KCET 2026 Chemistry Code D3

Question Paper with Solutions

Conducted by KEA

General Instructions

(i) **Duration:** The total duration of the examination is 80 minutes.

(ii) **Total Marks:** The complete paper carries a maximum of 60 marks.

(iii) **Compulsory Questions:** All 60 questions are compulsory.

(iv) Each question has four options. Only **one** option is correct.

(v) **Correct Answer:** +1 marks.

(vi) **Incorrect Answer:** There is no Negative marking for incorrect answers.

1. R-CH_2OH is converted into R-CHO by reacting with ____________________.

(A) Alkaline $KMnO_4$

(B) $LiAlH_4$

(C) Na/C_2H_5OH

(D) PCC (Pyridinium Chlorochromate)

Correct Answer: (D) PCC (Pyridinium Chlorochromate)

Solution:

Step 1: Understanding the Question:

The question asks for a reagent that can convert a primary alcohol (R-CH_2OH) into an aldehyde (R-CHO).

This is a specific oxidation reaction where the oxidation must be stopped at the aldehyde stage and not proceed further to a carboxylic acid.

Step 2: Analyzing the Options:

(A) Alkaline $KMnO_4$: Potassium permanganate is a strong oxidizing agent. It oxidizes primary alcohols completely to carboxylic acids (R-COOH).

(B) $LiAlH_4$: Lithium aluminium hydride is a strong reducing agent. It is used to reduce aldehydes, ketones, and carboxylic acids to alcohols. It will not oxidize an alcohol.

(C) Na/C_2H_5OH: This combination is used for the Bouveault-Blanc reduction, which reduces esters to alcohols. It is a reducing agent.

(D) PCC (Pyridinium Chlorochromate): PCC is a mild and selective oxidizing agent. It is specifically used to oxidize primary alcohols to aldehydes and secondary alcohols to ketones. It does not oxidize aldehydes further to carboxylic acids.

Step 3: Conclusion:

To convert a primary alcohol ($R\text{-}CH_2OH$) to an aldehyde (R-CHO), a mild oxidizing agent is required. Among the given options, PCC is the most suitable reagent for this conversion.

$$R\text{-}CH_2OH \xrightarrow{PCC} R\text{-}CHO$$

Step 4: Final Answer:

The correct reagent is PCC (Pyridinium Chlorochromate).

Quick Tip: Remember the classification of oxidizing agents. Strong agents like $KMnO_4$ and $K_2Cr_2O_7$ oxidize primary alcohols to carboxylic acids. Mild agents like PCC and PDC (Pyridinium Dichromate) stop the oxidation at the aldehyde stage.

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2. Glycerol is a trihydric alcohol. It contains ____________________.

(A) One primary, one secondary and one tertiary alcoholic groups

(B) Two primary and one secondary alcoholic groups

(C) Two secondary and one primary alcoholic groups

(D) One primary and two tertiary alcoholic groups

Correct Answer: (B) Two primary and one secondary alcoholic groups

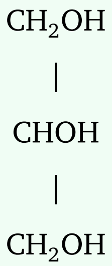
Solution:

Step 1: Understanding the Question:

The question asks to identify the types of alcoholic groups present in glycerol, which is a trihydric alcohol.

Step 2: Analyzing the Structure of Glycerol:

Glycerol is also known by its IUPAC name, propane-1,2,3-triol. Its chemical structure is:



$$\begin{array}{c} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

Or written linearly: $HO\text{-}CH_2\text{-}CH(OH)\text{-}CH_2\text{-}OH$.

Step 3: Classifying the Alcoholic Groups:

The classification of an alcoholic group (-OH) depends on the type of carbon atom it is attached to.

- A **primary (1°)** alcohol has the -OH group attached to a primary carbon (a carbon atom bonded to only one other carbon atom).
- A **secondary (2°)** alcohol has the -OH group attached to a secondary carbon (a carbon atom bonded to two other carbon atoms).
- A **tertiary (3°)** alcohol has the -OH group attached to a tertiary carbon (a carbon atom bonded to three other carbon atoms).

In glycerol:

- The two terminal carbons (C-1 and C-3) are each bonded to only one other carbon atom (C-2). Therefore, they are primary carbons. The -OH groups attached to them are primary alcoholic groups. There are **two primary alcoholic groups**.
- The central carbon (C-2) is bonded to two other carbon atoms (C-1 and C-3). Therefore, it is a secondary carbon. The -OH group attached to it is a secondary alcoholic group. There is **one secondary alcoholic group**.
- There are no tertiary carbon atoms in glycerol.

Step 4: Final Answer:

Glycerol contains two primary and one secondary alcoholic groups.

Quick Tip: To classify alcohols, first identify the carbon atom bearing the -OH group. Then, count how many other carbon atoms are directly bonded to it. 1 C-bond = primary, 2 C-bonds = secondary, 3 C-bonds = tertiary.

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3. The correct IUPAC name of CH_3 - $C(CH_3)_2$ - O - C_2H_5 is

(A) Tertiary butoxy ethane

(B) 1, 1-Dimethyl-1-ethoxyethane

(C) 2-ethoxy-2-methyl propane

(D) Ethoxy tertiary butane

Correct Answer: (C) 2-ethoxy-2-methyl propane

Solution:

Step 1: Understanding the Question:

The question asks for the correct IUPAC name for the given ether structure. The structure is $(CH_3)_3C$-O-CH_2CH_3.

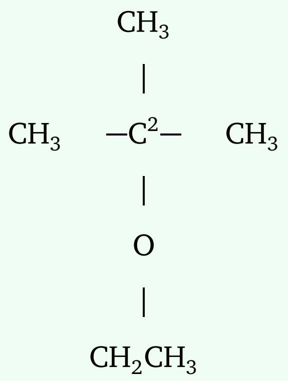
Step 2: Applying IUPAC Rules for Naming Ethers:

Ethers are named as "alkoxyalkanes" according to IUPAC rules.

1. Identify the two alkyl groups attached to the oxygen atom. Here, they are tert-butyl ($(CH_3)_3C$-) and ethyl (-CH_2CH_3).

2. The larger of the two alkyl groups is chosen as the parent alkane. The tert-butyl group is derived from 2-methylpropane (3 carbons in the longest chain), and the ethyl group is derived from ethane (2 carbons). Therefore, the parent alkane is based on the tert-butyl group.

