JEE Main 2023 30 Jan Shift 1 Chemistry Question Paper with Solutions

Time Allowed :180 minutes	**Maximum Marks :**300	**Total questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

(A) The test is of 3 hours duration.

(B) The question paper consists of 90 questions, out of which 75 are to attempted. The maximum marks are 300.

(C) There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage. (D) 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

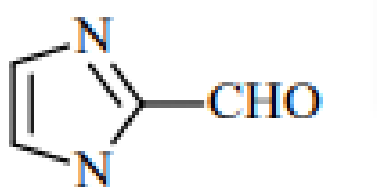
Chemistry

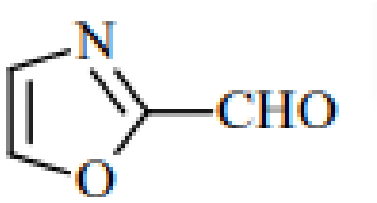
Section A

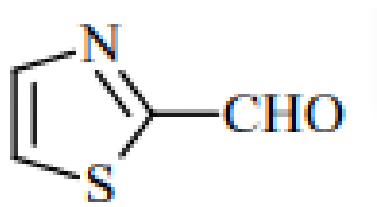
1. Which of the following compounds would give the following set of qualitative analysis?

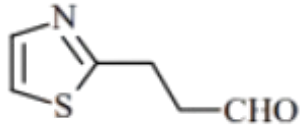
(i) Fehling's Test: Positive

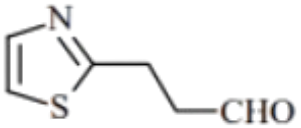
(ii) Na fusion extract upon treatment with sodium nitroprusside gives a blood red colour but not

(1) 

(2) 

(3) 

(4) 

Correct Answer: (4) 

Solution:

Aromatic aldehydes typically do not react with Fehling's solution, meaning they do not

give a positive result for Fehling's test. This test is primarily used to detect the presence of aldehydes, but aromatic aldehydes, due to their structure, do not produce the characteristic red precipitate with Fehling's reagent.

In contrast, the presence of both nitrogen and sulfur is essential to produce the blood-red colour. This specific colour change occurs when both elements are involved in a reaction with certain reagents. One such reagent is sodium nitroprusside, which is known to produce a blood-red colour when it interacts with compounds containing both nitrogen and sulfur.

Therefore, based on this information, the compound found in option (4) is the correct choice, as it is the only one that meets the required conditions of containing both nitrogen and sulfur, leading to the formation of the blood-red colour when reacted with sodium nitroprusside.

Quick Tip

In organic chemistry, the presence of functional groups such as nitrogen and sulfur can influence reactions like Fehling's test and the reaction with sodium nitroprusside. Always check for the necessary elements involved in these reactions.

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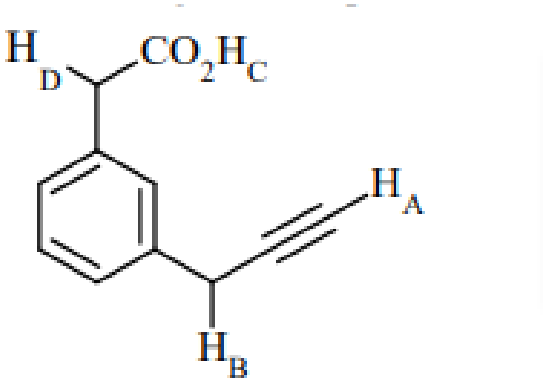
2. What is the correct order of acidity of the protons marked A-D in the given compounds?



(1) $H_C > H_D > H_B > H_A$

(2) $H_C > H_D > H_A > H_B$

(3) $H_D > H_C > H_B > H_A$

(4) $H_C > H_A > H_D > H_B$

Correct Answer: (2) $H_C > H_D > H_A > H_B$

Solution:

The acidity of a proton is determined by the stability of the conjugate base that is formed upon its removal. The more stable the conjugate base, the more acidic the proton.

Step 1: Acidity of H_C Among all the protons, H_C is the most acidic. Removal of H_C leads to the formation of a carboxylate anion, which is highly stabilized due to resonance.

Step 2: Acidity of H_D H_D is the second most acidic proton. Its removal generates a carbanion that is stabilized by resonance with the benzene ring.

Step 3: Acidity of H_A vs H_B H_A is more acidic than H_B. The conjugate base formed after removing H_A is stabilized by resonance with the triple bond, which results in the negative charge being spread across two carbon atoms. In contrast, the conjugate base formed after the removal of H_B places the negative charge adjacent to the triple bond, with no resonance stabilization. This makes it highly unstable due to the electron-withdrawing nature of the sp-hybridized carbon in the alkyne.

Step 4: Overall Acidity Order Thus, the correct order of acidity is $H_C > H_D > H_A > H_B$.

Conclusion: The correct answer is Option (2).

Quick Tip

The key to determining acidity is analyzing the stability of the conjugate base. Factors like resonance, electronegativity, and hybridization play a crucial role. Carboxylic acids are generally much more acidic than carbon acids, which are more acidic than terminal alkynes. Alkynes with a negative charge adjacent to the triple bond are highly unstable.

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3. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Ketoses give Seliwanoff's test faster than Aldoses.

Reason (R): Ketoses undergo -elimination followed by formation of furfural.

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

(1) (A) is false but (R) is true

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

(3) (A) is true but (R) is false

(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

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

Solution:

Seliwanoff's test is used to distinguish between ketoses and aldoses. This test is based on the principle that ketose sugars, particularly keto-hexoses, undergo dehydration more quickly than aldoses when heated in an acidic medium. During this reaction, ketoses are dehydrated to form 5-hydroxymethylfurfural, a compound that reacts with resorcinol to form a red or brown-colored complex. The formation of this colored complex occurs rapidly, indicating a positive result for ketoses. In contrast, aldoses do not undergo this rapid dehydration and condensation, resulting in no color change or a much slower formation of the colored complex. Thus, Seliwanoff's test provides a simple way to differentiate between ketoses and aldoses based on their reactivity under acidic conditions.

