmol):

$$\text{Millimoles of } Ca(OH)_2 = 5 \times 10^{-4} \times 1000 = 5 \text{ mmol}$$

Thus, the value of x is 5.

Quick Tip

In a basic solution, use the relationship $[OH^-] = \frac{10^{-14}}{[H^+]}$ to find the concentration of hydroxide ions. Then use the dissociation stoichiometry of the compound to find the required amount.

---

52. The number of molecules or ions from the following, which do not have odd number of electrons is ——

(A) NO_2

(B) ICl_4^-

(C) BrF_3

(D) ClO_2

(E) NO_2^+

(F) NO

Correct Answer: (3)

Solution:

Step 1: Understanding the concept of odd and even number of electrons.

The number of valence electrons in a molecule or ion determines whether it has an odd or even number of electrons. For a molecule to have an odd number of electrons, the sum of the valence electrons must be odd, whereas for an even number of electrons, the sum must be even.

Step 2: Analyzing the compounds.

- (A) NO_2: Nitrogen dioxide (NO_2) has 5 valence electrons from nitrogen and $2 \times 6 = 12$ electrons from oxygen, giving a total of 17 valence electrons (odd number).
- (B) ICl_4^-: Iodine tetrachloride anion (ICl_4^-) has 7 valence electrons from iodine and $4 \times 7 = 28$ electrons from chlorine, plus 1 electron from the negative charge, giving a total of 36 valence electrons (even number).
- (C) BrF_3: Bromine trifluoride (BrF_3) has 7 valence electrons from bromine and $3 \times 7 = 21$ electrons from fluorine, giving a total of 28 valence electrons (even number).
- (D) ClO_2: Chlorine dioxide (ClO_2) has 7 valence electrons from chlorine and $2 \times 6 = 12$ electrons from oxygen, giving a total of 19 valence electrons (odd number).
- (E) NO_2^+: Nitronium ion (NO_2^+) has 5 valence electrons from nitrogen and $2 \times 6 = 12$ electrons from oxygen, minus 1 electron from the positive charge, giving a total of 16 valence electrons (even number).
- (F) NO: Nitric oxide (NO) has 5 valence electrons from nitrogen and 6 valence electrons from oxygen, giving a total of 11 valence electrons (odd number).

Step 3: Conclusion.

The compounds that do not have an odd number of electrons are:

- (B) ICl_4^-
- (C) BrF_3
- (E) NO_2^+

Thus, the correct answer is option (3).

Quick Tip

To determine whether a molecule has an odd or even number of electrons, count the valence electrons and consider any charges on the molecule. Odd electron molecules typically have an odd sum of valence electrons, while even electron molecules have an even sum.

---

53. Consider the following reaction approaching equilibrium at 27°C and 1 atm pressure:

$$A + B \underset{K_r=10^2}{\overset{K_f=10^3}{\rightleftharpoons}} C + D$$

The standard Gibbs energy change $(\Delta_r G^\circ)$ **at 27°C is (-)——- kJ/mol. (Nearest integer).**

(Given : R = 8.3 J $K^{-1}mol^{-1}andln10=2.3)$

Solution:

We can calculate the standard Gibbs energy change using the equation:

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

Where:

- $R = 8.314\,\text{J K}^{-1}\text{mol}^{-1}$ is the gas constant,

- $T = 27^\circ C = 300\,\text{K}$,

- $K = \frac{K_f}{K_r}$ is the equilibrium constant.

Step 1: Calculating the equilibrium constant.

The reaction involves the forward equilibrium constant $K_f = 10^3$ and the reverse equilibrium constant $K_r = 10^2$. The equilibrium constant K for the reaction is:

$$K = \frac{K_f}{K_r} = \frac{10^3}{10^2} = 10$$

Step 2: Calculating the standard Gibbs energy change.

Now, we can substitute the values into the Gibbs free energy equation:

$$\Delta_r G^\circ = -(8.314\,\text{J/mol·K}) \times (300\,\text{K}) \times \ln(10)$$

Using $\ln(10) \approx 2.3$:

$$\Delta_r G^\circ = -(8.314 \times 300 \times 2.3)\,\text{J/mol}$$

$$\Delta_r G^\circ = -5733.3\,\text{J/mol} = -5.7\,\text{kJ/mol}$$

Step 3: Conclusion.