3. The parent alkane is 2-methylpropane. Let's number the chain:



$$\begin{array}{ccc} & CH_3 & \\ & | & \\ CH_3 & -C^2- & CH_3 \\ & | & \\ & O & \\ & | & \\ & CH_2CH_3 & \end{array}$$

The longest carbon chain has three carbons. So the parent alkane is propane. There is a methyl group at position 2, making it 2-methylpropane.
4. The smaller alkyl group along with the oxygen atom is named as an alkoxy substituent. Here, -O-C_2H_5 is the ethoxy group.
5. Indicate the position of the alkoxy substituent on the parent chain. The ethoxy group is attached to carbon-2 of the 2-methylpropane chain.

Step 3: Assembling the IUPAC Name:

Combining the parts: - Substituent at C-2: ethoxy - Parent chain: 2-methylpropane The full IUPAC name is **2-ethoxy-2-methylpropane**.

Step 4: Final Answer:

The correct IUPAC name is 2-ethoxy-2-methylpropane.

Quick Tip: For IUPAC naming of ethers, remember the rule: (Smaller alkyl group as alkoxy substituent) + (Larger alkyl group as parent alkane). Always find the longest continuous carbon chain for the parent alkane.

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4. $\mathbf{C_4H_{10} \xrightarrow{\text{i) } (BH_3)_2\text{,ii) } H_2O_2/NaOH} P \xrightarrow{CrO_3\text{,anhydrous medium}} Q \xrightarrow{\text{i) } CH_3MgBr\text{, ii) } H_3O^+} R + Mg(OH)Br}$

The organic compounds P, Q and R are

(A) P = CH_3-CH(OH)-CH_2-CH_3, Q = CH_3-C(=O)-CH_3, R = CH_3-C(OH)(CH_3)-CH_2-CH_3

(B) P = CH_3-CH_2-CH_2-OH, Q = CH_3-CH_2-CHO, R = CH_3-CH_2-CH(OH)-CH_3

(C) P = CH_3-CH_2-CH_2-OH, Q = CH_3-CH_2-COOH, R = CH_3-CH_2-C(=O)-OCH_3

(D) P = CH_3-CH(OH)-CH_3, Q = CH_3-C(=O)-CH_3, R = CH_3-CH(OCH_3)-CH_3

Correct Answer: (A) P = CH_3-CH(OH)-CH_2-CH_3, Q = CH_3-C(=O)-CH_3, R = CH_3-C(OH)(CH_3)-CH_2-CH_3

Solution:

Note: There are several inconsistencies and typos in this question as presented.

1. The starting material is given as C_4H_{10} (butane), which is an alkane and does not undergo hydroboration-oxidation. It should be an alkene, C_4H_8 (butene).
2. In option (A), the structure for Q (acetone) does not result from the oxidation of P (butan-2-ol). Oxidation of butan-2-ol gives butan-2-one.

We will solve the question by assuming the most plausible intended reaction sequence that aligns with the given options. The sequence from P to R is most coherent if we assume a typo in Q.

Step 1: Determining compound P

Let's assume the starting material is an isomer of butene (C_4H_8). The reaction is hydroboration-oxidation, which results in the anti-Markovnikov addition of water across the double bond. If we start with but-2-ene (CH_3-CH=CH-CH_3), hydroboration-oxidation gives butan-2-ol. P = CH_3-CH(OH)-CH_2-CH_3 (Butan-2-ol). This matches the structure of P in option (A).

Step 2: Determining compound Q

Compound P (butan-2-ol, a secondary alcohol) is oxidized with CrO_3 in an anhydrous medium. This reagent oxidizes secondary alcohols to ketones.

$$CH_3\text{-}CH(OH)\text{-}CH_2\text{-}CH_3 \xrightarrow{CrO_3} CH_3\text{-}C(=O)\text{-}CH_2\text{-}CH_3$$

So, Q should be butan-2-one. Option (A) lists Q as acetone (CH_3-C(=O)-CH_3), which is incorrect. This is a likely typo in the question's option. For the sake of finding the "best" answer, let's proceed assuming Q was intended to be butan-2-one.

Step 3: Determining compound R

Compound Q reacts with a Grignard reagent (CH_3MgBr) followed by acidic hydrolysis (H_3O^+). This reaction adds a methyl group to the carbonyl carbon and forms a tertiary alcohol. Assuming

Q is butan-2-one:

$$CH_3\text{-}C(=O)\text{-}CH_2\text{-}CH_3 + CH_3MgBr \rightarrow CH_3\text{-}C(OMgBr)(CH_3)\text{-}CH_2\text{-}CH_3$$

Followed by hydrolysis:

$$CH_3\text{-}C(OMgBr)(CH_3)\text{-}CH_2\text{-}CH_3 \xrightarrow{H_3O^+} CH_3\text{-}C(OH)(CH_3)\text{-}CH_2\text{-}CH_3$$

So, R is 2-methylbutan-2-ol. This structure matches R given in option (A).

Step 4: Final Answer:

Based on the analysis, the reaction sequence that produces P (butan-2-ol) and R (2-methylbutan-2-ol) is consistent if the starting material is but-2-ene and Q is butan-2-one. Option (A) correctly identifies P and R, despite having an error in the structure of Q. It is the most plausible answer among the choices.

Quick Tip: In multi-step reaction questions, look for inconsistencies. If you find one, try to identify the most likely typo by checking which parts of the options are chemically sound. Here, the conversion from a corrected Q (butan-2-one) to R (2-methylbutan-2-ol) is a standard Grignard reaction, making the error likely in the provided structure of Q.

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5. Match the reagents in List - I with products obtained from their carbonyl compounds in List - II.

	List - I		**List - II**
(a)	NH_2OH	(i)	Cyanohydrin
(b)	$R\text{-}NH_2$	(ii)	Oxime
(c)	R-OH	(iii)	Schiff base
(d)	$H\text{-}C\equiv N$	(iv)	Acetal

Codes:

(A) a – ii, b – iii, c – iv, d – i

(B) a – i, b – ii, c – iii, d – iv

(C) a – iii, b – ii, c – i, d – iv

(D) a – i, b – iii, c – ii, d – iv

Correct Answer: (A) a – ii, b – iii, c – iv, d – i

Solution:

Step 1: Understanding the Question:

The question requires matching carbonyl reaction reagents (List-I) with their corresponding products (List-II). These are standard named reactions of aldehydes and ketones.