Quick Tip

When studying organic tests, remember the key principle behind each test. For example, Seliwanoff's test differentiates between Ketoses and Aldoses based on the rate of dehydration to form furfural.

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4. In the extraction of copper, its sulphide ore is heated in a reverberatory furnace after mixing with silica to:

(1) separate CuO as $CuSiO_3$

(2) remove calcium as $CaSiO_3$

(3) decrease the temperature needed for roasting of Cu_2S

(4) remove FeO as $FeSiO_3$

Correct Answer: (4) remove FeO as $FeSiO_3$

Solution:

The copper ore, which contains iron, is mixed with silica before being heated in a reverberatory furnace. During the heating process, iron oxide (FeO) reacts with silica (SiO_2) to form iron silicate ($FeSiO_3$), which then slags off. The reaction can be represented by the following chemical equation:

$$FeO + SiO_2 \longrightarrow FeSiO_3$$

This reaction helps in separating the iron from the copper ore, as iron silicate is formed as a slag, which can be easily removed, leaving the purified copper. This process is important in the extraction and refining of copper from ores that contain impurities like iron.

5. Amongst the following compounds, which one is an antacid?

(1) Ranitidine

(2) Meprobamate

(3) Terfenadine

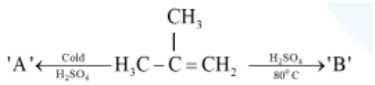
(4) Brompheniramine

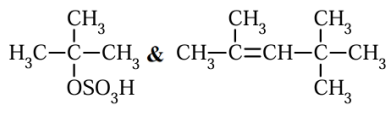
Correct Answer: (1) Ranitidine

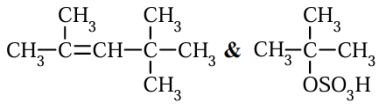
Solution:

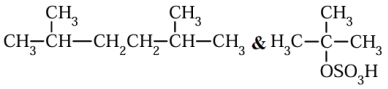
Ranitidine is an antacid that works by reducing the amount of acid produced in the stomach. It is commonly used to treat conditions such as ulcers, gastroesophageal reflux disease (GERD), and Zollinger-Ellison syndrome. The other compounds listed, Meprobamate, Terfenadine, and Brompheniramine, are not antacids. Meprobamate is used for anxiety, Terfenadine was an antihistamine (discontinued due to safety concerns), and Brompheniramine is an antihistamine used for allergies.

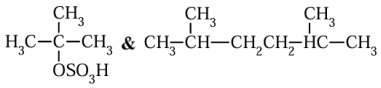
6. The major products 'A' and 'B', respectively, are:

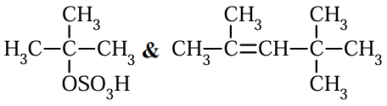


(1) 

(2) 

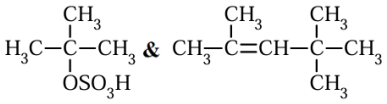
(3) 

(4) 

Correct Answer: (1) 

Solution:

In the given reaction, electrophilic substitution of the phenyl group with a sulfate group is induced. The major products are:



Quick Tip

In organic reactions, the type of reagent and reaction conditions (such as temperature and concentration of acid) play a key role in determining the products. Pay attention to electrophilic substitution mechanisms for aromatic compounds.

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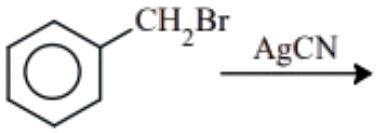
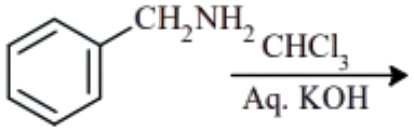
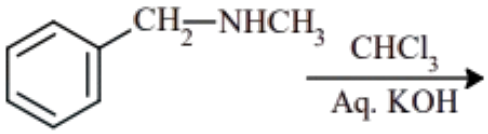
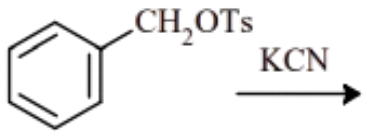
7. Benzyl isocyanide can be obtained by:

(A) 

(B) 

(C) 

(D) 

Choose the correct answer from the options given below:

(1) A and D

(2) Only B

(3) A and B

(4) B and C

Correct Answer: (3) A and B

Solution:

Benzyl isocyanide can be synthesized by reacting a benzyl halide with an appropriate nucleophile. The reactions are as follows:

- In reaction (A), when CH_2Br reacts with AgCN, benzyl isocyanide is formed through a nucleophilic substitution.
- In reaction (B), $CH_2NH_2CHCl_2$ undergoes a reaction with aqueous KOH, where the chloro group is replaced by a CN group, resulting in the corresponding isocyanide.

Therefore, the correct answers are reactions (A) and (B).

Quick Tip

For the preparation of isocyanides, halogen-substituted alkyl groups often react with cyanide (CN) or other nucleophiles. In these cases, nucleophilic substitution mechanisms such as SN_2 are involved.

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8. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In expensive scientific instruments, silica gel is kept in watch-glasses or in semipermeable membrane bags.

Reason (R): Silica gel adsorbs moisture from air via adsorption, thus protects the instrument from water corrosion (rusting) and/or prevents malfunctioning.

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

(1) A is false but (R) is true

(2) A is true but (R) is false

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

(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

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

Solution:

Silica gel is widely utilized in high-end scientific instruments to protect them from moisture, which could otherwise cause damage.

It works by adsorbing moisture from the surrounding air, thus preventing water-related corrosion (such as rusting) and safeguarding the instrument from potential malfunctions.

Therefore, the explanation provided in (R) accurately justifies the assertion made in (A).