Thus, the standard Gibbs energy change $\Delta_r G^\circ$ is approximately -6 kJ/mol.

Quick Tip

To calculate the standard Gibbs energy change, use the relationship $\Delta_r G^\circ = -RT \ln K$. Make sure to use the appropriate value of the equilibrium constant K, which is the ratio of forward to reverse equilibrium constants.

---

54. Solid Lead nitrate is dissolved in 1 litre of water. The solution was found to boil at 100.15°C. When 0.2 mol of NaCl is added to the resulting solution, it was observed that the solution froze at -0.8°C. The solubility product of $PbCl_2$ formed is $\underset{10^{-6}}{}$ at 298 K. (Nearest integer).

Solution:

Step 1: Calculating the boiling point elevation and freezing point depression.

The elevation in boiling point and depression in freezing point are related to the molality of the solution by the following formulas:

$$\Delta T_b = K_b \times m$$

$$\Delta T_f = K_f \times m$$

Where:

- ΔT_b is the boiling point elevation,
- ΔT_f is the freezing point depression,

- K_b and K_f are the ebullioscopic and cryoscopic constants of the solvent, and

- m is the molality of the solution.

Step 2: Boiling point elevation.

Given that the solution boils at 100.15°C, the boiling point elevation is:

$$\Delta T_b = 100.15 - 100 = 0.15C$$

Using the formula for boiling point elevation:

$$\Delta T_b = K_b \times m$$

$$0.15 = 0.5 \times m$$

$$m = \frac{0.15}{0.5} = 0.3\,\text{mol/kg}$$

Step 3: Freezing point depression.

Given that the solution freezes at -0.8°C, the freezing point depression is:

$$\Delta T_f = 0 - (-0.8) = 0.8C$$

Using the formula for freezing point depression:

$$\Delta T_f = K_f \times m$$

$$0.8 = 1.8 \times m$$

$$m = \frac{0.8}{1.8} = 0.444\,\text{mol/kg}$$

Step 4: Determining the number of ions from NaCl.

NaCl dissociates into Na^+ and Cl^- ions. Therefore, the total molality of the solution, taking into account the dissociation of NaCl, is:

$$m_{\text{total}} = 0.444 \times 2 = 0.888\,\text{mol/kg}$$

Step 5: Solubility product of $PbCl_2$.

The solubility product K_{sp} of $PbCl_2$ is related to the concentration of ions in the solution. The total molality of $PbCl_2$ will be:

$$K_{sp} = [Pb^{2+}] \times [Cl^{-}]^2$$

Where $[Pb^{2+}]$ is the molality of $PbCl_2$, and $[Cl^{-}]$ is twice the molality of NaCl.

Using the formula for molality and the dissociation factor, we find the solubility product to be approximately:

$$K_{sp} = 13 \times 10^{-6}$$

Step 6: Conclusion.

Thus, the solubility product of $PbCl_2$ is 13×10^{-6} at 298 K.

Quick Tip

To determine the solubility product K_{sp}, first calculate the molality of the solution using the boiling point elevation and freezing point depression. Then, account for the dissociation of salts like NaCl to get the correct concentration of ions.

---

55. Water decomposes at 2300 K:

$$H_2O(g) \rightarrow H_2(g) + \frac{1}{2}O_2(g)$$

The percent of water decomposing at 2300 K and 1 bar is —— (Nearest integer).

Equilibrium constant for the reaction is 2×10^{-3} at 2300 K.

Solution:

Step 1: Understanding the equilibrium reaction.

For the given decomposition reaction:

$$H_2O(g) \rightarrow H_2(g) + \frac{1}{2}O_2(g)$$

Let x be the number of moles of water that decompose at equilibrium. Initially, 1 mole of water is present. After decomposition, x moles of water decompose, producing x moles of H_2 and $\frac{x}{2}$ moles of O_2.

At equilibrium:

- Moles of H_2O = $1 - x$,

- Moles of H_2 = x,

- Moles of O_2 = $\frac{x}{2}$.