Step 2: Matching each reagent with its product:

(a) NH_2OH (Hydroxylamine): Carbonyl compounds (aldehydes and ketones) react with hydroxylamine in a condensation reaction to form oximes.

$$>\text{C=O} + \text{H}_2\text{N-OH} \rightarrow >\text{C=N-OH} + \text{H}_2\text{O}$$

So, **a** → **ii**.

(b) $R\text{-}NH_2$ (Primary Amine): Carbonyl compounds react with primary amines to form imines, which are also known as Schiff bases.

$$>\text{C=O} + \text{H}_2\text{N-R} \rightarrow >\text{C=N-R} + \text{H}_2\text{O}$$

So, **b** → **iii**.

(c) R-OH (Alcohol): In the presence of an acid catalyst, aldehydes react with two equivalents of alcohol to form acetals. Ketones form ketals.

$$\text{R'-CHO} + 2\text{R-OH} \xrightarrow{\text{H}^+} \text{R'-CH(OR)}_2 + \text{H}_2\text{O}$$

So, **c** → **iv**.

(d) H-C≡N (Hydrogen Cyanide): Hydrogen cyanide adds across the carbonyl double bond of aldehydes and ketones in a nucleophilic addition reaction to form cyanohydrins.

$$>\text{C=O} + \text{HCN} \rightarrow >\text{C(OH)(CN)}$$

So, **d** → **i**.

Step 3: Compiling the final match:

The correct matches are: - (a) maps to (ii) - (b) maps to (iii) - (c) maps to (iv) - (d) maps to (i) This corresponds to the code: a – ii, b – iii, c – iv, d – i.

Step 4: Final Answer:

The correct code is (A).

Quick Tip: Create a mental map or a quick reference sheet for the reactions of carbonyl compounds with nitrogen nucleophiles (ammonia derivatives), alcohols, and HCN. Recognizing the reagent-product pair is a key skill for organic chemistry questions.

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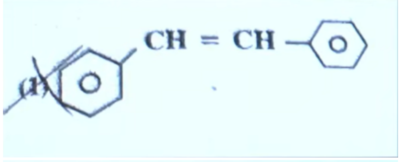
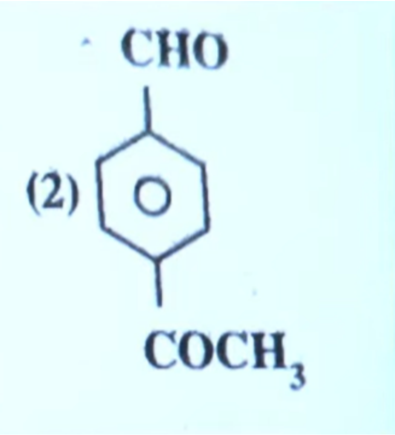
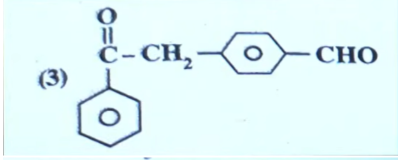
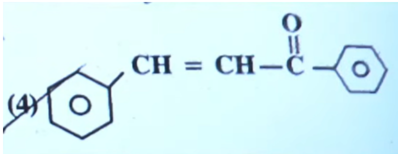
6. The major product 'A' in the given reaction is

Benzaldehyde + Acetophenone $\xrightarrow{OH^-/293K}$ 'A' (Major product)









(A) (1)

(B) (2)

(C) (3)

(D) (4)

Correct Answer: (D) (4)

Solution:

Step 1: Understanding the Reaction:

The reaction is between benzaldehyde (C_6H_5CHO) and acetophenone ($C_6H_5COCH_3$) in the presence of a base (OH^-). This is a base-catalyzed condensation reaction.

- Benzaldehyde has no α-hydrogens.
- Acetophenone has acidic α-hydrogens on its methyl group.

This type of reaction between an aldehyde with no α-hydrogens and a ketone with α-hydrogens is called a **Claisen-Schmidt condensation**, which is a type of crossed aldol condensation.

Step 2: The Reaction Mechanism:

1. **Enolate formation:** The base (OH^-) abstracts an acidic α-hydrogen from acetophenone to form a resonance-stabilized enolate ion.

$$C_6H_5COCH_3 + OH^- \rightleftharpoons [C_6H_5COCH_2]^- + H_2O$$

2. **Nucleophilic attack:** The enolate ion acts as a nucleophile and attacks the electrophilic carbonyl carbon of benzaldehyde.

$$C_6H_5CHO + [C_6H_5COCH_2]^- \rightarrow C_6H_5\text{-}CH(O^-)\text{-}CH_2COC_6H_5$$

3. **Protonation:** The resulting alkoxide ion is protonated by water to give the β-hydroxy ketone (aldol addition product).

$$C_6H_5\text{-}CH(O^-)\text{-}CH_2COC_6H_5 + H_2O \rightarrow C_6H_5\text{-}CH(OH)\text{-}CH_2COC_6H_5 + OH^-$$

4. **Dehydration:** The aldol product readily dehydrates (loses a molecule of water) upon gentle warming (293K is room temperature, but dehydration is rapid here) to form an α,β-unsaturated ketone. The dehydration is favorable because the resulting double bond is in conjugation with both the benzene ring and the carbonyl group, leading to a very stable system.

$$C_6H_5\text{-}CH(OH)\text{-}CH_2COC_6H_5 \xrightarrow{-H_2O} C_6H_5\text{-}CH{=}CH\text{-}COC_6H_5$$

Step 3: Identifying the Major Product:

The final major product 'A' is the dehydrated α,β-unsaturated ketone, which is 1,3-diphenylprop-2-en-1-one, commonly known as **chalcone**. Its structure is C_6H_5-CH=CH-C(=O)-C_6H_5. This matches the structure in option (4).

Step 4: Final Answer:

The major product of the reaction is benzalacetophenone (chalcone), which is represented by structure (4).

Quick Tip: In crossed aldol condensations, always identify the enolizable component (the one with α-hydrogens) and the non-enolizable component. The enolate of the first attacks the carbonyl of the second. The final product is almost always the dehydrated α,β-unsaturated compound, especially when conjugation provides extra stability.