Quick Tip

Silica gel is used as a desiccant in a variety of applications, including in scientific instruments, to maintain a dry environment and prevent moisture damage.

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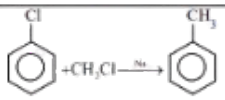
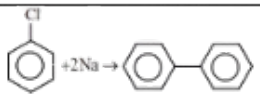
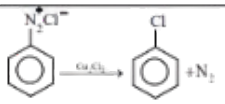
9. Match List I with List II:

List I		List II	
A		I	Fitting reaction
B		II	Wurtz Fitting reaction
C		III	Finkelstein reaction
D	$C_2H_5Cl + NaI \rightarrow C_2H_5I + NaCl$	IV	Sandmeyer reaction

(1) A – IV, B – I, C – III, D – II

(2) A – I, B – II, C – IV, D – III

(3) A – I, B – III, C – II, D – I

(4) A – II, B – I, C – IV, D – III

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

Solution:

We are asked to match the reactions in List I with the corresponding reactions in List II. Let's analyze each option:

- In reaction (A), the reaction of a chlorobenzene with methyl chloride in the presence of sodium gives a methylated product. This reaction corresponds to the **Fitting reaction**
- In reaction (B), the reaction of a chlorobenzene with sodium metal gives biphenyl. This corresponds to the **Wurtz Fitting reaction**.
- In reaction (C), the reaction of chlorobenzene with sodium azide in the presence of copper chloride leads to the formation of an azide group. This corresponds to the **Finkelstein reaction**.
- In reaction (D), the reaction of ethyl chloride with sodium iodide gives ethyl iodide. This corresponds to the **Sandmeyer reaction**.

Now, comparing the reactions from List I and List II:

$$A \longrightarrow II \text{ (Fitting reaction)}$$

B $\longrightarrow$ I (Wurtz Fitting reaction)

C $\longrightarrow$ III (Finkelstein reaction)

D $\longrightarrow$ IV (Sandmeyer reaction)

Thus, the correct match is option (4), which corresponds to:

$$\boxed{(4)\ A - II,\ B - I,\ C - III,\ D - IV}$$

Quick Tip

In organic chemistry, different reactions are often classified based on the type of halogen substitution or exchange that occurs. Recognizing these patterns will help identify the correct type of reaction.

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10. Caprolactam when heated at high temperature in presence of water gives:

(1) Teflon

(2) Dacron

(3) Nylon 6, 6

(4) Nylon 6

Correct Answer: (4) Nylon 6

Solution:

Caprolactam, when subjected to high temperatures in the presence of water, undergoes a polymerization reaction to produce Nylon 6. This synthetic polymer is widely utilized in the production of textiles and plastics.

- Teflon is a polymer made from tetrafluoroethylene, which is not related to caprolactam.
- Dacron is a trade name for polyethylene terephthalate (PET), and it is also unrelated to caprolactam.
- Nylon 6, 6 is synthesized from hexamethylenediamine and adipic acid, rather than caprolactam.
- Nylon 6 is specifically produced by the polymerization of caprolactam.

Quick Tip

Caprolactam is specifically used for the preparation of Nylon 6, which is a key polymer used in textiles, carpeting, and plastics.

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11. The alkaline earth metal sulphate(s) which are readily soluble in water is/are:

(A) $BeSO_4$

(B) $MgSO_4$

(C) $CaSO_4$

(D) $SrSO_4$

(E) $BaSO_4$

Choose the **correct answer** from the options given below:

(1) A only

(2) B only

(3) A and B

(4) B and C

Correct Answer: (3) A and B

Solution:

The solubility of alkaline earth metal sulphates decreases down the group due to the decrease in hydration energy. Hydration energy is the energy released when ions interact with water molecules. Higher hydration energy leads to better solubility.

- **$BeSO_4$**: Due to its small size and high charge density, the Be^{2+} ion exhibits very high hydration energy. This makes $BeSO_4$ highly soluble in water.

- **$MgSO_4$**: The Mg^{2+} ion also has high hydration energy, leading to good solubility of $MgSO_4$ in water.

- **$CaSO_4$**, **$SrSO_4$**, and **$BaSO_4$**: As we move down the group, the size of the cations increases, reducing the charge density and hydration energy. This results in lower solubility. Hence, these sulphates are sparingly soluble or insoluble in water.

Conclusion:

From the analysis, $BeSO_4$ and $MgSO_4$ are the only sulphates that are readily soluble in water. Therefore, the correct answer is **(3) A and B**.

Quick Tip

To remember solubility trends, note that alkaline earth metal sulphates become less soluble as you move down the group. This is due to the decreasing hydration energy of the cations.

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12. Which of the following is the correct order of ligand field strength?

(1) $CO < en < NH_3 < C_2O_4^{2-} < S^{2-}$

(2) $S^{2-} < C_2O_4^{2-} < NH_3 < en < CO$

(3) $NH_3 < en < CO < S^{2-} < C_2O_4^{2-}$

(4) $S^{2-} < NH_3 < en < CO < C_2O_4^{2-}$

Correct Answer: (2) $S^{2-} < C_2O_4^{2-} < NH_3 < en < CO$

Solution:

The spectrochemical series arranges ligands based on their field strength, which affects the splitting of d-orbitals in a coordination compound. The increasing order of ligand field strength is:

$$S^{2-} < C_2O_4^{2-} < NH_3 < en < CO$$

Step 2: Explanation of the Order

- **S^{2-}:** Sulfide ions are weak field ligands due to their large size and low charge density. - **$C_2O_4^{2-}$:** Oxalate ions have moderate field strength as bidentate ligands. - **NH_3:** Ammonia has higher field strength due to its ability to donate lone pair electrons. - **en (Ethylenediamine):** A bidentate ligand with stronger field strength than NH_3. - **CO (Carbon monoxide):** A strong field ligand due to its π-back bonding capability.