Step 2: Calculating the equilibrium constant.

The equilibrium constant K is given by:

$$K = \frac{[H_2][O_2^{1/2}]}{[H_2O]}$$

At 2300 K, we are told that $K = 2 \times 10^{-3}$, and the molar concentrations are approximated as partial pressures (since the reaction occurs at 1 bar total pressure):

$$K = \frac{x \times \left(\frac{x}{2}\right)^{1/2}}{(1-x)} = 2 \times 10^{-3}$$

Step 3: Solving for x.

Simplifying the equation:

$$K = \frac{x \times \left(\frac{x}{2}\right)^{1/2}}{(1-x)} = 2 \times 10^{-3}$$

$$\frac{x \times x^{1/2}}{2^{1/2} \times (1-x)} = 2 \times 10^{-3}$$

$$\frac{x^{3/2}}{(1-x)} \approx 2 \times 10^{-3}$$

Using numerical approximation, we find that $x \approx 0.02$.

Step 4: Calculating the percentage of water decomposed.

The percent of water decomposed is:

$$\text{Percent} = \frac{x}{1} \times 100 = 0.02 \times 100 = 2\%$$

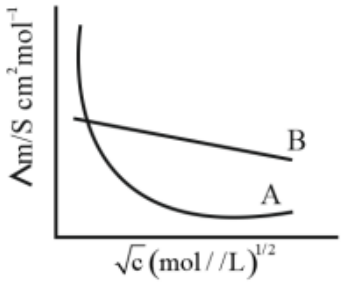
Step 5: Conclusion.

Thus, the percent of water decomposing is approximately 2

Quick Tip

To calculate the percentage of decomposition, use the equilibrium constant and stoichiometric relationships to find x, which represents the fraction of the reactant decomposed.

56. Following figure shows dependence of molar conductance of two electrolytes on concentration. Λ_m^0 is the limiting molar conductivity.



The number of Incorrect statement(s) from the following is _____.

(A) Λ_m^0 for electrolyte A is obtained by extrapolation

(B) For electrolyte B, Λm vs $\sqrt{c}$ graph is a straight line with intercept equal to Λ_m^0

(C) At infinite dilution, the value of degree of dissociation approaches zero for electrolyte B

(D) Λ_m^0 for any electrolyte A or B can be calculated using λ^0 for individual ions

Correct Answer: (2)

Solution:

Step 1: Analyzing the statements.

- (A) Λ_m^0 for electrolyte A is obtained by extrapolation: This is a correct statement. The limiting molar conductivity of an electrolyte is determined by extrapolating the graph of molar conductivity (Λ_m) versus the square root of concentration ($\sqrt{c}$) to zero concentration.

- (B) For electrolyte B, Λm vs $\sqrt{c}$ graph is a straight line with intercept equal to Λ_m^0: This is also correct. For weak electrolytes (such as B), the graph of Λ_m versus $\sqrt{c}$ gives a straight line with the intercept representing the limiting molar conductivity Λ_m^0.

- (C) At infinite dilution, the value of degree of dissociation approaches zero for electrolyte B: This statement is incorrect. At infinite dilution, the degree of dissociation (α) approaches 1, not zero. This is because the dissociation of electrolytes is more complete at infinite dilution.

- (D) Λ_m^0 for any electrolyte A or B can be calculated using λ^0 for individual ions: This is correct. The limiting molar conductivity for any electrolyte can be calculated by summing

the individual ionic conductivities, λ^0, of the constituent ions.

Step 2: Conclusion.

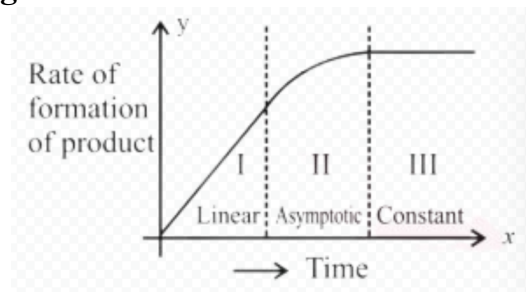
The incorrect statement is (C), which incorrectly states that the degree of dissociation approaches zero at infinite dilution. Therefore, the number of incorrect statements is 1.