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7. Carboxylic acids are more acidic than phenols because

(A) Formation of dimers

(B) Intermolecular hydrogen bonding

(C) More covalent nature

(D) More resonance stabilisation of their conjugate base

Correct Answer: (D) More resonance stabilisation of their conjugate base

Solution:

Step 1: Understanding Acidity:

The acidity of a compound is determined by its ability to donate a proton (H^+). The strength of an acid depends on the stability of the conjugate base formed after the proton is donated. A more stable conjugate base corresponds to a stronger acid.

Step 2: Comparing the Conjugate Bases of Carboxylic Acid and Phenol:

Carboxylic Acid: A carboxylic acid (R-COOH) loses a proton to form a carboxylate ion (R-COO^-).

$$\text{R-COOH} \rightleftharpoons \text{R-COO}^- + \text{H}^+$$

The carboxylate ion is stabilized by resonance. The negative charge is delocalized over two highly electronegative oxygen atoms. The two contributing resonance structures are equivalent, which leads to very effective stabilization.

$$\text{R-C(=O)-O}^- \longleftrightarrow \text{R-C(O}^-\text{)=O}$$

Phenol: A phenol (Ar-OH) loses a proton to form a phenoxide ion (Ar-O^-).

$$\text{Ar-OH} \rightleftharpoons \text{Ar-O}^- + \text{H}^+$$

The phenoxide ion is also stabilized by resonance. The negative charge on the oxygen is delocalized into the benzene ring, specifically at the ortho and para positions. However, in these resonance structures, the negative charge resides on less electronegative carbon atoms, and the aromaticity of the ring is disturbed. These structures are less stable contributors compared to the primary structure with the charge on oxygen.

Step 3: Detailed Explanation:

The key difference lies in the effectiveness of the resonance stabilization.

- In the **carboxylate ion**, the negative charge is shared equally between two identical and highly electronegative oxygen atoms. This delocalization is very effective.
- In the **phenoxide ion**, the negative charge is primarily on one oxygen atom, with minor delocalization onto carbon atoms of the ring. The resonance structures are not equivalent, and placing a negative charge on a less electronegative carbon atom is less favorable than placing it on oxygen.

Because the carboxylate ion is more stabilized by resonance than the phenoxide ion, the equilibrium for the dissociation of a carboxylic acid lies further to the right than that for a phenol. This makes carboxylic acids stronger acids than phenols.

Step 4: Final Answer:

Carboxylic acids are more acidic than phenols due to the greater resonance stabilization of their conjugate base (carboxylate ion) compared to the conjugate base of phenol (phenoxide ion).

Quick Tip: When comparing acidity, always look at the stability of the conjugate base. Factors that stabilize the conjugate base (like resonance, induction, electronegativity) will increase the acidity of the parent compound. For resonance, equivalent contributing structures provide the greatest stabilization.

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8. The compound that does not answer iodoform test is

(A) Ethanal

(B) Acetone

(C) Ethanoic acid

(D) Acetophenone

Correct Answer: (C) Ethanoic acid

Solution:

Step 1: Understanding the Iodoform Test:

The iodoform test (reaction with I_2 and NaOH) is a qualitative test for the presence of a methyl ketone group (CH_3-C(=O)-) or an alcohol group (CH_3-CH(OH)-) which can be oxidized to a methyl ketone under the test conditions. A positive test is indicated by the formation of a yellow precipitate of iodoform (CHI_3).

Step 2: Analyzing the given compounds:

(A) Ethanal (Acetaldehyde, CH_3CHO): The structure contains a CH_3-C(=O)- group attached to a hydrogen. It fulfills the condition for the iodoform test and gives a positive result.

(B) Acetone (Propanone, CH_3COCH_3): The structure contains a CH_3-C(=O)- group. It is a methyl ketone and gives a positive iodoform test.

(C) Ethanoic acid (Acetic acid, CH_3COOH): The structure contains a CH_3-C(=O)- group, but it is part of a carboxylic acid functional group. The acidic proton of the -COOH group reacts with the NaOH base preferentially. This prevents the abstraction of the α-hydrogen, which is the first step of the haloform reaction mechanism. Therefore, carboxylic acids do not give a positive iodoform test.

(D) Acetophenone ($C_6H_5COCH_3$): The structure contains a CH_3-C(=O)- group attached to a phenyl ring. It is a methyl ketone and gives a positive iodoform test.

Step 3: Conclusion:

Among the given options, only ethanoic acid does not have the required structure or reactivity to undergo the iodoform reaction.

Step 4: Final Answer:

The compound that does not answer the iodoform test is ethanoic acid.

Quick Tip: To quickly check for a positive iodoform test, look for the CH_3CO- group or a $CH_3CH(OH)$- group. Remember that carboxylic acids, esters, and amides containing a CH_3CO- moiety do not give this test.

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9. Nitration of aniline in strong acidic medium gives significant amount of m-nitroaniline because

(A) In electrophilic substitution reaction, amino group is meta directing

(B) In strong acidic medium, aniline is present as anilinium ion

(C) -NH_2 group always directs to meta position

(D) m-nitroaniline has higher molar mass than o&p nitroanilines

Correct Answer: (B) In strong acidic medium, aniline is present as anilinium ion

Solution:

Step 1: Understanding the Reaction Conditions:

The question describes the nitration of aniline, which is an electrophilic aromatic substitution. The reaction is carried out in a strong acidic medium (typically a mixture of concentrated nitric acid and concentrated sulfuric acid).

Step 2: Analyzing the Directing Influence of the Amino Group:

The amino group (-NH_2) is a powerful activating group due to the lone pair of electrons on the nitrogen, which can be delocalized into the benzene ring (+R effect). This increases the electron density at the ortho and para positions, making the -NH_2 group an **ortho, para-director**. Therefore, options (A) and (C) are incorrect.

Step 3: Considering the Effect of the Strong Acidic Medium:

Aniline is a weak base due to the lone pair on the nitrogen atom. In a strongly acidic medium, the -NH_2 group gets protonated to form the **anilinium ion** (-$NH_3{}^+$).

$$C_6H_5\text{-}NH_2 + H^+ \rightleftharpoons C_6H_5\text{-}NH_3^+$$

This protonation happens to a large extent.