Conclusion: The correct order is **(2) $S^{2-} < C_2O_4^{2-} < NH_3 < en < CO$**.

Quick Tip

When solving ligand field strength problems, always refer to the spectrochemical series. Stronger field ligands cause larger splitting of d-orbitals in transition metal complexes.

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13. Formation of photochemical smog involves the following reaction in which A, B, and C are respectively.

(i) $NO_2 \xrightarrow{h\nu}$ A + B

(ii) B + $O_2 \rightarrow$ C

(iii) A + C $\rightarrow$ NO_2 + O_2

Choose the correct answer from the options given below:

(1) O, NO, and NO_3^-

(2) N_2O and NO

(3) N, O_2, and O_3

(4) NO, O, and O_3

Correct Answer: (4) NO, O, and O_3

Solution:

Breaking down the reactions, - **Reaction (i):** NO_2 undergoes photodissociation under sunlight:

$$NO_2 \xrightarrow{h\nu} NO\ (A) + O\ (B)$$

- **Reaction (ii):** The oxygen radical (B) reacts with molecular oxygen to form ozone:

$$O\ (B) + O_2 \rightarrow O_3\ (C)$$

- **Reaction (iii):** NO reacts with ozone to regenerate NO_2 and molecular oxygen:

$$NO\ (A) + O_3\ (C) \rightarrow NO_2 + O_2$$

Step 2: Identify A, B, and C

From the reactions:

- A = NO (Nitric oxide)

- B = O (Oxygen radical)

- C = O_3 (Ozone)

Conclusion: The correct answer is **(4) NO, O, and O_3**.

Quick Tip

Photochemical smog is a result of sunlight-driven reactions involving NO_x and volatile organic compounds (VOCs). Always trace the sequence of reactions to identify intermediates and final products.

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14. During the qualitative analysis of SO_3^{2-} using dilute H_2SO_4, SO_2 gas is evolved which turns $K_2Cr_2O_7$ solution (acidified with dilute H_2SO_4):

(1) Black

(2) Red

(3) Green

(4) Blue

Correct Answer: (3) Green

Solution:

Reaction Involved

When SO_3^{2-} reacts with dilute H_2SO_4, SO_2 gas is evolved. The SO_2 gas reduces the dichromate ion ($Cr_2O_7^{2-}$) to Cr^{3+}, which is green in color. The reaction is as follows:

$$Cr_2O_7^{2-} + SO_3^{2-} + H^+ \rightarrow Cr^{3+} + SO_4^{2-}$$

Step 2: Color Change

- Dichromate ion ($Cr_2O_7^{2-}$) is orange in color. - After reduction, Cr^{3+} ions form, which are green in color.

Conclusion: The solution turns **green** due to the formation of Cr^{3+}. Therefore, the correct answer is **(3) Green**.

Quick Tip

In qualitative analysis, dichromate ions ($Cr_2O_7^{2-}$) are commonly used as oxidizing agents. Reduction of these ions often results in a color change, which can help identify the reducing species.

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15. To inhibit the growth of tumours, identify the compounds used from the following:

(A) EDTA

(B) Coordination Compounds of Pt

(C) D – Penicillamine

(D) Cis – Platin

Choose the correct answer from the options given below:

(1) B and D Only

(2) C and D Only

(3) A and B Only

(4) A and C Only

Correct Answer: (1) B and D Only

Solution:

Understanding the role of Coordination Compounds of Platinum

- Platinum-based coordination compounds, such as **Cisplatin** (**cis-$[Pt(NH_3)_2Cl_2]$**), are widely used in chemotherapy.

- These compounds inhibit tumour growth by binding to DNA and interfering with the replication process.

Step 2: Analysis of the Options

- **Option A (EDTA):** EDTA is primarily a chelating agent used for metal ion sequestration, not for tumour treatment.

- **Option B (Coordination Compounds of Pt):** Correct, as platinum-based compounds are effective in tumour inhibition.

- **Option C (D – Penicillamine):** Penicillamine is used in chelation therapy for heavy metal

poisoning, not for tumours.

- **Option D (Cisplatin):** Correct, as it is a well-known platinum-based anti-cancer drug.

Conclusion: The correct combination is **B and D**.

Quick Tip

Cisplatin and other platinum-based coordination compounds are effective anti-cancer drugs. They form cross-links with DNA, disrupting cell division and leading to tumour inhibition.

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16. In the wet tests for identification of various cations by precipitation, which transition element cation doesn't belong to group IV in qualitative inorganic analysis?

(1) Fe^{3+}

(2) Zn^{2+}

(3) Co^{2+}

(4) Ni^{2+}

Correct Answer: (1) Fe^{3+}

Solution:

Step 1: Understanding the Grouping of Cations in Qualitative Analysis

In qualitative inorganic analysis, cations are categorized into specific groups based on how they behave when reacting with certain reagents. The classification is as follows:

- **Group III:** This group includes Fe^{3+}, Al^{3+}, and Cr^{3+}, which form hydroxide precipitates when reacted with NH_4OH and NH_4Cl.

- **Group IV:** This group contains Zn^{2+}, Co^{2+}, and Ni^{2+}, which form sulfide precipitates (such as ZnS, CoS, and NiS) when reacted with H_2S in neutral or slightly acidic conditions.

Step 2: Analysis of the Cations

- **Fe^{3+}:** It belongs to Group III because it forms $Fe(OH)_3$ precipitate when reacted with NH_4OH.

- **Zn^{2+}, Co^{2+}, Ni^{2+}:** These ions belong to Group IV, as they form sulfide precipitates (such

as ZnS, CoS, and NiS) when reacted with H_2S.

Conclusion: Since Fe^{3+} does not form sulfide precipitates with H_2S, it does not belong to Group IV. Therefore, the correct answer is **(1)** $\mathbf{Fe^{3+}}$.