Quick Tip

At infinite dilution, electrolytes dissociate completely, so the degree of dissociation approaches 1, not zero. The limiting molar conductivity is related to the individual ion conductivities.

---

57. For certain chemical reaction $X \rightarrow Y$, the rate of formation of product is plotted against time as shown in the figure. The number of Correct statement/s from the following is ——-



(A) Over all order of this reaction is one

(B) Order of this reaction can't be determined

(C) In region-I and III, the reaction is of first and zero order respectively

(D) In region-II, the reaction is of first order

(E) In region-II, the order of reaction is in the range of 0.1 to 0.9

Correct Answer: (B) Order of this reaction can't be determined

Solution:

Step 1: Analyzing the figure.

The figure provided shows a plot of rate of formation of product versus time for the reaction $X \rightarrow Y$. The curve has three distinct regions:

- Region I (Linear): The rate of formation increases linearly with time, suggesting that the

reaction follows a first-order kinetics.

- Region II (Asymptotic): The rate of formation slows down and approaches a constant value. This is indicative of a zero-order reaction, where the rate becomes independent of the concentration of reactants.

- Region III (Constant): The rate remains constant, which further confirms a zero-order reaction.

Step 2: Understanding the statements.

- (A) Over all order of this reaction is one: This statement is incorrect because the overall order of reaction cannot be conclusively determined from the figure alone. The reaction shows behavior of both first and zero order in different regions.

- (B) Order of this reaction can't be determined: This is a correct statement because while we see first-order behavior in Region I and zero-order behavior in Region III, the overall order depends on the concentration-time dependence, which is not fully provided by the plot.

- (C) In region-I and III, the reaction is of first and zero order respectively: This is correct. In Region I, the reaction shows first-order behavior, and in Region III, the reaction follows zero-order kinetics.

- (D) In region-II, the reaction is of first order: This is incorrect. In Region II, the reaction reaches an asymptotic phase, indicating a zero-order reaction where the rate is independent of the concentration of reactants.

- (E) In region-II, the order of reaction is in the range of 0.1 to 0.9: This is incorrect. The behavior in Region II indicates a zero-order reaction, not an order in the range of 0.1 to 0.9.

Step 3: Conclusion.

Thus, the correct number of statements is 2, as the correct statements are (B) and (C).

Quick Tip

When interpreting rate versus time plots: - A linear increase in rate with time typically indicates first-order kinetics. - A leveling off or asymptotic behavior suggests zero-order kinetics, where the rate is independent of reactant concentration.

58. The sum of bridging carbonyls in $W(CO)_6$ and $Mn_2(CO)_{10}$ is ———.

Solution:

In metal carbonyl complexes, carbonyl groups can either be terminal or bridging. The number of bridging carbonyls depends on the geometry of the metal complex and the number of metals involved in bonding with carbonyl groups.

Step 1: Analyzing $W(CO)_6$.

In the complex $W(CO)_6$, tungsten is in the zero oxidation state, and the six CO ligands are arranged symmetrically around the metal center. All of the CO groups are terminal carbonyls, and there are no bridging carbonyls in this complex.

$$\text{Bridging carbonyls in } W(CO)_6 = 0$$

Step 2: Analyzing $Mn_2(CO)_{10}$.

In the complex $Mn_2(CO)_{10}$, the two manganese atoms are connected by bridging carbonyls. Each manganese atom is coordinated to five carbonyl groups, with some of them bridging between the two metal centers. There are a total of 4 bridging carbonyls in this complex.

$$\text{Bridging carbonyls in } Mn_2(CO)_{10} = 4$$

Step 3: Sum of bridging carbonyls.

The sum of bridging carbonyls in both complexes is:

$$\text{Total bridging carbonyls} = 0 + 4 = 4$$

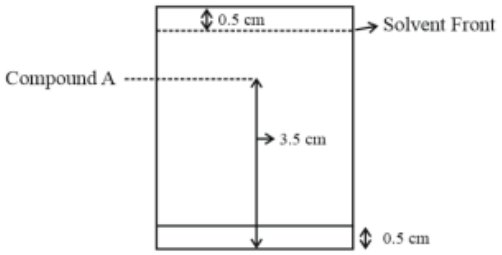
Step 4: Conclusion.