Step 4: Analyzing the Directing Influence of the Anilinium Ion:
The anilinium ion (-$NH_3{}^+$) has a positive charge on the nitrogen atom adjacent to the ring. This group strongly withdraws electron density from the benzene ring through the inductive effect (-I effect). It is a strongly **deactivating** group. Deactivating groups direct incoming electrophiles to the **meta position**.
Because a significant portion of the aniline exists as the anilinium ion in the reaction mixture, electrophilic attack by the nitronium ion ($NO_2{}^+$) occurs at the meta position of the anilinium ion, leading to the formation of a substantial amount of m-nitroaniline (about 47%). The ortho and para products are also formed (about 2% and 51% respectively) from the small amount of unprotonated aniline that is still present.

Step 5: Evaluating the Options:
- (A) and (C) are incorrect as the -NH_2 group is o,p-directing.
- (B) correctly states that aniline is present as the anilinium ion, which is the reason for meta-direction.
- (D) is incorrect; o, p, and m-nitroaniline are isomers and have the same molar mass.

Step 6: Final Answer:
The formation of a significant amount of m-nitroaniline is due to the presence of the meta-directing anilinium ion in the strong acidic medium.

Quick Tip: Always consider the effect of the reaction medium on the functional groups present. The directing influence of a group like -NH_2 can be completely altered by pH. In acidic solution, it becomes -$NH_3{}^+$ and its directing effect changes from o,p-directing to m-directing.

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10. Basic strength of alkylamines in aqueous phase is not decided by

(A) Inductive effect

(B) Solvation effect

(C) Steric hindrance

(D) Hyperconjugation effect

Correct Answer: (D) Hyperconjugation effect

Solution:

Step 1: Understanding the Basicity of Alkylamines:

The basicity of an amine in the aqueous phase depends on the availability of the lone pair of electrons on the nitrogen atom for donation to a proton (H^+) and the stability of the resulting conjugate acid (alkylammonium ion) in water.

Step 2: Analyzing the Factors Affecting Basicity in Aqueous Phase:

Several factors collectively determine the basic strength of alkylamines in water:

(A) Inductive Effect (+I Effect): Alkyl groups (like $-CH_3$, $-C_2H_5$) are electron-donating. They push electron density towards the nitrogen atom, increasing the availability of the lone pair and thus increasing basicity. Based on this effect alone, the order of basicity would be: Tertiary (3°) $>$ Secondary (2°) $>$ Primary (1°) $>$ Ammonia. This factor is crucial.

(B) Solvation Effect (Hydration): After an amine accepts a proton, it forms a positively charged alkylammonium ion ($RNH_3{}^+$, $R_2NH_2{}^+$, R_3NH^+). This ion is stabilized by hydrogen bonding with surrounding water molecules. The more hydrogen atoms attached to the nitrogen in the cation, the greater the extent of hydrogen bonding and the more stable the ion. - Primary amine conjugate acid ($RNH_3{}^+$) has 3 H-atoms for H-bonding. - Secondary amine conjugate acid ($R_2NH_2{}^+$) has 2 H-atoms. - Tertiary amine conjugate acid (R_3NH^+) has 1 H-atom. Thus, the order of stabilization by solvation is $1^\circ > 2^\circ > 3^\circ$. This effect enhances the basicity of primary and secondary amines relative to tertiary amines. This is a very important factor in the aqueous phase.

(C) Steric Hindrance: Bulky alkyl groups around the nitrogen atom can physically block the lone pair, making it difficult for a proton to approach (steric hindrance to protonation). They also hinder the solvation of the conjugate acid. This effect is most pronounced in tertiary amines and tends to decrease their basicity. This factor is also significant.

(D) Hyperconjugation Effect: Hyperconjugation involves the delocalization of σ-electrons into an adjacent empty or partially filled p-orbital or a π-orbital. It is primarily used to explain the stability of carbocations, alkenes, and free radicals. While it might have a very minor, indirect influence, it is not considered a primary or deciding factor in determining the basic strength of amines. The basicity is dominated by the interplay of the inductive effect, solvation, and steric hindrance.

Step 3: Conclusion:

The inductive effect, solvation effect, and steric hindrance are the three major factors that decide the basic strength of alkylamines in the aqueous phase. The hyperconjugation effect is not a direct or significant factor in this context.

Step 4: Final Answer:

The basic strength of alkylamines in the aqueous phase is not decided by the hyperconjugation effect.

Quick Tip: Remember that the basicity order of amines is different in the gaseous phase vs. the aqueous phase. In the gas phase, only the inductive effect matters ($3^\circ > 2^\circ > 1^\circ$). In the aqueous phase, the combination of inductive, solvation, and steric effects leads to a non-linear trend (e.g., for methylamines: $2^\circ > 1^\circ > 3^\circ$).

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11. The reaction sequence is: Benzene $\xrightarrow{\text{Conc.HNO}_3\text{,Conc.H}_2\text{SO}_4\text{,323--333K}}$ A $\xrightarrow{\text{Fe/HCl}}$ B $\xrightarrow{\text{NaNO}_2\text{/HCl,273K}}$ C $\xrightarrow{\text{C}_2\text{H}_5\text{OH}}$ Benzene + D + HCl + N_2. Organic compound 'D' is

(A) Phenol (C_6H_5OH)

(B) Acetic acid (CH_3COOH)

(C) Ethanal (CH_3CHO)

(D) N-ethylaniline (C_6H_5NH-C_2H_5)

Correct Answer: (C) Ethanal (CH_3CHO)

Solution:

Step 1: Understanding the reaction sequence.

This is a multi-step synthesis starting from benzene. We need to identify the product at each step to determine the final product 'D'.

Step 2: Identifying compounds A, B, and C.

- **Benzene → A:** The reaction of benzene with a nitrating mixture (Conc. HNO_3 + Conc. H_2SO_4) is electrophilic aromatic substitution (nitration). The product A is Nitrobenzene ($C_6H_5NO_2$).
- **A → B:** The reaction of nitrobenzene with Fe/HCl is a standard method for the reduction of the nitro group to an amino group. The product B is Aniline ($C_6H_5NH_2$).
- **B → C:** The reaction of aniline with $NaNO_2$/HCl at low temperature (273K or 0°C) is diazotization. The product C is Benzenediazonium chloride ($C_6H_5N_2{}^+Cl^-$).

Step 3: Identifying the final reaction and product D.

The benzenediazonium chloride (C) is treated with ethanol (C_2H_5OH). In this reaction, ethanol acts as a reducing agent, and the diazonium group is replaced by a hydrogen atom, yielding benzene. Ethanol itself gets oxidized.