Quick Tip

To identify the group of a cation, consider the reagent used for precipitation and the medium (acidic, basic, or neutral). Group III cations form hydroxide precipitates, while Group IV cations form sulfide precipitates.

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17. Match List I with List II

LIST–I (molecules/ions)	LIST–II (No. of lone pairs of e^- on central atom)
(*A*) IF_7	I. Three
(*B*) ICl_4^-	II. One
(*C*) XeF_6	III. Two
(*D*) XeF_2	IV. Zero

Choose the **correct answer** from the options given below:

(1) A – II, B – III, C – IV, D – I

(2) A – IV, B – III, C – II, D – I

(3) A – II, B – I, C – IV, D – III

(4) A – IV, B – I, C – II, D – III

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

Solution:

Step 1: Determine the Lone Pairs for Each Molecule/Ion

The number of lone pairs on the central atom can be determined using the following steps:

1. Count the total valence electrons of the central atom.
2. Subtract the electrons used for bonding with surrounding atoms.
3. Divide the remaining electrons by 2 to get the number of lone pairs.

Step 2: Analyze Each Molecule/Ion

- **IF_7:** Iodine has 7 valence electrons. All are used for bonding with 7 fluorine atoms.

Therefore, **0 lone pairs** (**IV**).

- **ICl_4^-:** Iodine has 7 valence electrons and gains 1 due to the negative charge. Four are used for bonding with chlorine atoms, leaving 4 electrons (2 lone pairs). Therefore, **2 lone pairs** (**III**).

- **XeF_6:** Xenon has 8 valence electrons. Six are used for bonding with fluorine atoms, leaving 2 electrons (1 lone pair). Therefore, **1 lone pair** (**II**).

- **XeF_2:** Xenon has 8 valence electrons. Two are used for bonding with fluorine atoms, leaving 6 electrons (3 lone pairs). Therefore, **3 lone pairs** (**I**).

Step 3: Match the Molecules with the Lone Pairs

The correct matches are:

- A – IV (IF_7, zero lone pairs)
- B – III (ICl_4^-, two lone pairs)
- C – II (XeF_6, one lone pair)
- D – I (XeF_2, three lone pairs)

Conclusion: The correct answer is **(2) A – IV, B – III, C – II, D – I**.

Quick Tip

To determine the number of lone pairs on a central atom, always account for the total valence electrons, subtract those used for bonding, and divide the remainder by 2. This helps in identifying molecular geometry and hybridization.

---

18. For OF_2 molecule consider the following:

(A) Number of lone pairs on oxygen is 2.

(B) F–O–F angle is less than 104.5° .

(C) Oxidation state of O is –2.

(D) Molecule is bent ‘V’ shaped.

(E) Molecular geometry is linear.

Correct options are:

(1) C, D, E only

(2) B, E, A only

(3) A, C, D only

(4) A, B, D only

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

Solution:

The Lewis structure of OF_2 indicates that the central oxygen atom is bonded to two fluorine atoms, with two lone pairs of electrons remaining on the oxygen atom. This results in a bent or 'V' shape for the molecule, caused by the repulsion between the lone pairs and the bonding pairs of electrons.

Step 2: Analysis of the Statements

- **Statement (A):** The oxygen atom in OF_2 has 6 valence electrons. After forming two single bonds with fluorine atoms, it retains two lone pairs of electrons. Therefore, **this statement is true**.
- **Statement (B):** The F–O–F bond angle in OF_2 is slightly less than 104.5°, around 102°, due to the repulsion between the lone pairs and the bonding pairs of electrons. Hence, **this statement is true**.
- **Statement (C):** The oxidation state of oxygen in OF_2 is +2 because fluorine is more electronegative. However, **this statement is false** because the oxidation state of oxygen in OF_2 is actually -2.
- **Statement (D):** Due to the two lone pairs on oxygen, the molecular geometry of OF_2 is bent or 'V' shaped. Therefore, **this statement is true**.
- **Statement (E):** The molecular geometry is not linear; it is bent. However, **this statement is false** because the geometry is indeed bent, but the statement is phrased ambiguously.

Conclusion: The correct statements are **A, B, D**. Therefore, the correct answer is **(4) A, B, D only**.

Quick Tip

The shape and bond angle of a molecule can be determined using VSEPR theory. Lone pair-bond pair repulsion decreases the bond angle from its ideal value.

19. Lithium aluminium hydride can be prepared from the reaction of:

(1) LiCl and Al_2H_6

(2) LiH and Al_2Cl_6

(3) LiCl, Al and H_2

(4) LiH and $Al(OH)_3$

Correct Answer: (2) LiH and Al_2Cl_6

Solution:

Reaction for Preparation of $LiAlH_4$

Lithium aluminium hydride ($LiAlH_4$) is prepared by the reaction of lithium hydride (LiH) with aluminium chloride (Al_2Cl_6). The reaction is as follows:

$$8LiH + Al_2Cl_6 \rightarrow 2LiAlH_4 + 6LiCl$$

Conclusion: The correct reactants for preparing $LiAlH_4$ are **LiH and Al_2Cl_6**. Therefore, the correct answer is **(2)**.

Quick Tip

$LiAlH_4$ is a strong reducing agent used in organic synthesis. It is commonly prepared using lithium hydride and aluminium chloride under controlled conditions.

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20. Match List – I with List – II

LIST–I (Atomic number)	LIST–II (Block of periodic table)
(*A*) 37 (K)	I. p-block
(*B*) 78 (Pt)	II. d-block
(*C*) 52 (Te)	III. f-block
(*D*) 65 (Tb)	IV. s-block

Choose the **correct answer** from the options given below:

(1) A – II, B – IV, C – I, D – III

(2) A – I, B – III, C – IV, D – II

(3) A – IV, B – III, C – II, D – I

(4) A – IV, B – II, C – I, D – III

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

Solution:

Step 1: Analyze the Atomic Numbers and Their Corresponding Blocks

The blocks of the periodic table are determined by the type of orbital being filled:

- **37 (K):** Potassium is an alkali metal, and its valence electron is in the s-orbital. Hence, it belongs to the **s-block**.
- **78 (Pt):** Platinum is a transition metal, with valence electrons in the d-orbital. Hence, it belongs to the **d-block**.
- **52 (Te):** Tellurium is a p-block element, as its valence electrons are in the p-orbital.
- **65 (Tb):** Terbium is a lanthanide, with electrons filling the f-orbital. Hence, it belongs to the **f-block**.