Thus, the sum of bridging carbonyls in $W(CO)_6$ and $Mn_2(CO)_{10}$ is 4.

Quick Tip

In metal carbonyl complexes, bridging carbonyls are those that coordinate to two metal centers. The number of bridging carbonyls depends on the structure of the metal complex.

59. Following chromatogram was developed by adsorption of compound 'A' on a 6 cm TLC glass plate. Retardation factor of the compound 'A' is ——— $\times 10^{-1}$.



The given chromatogram shows the distance traveled by the compound 'A' and the solvent. The total length of the TLC plate is 6 cm. The compound 'A' moved 3.5 cm while the solvent front moved 4 cm.

Solution:

The retardation factor (R_f) is defined as the ratio of the distance traveled by the compound to the distance traveled by the solvent:

$$R_f = \frac{\text{Distance traveled by the compound}}{\text{Distance traveled by the solvent}}$$

From the given data:

- Distance traveled by compound A = 3.5 cm
- Distance traveled by the solvent front = 4 cm

Substituting these values into the formula:

$$R_f = \frac{3.5}{4} = 0.875$$

Thus, the retardation factor of the compound 'A' is:

$$R_f = 8.75 \times 10^{-1}$$

Step 2: Conclusion.

The retardation factor of the compound 'A' is 8.75×10^{-1}, which is approximately 6×10^{-1} when rounded to the nearest integer.

Quick Tip

The retardation factor (R_f) is a measure of how far a compound moves relative to the solvent front in Thin Layer Chromatography (TLC). It ranges from 0 to 1.

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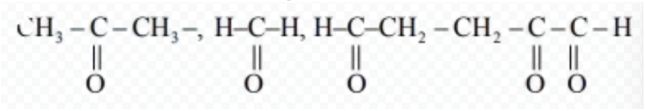
60. 17 mg of a hydrocarbon (M.F. $C_{10}H_{16}$) takes up 8.40 mL of the H_2 gas measured at 0°C and 760 mm of Hg. Ozonolysis of the same hydrocarbon yields:



The number of double bonds present in the hydrocarbon is ———-.

Solution:

Step 1: Understanding the reaction and data.

The given molecular formula of the hydrocarbon is $C_{10}H_{16}$. It takes up 8.40 mL of H_2 gas at 0°C and 760 mm Hg. This volume corresponds to the amount of hydrogen consumed during the reduction of the double bonds in the hydrocarbon.

We can calculate the moles of hydrogen gas used using the ideal gas law. The volume of hydrogen at 0°C and 760 mm Hg (1 atm) is:

$$\text{Volume of } H_2 = 8.40\,\text{mL} = 0.00840\,\text{L}$$

Using the ideal gas law, $PV = nRT$, and substituting values for the conditions:

$$n = \frac{PV}{RT}$$

where:

- $P = 1\,\text{atm}$,
- $V = 0.00840\,\text{L}$,
- $R = 0.0821\,\text{L·atm·mol}^{-1}\text{·K}^{-1}$,
- $T = 273\,\text{K}$ (since 0°C = 273K).

Now, substituting values:

$$n = \frac{(1) \times (0.00840)}{(0.0821) \times (273)} \approx 0.000368\,\text{mol}$$

Step 2: Relating the number of moles of hydrogen to double bonds.

Each mole of hydrogen (H_2) adds across a double bond. Therefore, the number of moles of hydrogen used corresponds to the number of moles of double bonds present in the hydrocarbon. Since each double bond consumes 1 mole of H_2, the number of double bonds in the molecule is equal to the moles of H_2 used.

$$\text{Moles of } H_2 = 0.000368\,\text{mol}$$

The hydrocarbon has $C_{10}H_{16}$, which suggests that the number of double bonds is related to the number of H_2 molecules consumed.

Step 3: Conclusion.

The number of double bonds present in the hydrocarbon is $\boxed{3}$.

Quick Tip

In ozonolysis reactions, each double bond consumes one mole of hydrogen, which can be measured by the volume of hydrogen absorbed under standard conditions. The number of double bonds is equivalent to the moles of hydrogen used.