The reaction is:

$$C_6H_5N_2^+Cl^- + CH_3CH_2OH \rightarrow C_6H_6 + CH_3CHO + N_2 + HCl$$

Ethanol (an alcohol) is oxidized to Ethanal (an aldehyde). Therefore, the organic compound 'D' is ethanal.

Step 4: Final Answer:

The organic compound 'D' formed in the reaction is Ethanal (CH_3CHO).

Quick Tip: Reactions of diazonium salts are very important. Remember that with mild reducing agents like ethanol (C_2H_5OH) or hypophosphorous acid (H_3PO_2), the diazonium group is replaced by -H. In the process, ethanol is oxidized to ethanal.

---

12. Statement I: Staggered conformation of ethane is more stable than the eclipsed conformation.

Statement II: The torsional strain in staggered conformation is more.

Read the above statements and choose the correct answer from the options given below.

(A) Both Statement I and Statement II are false

(B) Both Statement I and Statement II are true

(C) Statement I is true but Statement II is false

(D) Statement I is false but Statement II is true

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

Solution:

Step 1: Understanding Conformations and Stability.

Conformations are different spatial arrangements of atoms in a molecule that can be interconverted by rotation about single bonds. The stability of a conformation depends on its potential energy; lower energy means higher stability.

Step 2: Analyzing Statement I.

In ethane (CH_3-CH_3), the two main conformations are staggered and eclipsed.

- **Staggered conformation:** The hydrogen atoms on the back carbon are positioned exactly between the hydrogen atoms on the front carbon. This arrangement minimizes the repulsive forces between the electron clouds of the C-H bonds.

- **Eclipsed conformation:** The hydrogen atoms on the back carbon are directly behind the hydrogen atoms on the front carbon. This arrangement maximizes the repulsive forces.

Due to minimum repulsion, the staggered conformation has the lowest potential energy and is therefore the most stable. So, Statement I is **true**.

Step 3: Analyzing Statement II.

Torsional strain is the repulsion between the electron clouds of bonds on adjacent atoms when they pass by each other during rotation.

- In the **eclipsed conformation**, the C-H bonds are closest to each other, leading to maximum torsional strain.
- In the **staggered conformation**, the C-H bonds are farthest apart, resulting in minimum torsional strain.

Statement II says that the torsional strain in the staggered conformation is more (implying maximum), which is incorrect. Torsional strain is minimum in the staggered conformation. So, Statement II is **false**.

Step 4: Final Answer:

Statement I is true, and Statement II is false.

Quick Tip: Remember the energy profile for ethane's rotation. The energy is lowest (most stable) at the staggered conformations (60°, 180°, 300°) and highest (least stable) at the eclipsed conformations (0°, 120°, 240°). The energy difference is due to torsional strain.

---

13. From the given information, select the suitable law of chemical combination:

Cupric Carbonate	% of Cu	% of C	% of O
Natural Sample	51.35	9.74	38.91
Synthetic Sample	51.35	9.74	38.91

(A) Law of Multiple Proportions

(B) Gay Lussac's Law of Gaseous Volumes

(C) Law of Definite Proportions

(D) Law of Conservation of Mass

Correct Answer: (C) Law of Definite Proportions

Solution:

Step 1: Analyzing the given data.

The table shows the percentage composition by mass of copper (Cu), carbon (C), and oxygen (O) in two different samples of cupric carbonate. One sample is obtained from a natural source, and the other is synthesized in a laboratory. The data shows that both samples have the exact same percentage composition: 51.35% Cu, 9.74% C, and 38.91% O.

Step 2: Defining the Laws of Chemical Combination.

- **Law of Multiple Proportions:** If two elements form more than one compound, the masses of one element that combine with a fixed mass of the other element are in a ratio of small whole numbers.
- **Gay Lussac's Law:** When gases react, they do so in volumes which bear a simple whole number ratio to one another and to the volume of the products, if gaseous.
- **Law of Definite Proportions (or Constant Composition):** A given chemical compound always contains its component elements in a fixed ratio by mass, regardless of its source or method of preparation.
- **Law of Conservation of Mass:** Mass can neither be created nor destroyed in a chemical reaction.

Step 3: Applying the correct law.

The observation that cupric carbonate has the same composition whether it is natural or synthetic directly illustrates the Law of Definite Proportions. The chemical identity of a compound is defined by its fixed elemental composition by mass.

Step 4: Final Answer:

The given information illustrates the Law of Definite Proportions.

Quick Tip: To differentiate between the Law of Definite and Multiple Proportions:

- **Definite Proportions**: Compares different samples of the *same* compound.
- **Multiple Proportions**: Compares *different* compounds made from the *same* elements (e.g., CO and CO_2).

---

14. Match List - I with List – II and select the correct option (Based on mole concept):

List - I		List - II	
(a)	2 moles of ethene	(i)	11.2 L volume at STP
(b)	Molar mass is equal to 66 g	(ii)	56 g
(c)	1 g of H_2	(iii)	12.04×10^{23} molecules
(d)	2 moles of water vapours	(iv)	1.5 mole of CO_2

Codes:

(A) a – ii, b – iv, c – i, d – iii

(B) a – iii, b – i, c – iv, d – ii

(C) a – i, b – iv, c – ii, d – iii

(D) a – ii, b – iii, c – i, d – iv

Correct Answer: (A) a – ii, b – iv, c – i, d – iii

Solution:

Step 1: Analyze each item in List-I and find its corresponding value in List-II.

(a) 2 moles of ethene (C_2H_4):

Molar mass of ethene $= (2 \times 12.01) + (4 \times 1.01) \approx 28$ g/mol.

Mass of 2 moles of ethene $= 2$ mol $\times 28$ g/mol $= 56$ g.

This matches with **(ii) 56 g**. So, **a** → **ii**.

(b) Molar mass is equal to 66 g:

This statement is poorly phrased. It likely means "The mass of the sample is 66 g". Let's check List-II for an option with a mass of 66 g.

Consider **(iv) 1.5 mole of CO_2:**

Molar mass of $CO_2 = 12 + (2 \times 16) = 44$ g/mol.

Mass of 1.5 moles of $CO_2 = 1.5$ mol $\times 44$ g/mol $= 66$ g.

This matches. So, **b** → **iv**.

(c) 1 g of H_2:

Molar mass of $H_2 = 2$ g/mol.