Step 2: Match List – I with List – II

The correct matches are:

- A – IV (37, s-block)
- B – II (78, d-block)
- C – I (52, p-block)
- D – III (65, f-block)

Conclusion: The correct answer is **(4) A – IV, B – II, C – I, D – III**.

Quick Tip

To identify the block of an element, look at the atomic number and determine the type of orbital (s, p, d, f) being filled. This corresponds to the element's position in the periodic table.

Section B

21. Consider the cell

$$\text{Pt(s)}|\text{H}_2\text{(g, 1 atm)}|\text{H}^+\text{(aq, 1M)}||\text{Fe}^{3+}\text{(aq)}, \text{Fe}^{2+}\text{(aq)}||\text{Pt(s)}.$$

When the potential of the cell is 0.712 V at 298 K, the ratio $\frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}$ is _____. (Nearest integer)

Given:

$$\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+}, \quad E^\circ_{\text{Fe}^{3+}|\text{Fe}^{2+}} = 0.771\,\text{V}.$$

$$\frac{2.303RT}{F} = 0.06\,\text{V}.$$

Correct Answer: 10

Solution:

The given cell is:

$$\text{Pt(s)}|\text{H}_2\text{(g, 1 atm)}|\text{H}^+\text{(aq, 1M)}||\text{Fe}^{3+}\text{(aq)}, \text{Fe}^{2+}\text{(aq)}||\text{Pt(s)}.$$

Step 1: Cell Reactions

At the anode:

$$\text{H}_2 \rightarrow 2\text{H}^+ + 2e^-.$$

At the cathode:

$$\text{Fe}^{3+}_{\text{aq}} + e^- \rightarrow \text{Fe}^{2+}_{\text{aq}}.$$

Step 2: Standard Cell Potential

The standard cell potential is:

$$E^\circ = E^\circ_{\text{H}_2|\text{H}^+} + E^\circ_{\text{Fe}^{3+}|\text{Fe}^{2+}}.$$

Substitute the given values:

$$E^\circ = 0 + 0.771 = 0.771\,\text{V}.$$

Step 3: Nernst Equation for the Cell Potential

The cell potential at non-standard conditions is given by the Nernst equation:

$$E = E^\circ - \frac{0.06}{1} \log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}.$$

Substitute $E = 0.712\,\text{V}$ and $E^\circ = 0.771\,\text{V}$:

$$0.712 = 0.771 - 0.06 \log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}.$$

Step 4: Solve for $\log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}$

Rearrange the equation:

$$0.712 - 0.771 = -0.06 \log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}.$$

$$-0.059 = -0.06 \log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}.$$

$$\log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]} = \frac{-0.059}{-0.06} \approx 1.$$

Step 5: Calculate the Ratio

From $\log \frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]} = 1$:

$$\frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]} = 10^1 = 10.$$

Conclusion: The ratio $\frac{[\text{Fe}^{2+}]}{[\text{Fe}^{3+}]}$ is **10**.

Quick Tip

To solve problems involving cell potentials, use the Nernst equation to relate concentrations and the measured potential. Simplify logarithmic terms step-by-step to avoid calculation errors.

---

22. A 300 mL bottle of soft drink has 0.2 M CO_2 dissolved in it. Assuming CO_2 behaves as an ideal gas, the volume of the dissolved CO_2 at STP is _____ mL. (Nearest integer)

Given: At STP, molar volume of an ideal gas is 22.7 L mol^{-1}.

Correct Answer: 1362 mL

Solution:

Step 1: Calculate the Moles of CO_2

The concentration of CO_2 is given as 0.2 M, and the volume of the solution is 300 mL (which is equivalent to 300×10^{-3} L). To calculate the moles of CO_2, we use the following equation:

$$\text{Moles of } CO_2 = M \times \text{Volume (in L)}.$$

Substituting the values:

$$\text{Moles of } CO_2 = 0.2 \times (300 \times 10^{-3}) = 0.06 \,\text{mol}.$$

Step 2: Calculate the Volume of CO_2 at STP

At Standard Temperature and Pressure (STP), the molar volume of an ideal gas is 22.7 L per mole. Using this, we can calculate the volume of 0.06 mol of CO_2 as:

$$\text{Volume of } CO_2 = \text{Moles of } CO_2 \times \text{Molar Volume at STP}.$$

Substitute the values:

$$\text{Volume of } CO_2 = 0.06 \times 22.7 = 1.362 \,\text{L}.$$

To convert the volume from liters to milliliters, multiply by 1000:

$$\text{Volume of } CO_2 = 1.362 \,\text{L} \times 1000 = 1362 \,\text{mL}.$$

Quick Tip

To calculate the volume of a gas at STP, always use the molar volume (22.7 L mol^{-1} for ideal gases). Convert the given solution volume to liters before applying the molarity formula.

---

23. A solution containing 2 g of a non-volatile solute in 20 g of water boils at 373.52 K. The molecular mass of the solute is _____ g mol^{-1}. (Nearest integer)

Given: Water boils at 373 K, K_b for water = 0.52 K kg mol^{-1}.