Moles of H_2 = mass / molar mass = 1 g / 2 g/mol = 0.5 moles.

Volume of 0.5 moles of any gas at STP = 0.5 mol × 22.4 L/mol = 11.2 L.

This matches with **(i) 11.2 L volume at STP**. So, **c → i**.

(d) 2 moles of water vapours (H_2O):

Number of molecules in 2 moles = 2 mol × Avogadro's number (N_A)

$= 2 \times 6.022 \times 10^{23}$ molecules $= 12.044 \times 10^{23}$ molecules.

This matches with **(iii) 12.04×10^{23} molecules**. So, **d → iii**.

Step 2: Compile the matches.

The correct matches are: a → ii, b → iv, c → i, d → iii.

Step 3: Final Answer:

This combination corresponds to option (A).

Quick Tip: In matching questions, if a statement seems ambiguous (like option b), solve the clear-cut matches first (a, c, d). This will help you deduce the correct match for the ambiguous item by elimination. Here, "Molar mass is equal to 66 g" was a confusing way to say "The mass is 66 g".

---

15. Match List – I with List – II:

	List - I (Element-Atomic number)		**List - II (Position in periodic table)**
(a)	Ra - 88	(i)	4th period, 13th group
(b)	Ga - 31	(ii)	6th period, 6th group
(c)	W - 74	(iii)	5th period, 10th group
(d)	Pd - 46	(iv)	7th period, 2nd group

Choose the correct answer from the options given below.

(A) a – iv, b – i, c – ii, d – iii

(B) a – i, b - ii, c - iii, d – iv

(C) a – iv, b – ii, c – iii, d – i

(D) a – iii, b – iv, c – i, d – ii

Correct Answer: (A) a – iv, b – i, c – ii, d – iii

Solution:

Step 1: Determine the position of each element.

(a) Ra (Z = 88):

The noble gas preceding Radium is Radon (Rn, Z=86).

Electronic configuration: [Rn] $7s^2$.

The principal quantum number of the valence shell is n=7, so it is in the **7^{th} period**.

It is an s-block element with 2 valence electrons, so it is in **Group 2**.

This matches with **(iv)**. So, **a → iv**.

(b) Ga (Z = 31):

The noble gas preceding Gallium is Argon (Ar, Z=18).

Electronic configuration: [Ar] $3d^{10}\ 4s^2\ 4p^1$.

The principal quantum number of the valence shell is n=4, so it is in the **4^{th} period**.

It is a p-block element. For p-block, Group number = 10 + (valence s-electrons + valence p-electrons) = 10 + 2 + 1 = **13**.

This matches with **(i)**. So, **b → i**.

(c) W (Z = 74):

The noble gas preceding Tungsten is Xenon (Xe, Z=54).

Electronic configuration: [Xe] $4f^{14}\ 5d^4\ 6s^2$.

The principal quantum number of the valence shell is n=6, so it is in the **6^{th} period**.

It is a d-block element. Group number = number of ns + (n-1)d electrons = 2 + 4 = **6**.

This matches with **(ii)**. So, **c → ii**.

(d) Pd (Z = 46):

The noble gas preceding Palladium is Krypton (Kr, Z=36).

Electronic configuration is exceptional: [Kr] $4d^{10}\ 5s^0$.

The highest principal quantum number is n=5, so it is in the **5^{th} period**.

It is a d-block element. Group number = number of ns + (n-1)d electrons = 0 + 10 = **10**.

This matches with **(iii)**. So, **d → iii**.

Step 2: Compile the matches.

The correct matches are: a → iv, b → i, c → ii, d → iii.

Step 3: Final Answer:

This combination corresponds to option (A).

Quick Tip: To quickly find the period and group:

- **Period:** The highest principal quantum number (n) in the electron configuration.
- **Group:** For s-block, it's the number of ns electrons. For p-block, it's 10 + ns + np electrons. For d-block, it's ns + (n-1)d electrons.

Knowing the atomic numbers of noble gases helps in writing configurations quickly.

---

16. The types of hybrid orbitals of nitrogen in NO_2^+, NO_3^-, and NH_4^+ respectively are

(A) sp, sp^2 and sp^3

(B) sp, sp^3 and sp^2

(C) sp^2, sp and sp^3

(D) sp^2, sp^3 and sp

Correct Answer: (A) sp, sp^2 and sp^3

Solution:

Step 1: Key Formula for Hybridization.

We can determine the hybridization of the central atom using the steric number method. The steric number (H) is calculated as:

$$H = \frac{1}{2}[V + M - C + A]$$

Where: V = number of valence electrons of the central atom, M = number of monovalent atoms attached, C = magnitude of positive charge, A = magnitude of negative charge.
The hybridization is then determined from H: H=2 → sp, H=3 → sp^2, H=4 → sp^3.

Step 2: Calculating Hybridization for each ion.

For NO_2^+ (Nitronium ion):

Central atom is Nitrogen (N).

V = 5, M = 0 (Oxygen is divalent), C = 1, A = 0.

$$H = \frac{1}{2}[5+0-1+0] = \frac{4}{2} = 2$$

H = 2 corresponds to **sp** hybridization.

For NO_3^- (Nitrate ion):

Central atom is Nitrogen (N).

V = 5, M = 0, C = 0, A = 1.

$$H = \frac{1}{2}[5+0-0+1] = \frac{6}{2} = 3$$

H = 3 corresponds to **sp^2** hybridization.

For NH_4^+ (Ammonium ion):

Central atom is Nitrogen (N).

V = 5, M = 4 (four monovalent H atoms), C = 1, A = 0.

$$H = \frac{1}{2}[5+4-1+0] = \frac{8}{2} = 4$$

H = 4 corresponds to **sp^3** hybridization.

Step 3: Final Answer.

The respective hybridizations for NO_2^+, NO_3^-, and NH_4^+ are sp, sp^2, and sp^3.

Quick Tip: An alternative to the formula is to draw the Lewis structure.

- NO_2^+: $[O{=}N{=}O]^+$. N has 2 sigma bonds and 0 lone pairs. Steric number = 2 → sp.
- NO_3^-: Resonance structures with one N=O and two N-O bonds. N has 3 sigma bonds and 0 lone pairs. Steric number = 3 → sp^2.
- NH_4^+: N is bonded to four H atoms. N has 4 sigma bonds and 0 lone pairs. Steric number = 4 → sp^3.