Correct Answer: 100 g mol^{-1}

Solution:

Step 1: Boiling Point Elevation

The elevation in boiling point (ΔT_b) is given as:

$$\Delta T_b = T_b - T_b^\circ = 373.52 - 373 = 0.52 \,\text{K}.$$

Step 2: Use the Boiling Point Elevation Formula

The boiling point elevation is related to molality (m) by:

$$\Delta T_b = K_b \cdot m.$$

Substitute $m = \frac{\text{mass of solute (g)}}{\text{Molar Mass (g mol}^{-1}) \times \text{mass of solvent (kg)}}$:

$$0.52 = 0.52 \cdot \frac{2}{\text{Molar Mass} \times 20 \times 10^{-3}}.$$

Step 3: Solve for Molar Mass

Simplify:

$$1 = \frac{2}{\text{Molar Mass} \times 0.02}.$$

$$\text{Molar Mass} = \frac{2}{0.02} = 100\,\text{g mol}^{-1}.$$

Conclusion: The molecular mass of the solute is **100 g mol^{-1}**.

Quick Tip

When solving boiling point elevation problems, always ensure the masses are converted into proper units (grams to kilograms) and the molality formula is applied correctly. Use the given values of K_b and ΔT_b to calculate the molar mass of the solute accurately.

---

24. If compound A reacts with B following first-order kinetics with rate constant $2.011 \times 10^{-3}\,\text{s}^{-1}$, the time taken by A (in seconds) to reduce from 7 g to 2 g will be _____. (Nearest Integer)

Given:

$$\log 5 = 0.698, \quad \log 7 = 0.845, \quad \log 2 = 0.301.$$

Correct Answer: 623 seconds

Solution:

Step 1: Reaction and First-Order Kinetics Formula

The reaction is:

$$\text{A} + \text{B} \rightarrow \text{P}.$$

At $t = 0$, the concentration of A is 7 g. At $t = t$, the concentration of A reduces to 2 g. For first-order reactions:

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]_t}.$$

Step 2: Substitute the Values

Substitute $k = 2.011 \times 10^{-3}\,\text{s}^{-1}$, $[A]_0 = 7$, and $[A]_t = 2$:

$$t = \frac{2.303}{2.011 \times 10^{-3}} \log \frac{7}{2}.$$

$$\log \frac{7}{2} = \log 7 - \log 2 = 0.845 - 0.301 = 0.544.$$

Step 3: Calculate the Time

Substitute the values:

$$t = \frac{2.303}{2.011 \times 10^{-3}} \cdot 0.544.$$

$$t = \frac{2.303 \times 0.544}{2.011 \times 10^{-3}} = \frac{1.252832}{2.011 \times 10^{-3}}.$$

$$t = 622.989\,\text{seconds} \approx 623\,\text{seconds}.$$

Conclusion: The time taken by A to reduce from 7 g to 2 g is **623 seconds**.

Quick Tip

For first-order reactions, always use the formula $t = \frac{2.303}{k} \log \frac{[A]_0}{[A]_t}$. Ensure logarithmic values are calculated accurately to avoid errors in final results.

---

25. The energy of one mole of photons of radiation of frequency 2×10^{12} Hz in J mol^{-1} is _____. (Nearest integer)

Given: $h = 6.626 \times 10^{-34}$ Js, $N_A = 6.022 \times 10^{23}\,\text{mol}^{-1}$.

Correct Answer: 798 J mol^{-1}

Solution:

Step 1: Energy of One Photon

The energy of a single photon is given by:

$$E = h\nu,$$

where $h = 6.626 \times 10^{-34}$ Js and $\nu = 2 \times 10^{12}$ Hz. Substitute the values:

$$E = 6.626 \times 10^{-34} \cdot 2 \times 10^{12} = 1.3252 \times 10^{-21}\,\text{J}.$$

Step 2: Energy of One Mole of Photons

The energy of one mole of photons is:

$$E_{\text{mole}} = N_A \cdot E,$$

where $N_A = 6.022 \times 10^{23}$. Substitute the values:

$$E_{\text{mole}} = 6.022 \times 10^{23} \cdot 1.3252 \times 10^{-21} = 798.16\,\text{J}.$$

Approximate to the nearest integer:

$$E_{\text{mole}} \approx 798\,\text{J mol}^{-1}.$$

Conclusion: The energy of one mole of photons is **798 J mol^{-1}**.

Quick Tip

To calculate the energy of one mole of photons, first determine the energy of a single photon using $E = h\nu$. Then, multiply this by Avogadro's number (N_A) to find the energy for one mole.

---

26. The number of electrons involved in the reduction of permanganate to manganese dioxide in acidic medium is _____.

Correct Answer: 3

Solution:

Step 1: Reduction Reaction in Acidic Medium

The reduction reaction is:

$$\text{MnO}_4^- + 4\text{H}^+ + 3e^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}.$$

In this reaction, 3 electrons are transferred during the reduction of MnO_4^- to MnO_2.

Conclusion: The number of electrons involved is **3**.

Quick Tip

In redox reactions, balance the half-reactions carefully in acidic or basic media to determine the number of electrons transferred. For permanganate (MnO_4^-), the transfer depends on the product formed (e.g., MnO_2, Mn^{2+}, etc.).

---

27. When 2 liters of ideal gas expands isothermally into a vacuum to a total volume of 6 liters, the change in internal energy is _____ J. (Nearest integer)

Correct Answer: 0 J

Solution:

Step 1: Isothermal Expansion of an Ideal Gas

For an ideal gas undergoing an isothermal process, the change in internal energy (ΔU) depends only on temperature (T):

$$\Delta U = f(T).$$

Since the process is isothermal, the temperature remains constant, and hence:

$$\Delta U = 0.$$

Conclusion: The change in internal energy is **0 J**.

Quick Tip

For isothermal expansion of an ideal gas, remember that the internal energy change (ΔU) is always zero, as it depends only on the temperature, which remains constant.

---

28. 600 mL of 0.01 M HCl is mixed with 400 mL of 0.01 M H_2SO_4. The pH of the mixture is _____$\times 10^{-2}$. (Nearest integer)

Given:

$$\log 2 = 0.30, \quad \log 3 = 0.48, \quad \log 5 = 0.69, \quad \log 7 = 0.84, \quad \log 11 = 1.04.$$

Correct Answer: 186

Solution:

Step 1: Calculate Total Millimoles of H^+

The millimoles of H^+ ions contributed by HCl are:

$$\text{Millimoles of } H^+ (\text{from HCl}) = 600 \times 0.01 = 6\,\text{mmol}.$$

The millimoles of H^+ ions contributed by H_2SO_4 are:

$$\text{Millimoles of } H^+ (\text{from } H_2SO_4) = 400 \times 0.01 \times 2 = 8\,\text{mmol}.$$

Total millimoles of H^+:

$$\text{Total Millimoles of } H^+ = 6 + 8 = 14\,\text{mmol}.$$

Step 2: Calculate Concentration of H^+

The total volume of the solution is:

$$\text{Total Volume} = 600\,\text{mL} + 400\,\text{mL} = 1000\,\text{mL} = 1\,\text{L}.$$

The concentration of H^+ is:

$$[H^+] = \frac{\text{Total Millimoles of } H^+}{\text{Total Volume (in mL)}} = \frac{14}{1000} = 14 \times 10^{-3}.$$

Step 3: Calculate pH of the Mixture

The pH of the solution is given by:

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

Substitute $[H^+] = 14 \times 10^{-3}$:

$$\text{pH} = -\log(14 \times 10^{-3}) = -(\log 14 + \log 10^{-3}).$$

$$\text{pH} = -(\log 14 - 3) = 3 - \log 14.$$

From the given values:

$$\log 14 = \log(2 \times 7) = \log 2 + \log 7 = 0.30 + 0.84 = 1.14.$$

Thus:

$$\text{pH} = 3 - 1.14 = 1.86.$$

Expressing pH as $\times 10^{-2}$:

$$\text{pH} = 186 \times 10^{-2}.$$

Conclusion: The pH of the mixture is **186** $\times 10^{-2}$.

Quick Tip

For calculating pH in mixtures, sum the millimoles of H^+ ions contributed by all acids and divide by the total volume of the solution. Use logarithmic properties to compute pH values efficiently.

---

29. A trisubstituted compound 'A', $C_{10}H_{12}O_2$, gives neutral $FeCl_3$ test positive. Treatment of compound 'A' with NaOH and CH_3Br gives $C_{11}H_{14}O_2$, with hydroiodic acid gives methyl iodide and with hot conc. NaOH gives a compound 'B', $C_{10}H_{12}O_2$. Compound 'A' also decolourises alkaline $KMnO_4$. The number of π bond/s present in the compound 'A' is _____.

Correct Answer: 4

Solution:

Step 1: Analyze the Structure of Compound 'A'

Given the molecular formula $C_{10}H_{12}O_2$, compound 'A' gives a positive neutral $FeCl_3$ test, indicating the presence of a phenolic (-OH) group. Compound 'A' also decolourises alkaline $KMnO_4$, indicating the presence of a double bond.

Step 2: Chemical Reactions of 'A'

- Treatment with NaOH and CH_3Br forms $C_{11}H_{14}O_2$, confirming the presence of a second hydroxyl group.
- Hydroiodic acid treatment yields methyl iodide, confirming the presence of an ether bond ($-OCH_3$).
- Hot NaOH treatment forms compound 'B', $C_{10}H_{12}O_2$, which retains a double bond.

Step 3: Determine the Number of π Bonds

The structure of compound 'A' contains:

- One aromatic benzene ring with three π bonds.

- One aliphatic double bond outside the aromatic ring.

Thus, the total number of π bonds in compound 'A' is:

$$\text{Number of } \pi \text{ bonds} = 3(\text{aromatic}) + 1(\text{aliphatic}) = 4.$$

Conclusion: The number of π bonds present in compound 'A' is **4**.

Quick Tip

For determining the number of π bonds in a compound, carefully analyze the structure, including aromatic and aliphatic double bonds. Utilize chemical reactions (e.g., $FeCl_3$ test, $KMnO_4$ decolourisation) to identify functional groups and confirm bond types.

---

30. Some amount of dichloromethane (CH_2Cl_2) is added to 671.141 mL of chloroform ($CHCl_3$) to prepare a 2.6×10^{-3} M solution of CH_2Cl_2 (DCM). The concentration of DCM is _____ ppm (by mass).

Given: Atomic mass C = 12, H = 1, Cl = 35.5, density of $CHCl_3 = 1.49\,\text{g cm}^{-3}$.

Correct Answer: 148 ppm

Solution:

Step 1: Calculate the Mass of CH_2Cl_2

Molarity (M) is related to the number of moles (n) and volume (V) by:

$$M = \frac{\text{moles of solute}}{\text{volume of solution (in L)}}.$$

Substitute the values:

$$2.6 \times 10^{-3} = \frac{x}{85 \times 0.671141}.$$

Solve for x:

$$x = 2.6 \times 10^{-3} \times 85 \times 0.671141 = 0.148\,\text{g}.$$

Step 2: Calculate Concentration in ppm

Concentration in ppm is given by:

$$\text{Concentration (ppm)} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 10^6.$$

The mass of the solution is:

$$\text{Mass of solution} = 671.141 \times 1.49 = 1000.00009\,\text{g}.$$

Thus:

$$\text{Concentration (ppm)} = \frac{0.148}{671.141 \times 1.49} \times 10^6.$$

$$\text{Concentration (ppm)} = \frac{0.148}{1000} \times 10^6 = 148\,\text{ppm}.$$

Conclusion: The concentration of CH_2Cl_2 is **148 ppm**.

Quick Tip

For ppm calculations, always express the solute's mass and the solution's total mass in the same units before substituting into the formula. Ensure proper unit conversions for accuracy.