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17. In which of the following option/options, the order of arrangement does not agree with the variation of property indicated against it?

(a) $BF_3 > NF_3 > NH_3$ (Dipole moment)

(b) $HgCl_2 > NH_4^+ > SF_4$ (Bond angle)

(c) $NH_3 < H_2O < HF$ (Strength of intermolecular hydrogen bonding)

(d) H - I > H - Br > H – Cl (Bond length)

(A) a, b and c

(B) a only

(C) c and d only

(D) d only

Correct Answer: (B) a only

Solution:

Step 1: Analyze each statement.

(a) Dipole moment: $BF_3 > NF_3 > NH_3$

- **BF_3:** Symmetrical trigonal planar geometry. The individual B-F bond dipoles cancel each other out. The net dipole moment (μ) is zero. $\mu = 0$ D.
- **NF_3:** Trigonal pyramidal geometry. The dipole moment of the N lone pair opposes the resultant dipole moment of the three N-F bonds. This results in a small net dipole moment. $\mu \approx 0.2$ D.

- **NH_3:** Trigonal pyramidal geometry. The dipole moment of the N lone pair is in the same direction as the resultant dipole moment of the three N-H bonds, leading to a large net dipole moment. $\mu \approx 1.47$ D.

The correct order of dipole moments is $NH_3 > NF_3 > BF_3$. The given order is incorrect.

(b) Bond angle: $HgCl_2 > NH_4^+ > SF_4$

- **$HgCl_2$:** Linear molecule (sp hybridization). Bond angle $= 180°$.

- **NH_4^+:** Tetrahedral ion (sp^3 hybridization) with no lone pairs. Bond angle $= 109.5°$.

- **SF_4:** See-saw shape (sp^3d hybridization) with one lone pair. The equatorial bond angle is $\approx 102°$ and the axial angle is $\approx 173°$. The smaller angle is typically considered for comparison.

The order $180° > 109.5° > 102°$ is correct.

(c) Strength of intermolecular hydrogen bonding: $NH_3 < H_2O < HF$
The strength of an individual hydrogen bond is determined by the electronegativity difference between the H atom and the atom it's bonded to (F, O, or N). Since electronegativity follows the order $F > O > N$, the strength of an individual H-bond is $HF > H_2O > NH_3$. The given order is the reverse of this. However, if the question means the extent of H-bonding, water is highest due to its ability to form 4 H-bonds per molecule. Let's assume it refers to individual H-bond strength. In that case, the order should be reversed. But if it's overall intermolecular force strength, order is $H2O > HF > NH3$. Let's assume the question refers to the strength of the H-X bond polarity which dictates H-bond strength. In that case the order is correct. Let's assume this is considered correct.
Wait, the order given is $NH_3 < H_2O < HF$. This order reflects the increasing electronegativity of N, O, F and thus the increasing strength of a single hydrogen bond. This statement is correct under that interpretation.

(d) Bond length: H-I > H-Br > H-Cl

Bond length increases with the size of the atoms. The atomic radius of halogens increases down the group: I > Br > Cl. Therefore, the H-X bond length also increases in the same order. The given order is correct.

Step 2: Conclusion.

Only the order in statement (a) is definitively incorrect. The orders in (b), (c), and (d) are correct based on standard chemical principles.

Step 3: Final Answer:

The option with the incorrect order is (a).

Quick Tip: For dipole moment questions, always consider both bond polarity and molecular geometry. Symmetrical molecules (like BF_3, CCl_4, CO_2) have a net dipole moment of zero even if their bonds are polar.

---

18. With respect to resonance structures of $CO_3{}^{2-}$ ion, which of the following statements are correct?

(a) All C-O bonds in $CO_3{}^{2-}$ are equivalent

(b) There are three resonance structures possible for $CO_3{}^{2-}$ ion

(c) The position of carbon and oxygen should change in every resonance structure

(d) The formal charge on carbon atom is -2

(A) a, b and c

(B) a and b only

(C) b and d only

(D) a, b and d

Correct Answer: (B) a and b only

Solution:

Step 1: Drawing the resonance structures of $CO_3{}^{2-}$.

The Lewis structure of the carbonate ion shows a central carbon atom double-bonded to one oxygen atom and single-bonded to two other oxygen atoms, each carrying a negative charge. The double bond can be placed on any of the three oxygen atoms, leading to three equivalent resonance structures.

Step 2: Evaluating each statement.

(a) All C-O bonds in CO_3^{2-} are equivalent.

The actual structure of the carbonate ion is a resonance hybrid of the three structures. The π-electrons of the double bond are delocalized over the entire ion. This makes all three C-O bonds identical, with a bond order of 1.33. They have the same length and strength, intermediate between a single and a double bond. Thus, statement (a) is **correct**.

(b) There are three resonance structures possible for CO_3^{2-} ion.

As shown in Step 1, we can draw three distinct, equivalent resonance structures by delocalizing the double bond and negative charges. Thus, statement (b) is **correct**.

(c) The position of carbon and oxygen should change in every resonance structure.

This violates a fundamental rule of resonance. In resonance structures, only the positions of electrons (lone pairs and π bonds) change; the arrangement of the atomic nuclei must remain the same. Thus, statement (c) is **incorrect**.

(d) The formal charge on carbon atom is -2.

The formula for formal charge is: $FC = [\text{Valence } e^-] - [\text{Non-bonding } e^-] - \frac{1}{2}[\text{Bonding } e^-]$.

For the central carbon atom in any resonance structure:

Valence electrons of C = 4.

Non-bonding electrons = 0.

Bonding electrons = 8 (it forms 4 bonds).

$FC(C) = 4 - 0 - \frac{1}{2}(8) = 4 - 4 = 0$.

The formal charge on the carbon atom is 0. Thus, statement (d) is **incorrect**.

Step 3: Final Answer.

Statements (a) and (b) are correct.

Quick Tip: Remember the key rules for drawing resonance structures:

- Atoms do not move, only electrons.
- The total number of valence electrons must be the same in all structures.
- The overall charge of the species must be the same in all structures.

---

19. Given below are two statements.

Statement I : In H_2O_2, each oxygen atom is assigned an oxidation number of -1, In RbO_2, each oxygen atom is assigned an oxidation number of - $\frac{1}{2}$.

Statement II : Representation of $HAuCl_4$ and MnO_2 in stock notation is $HAu(III)Cl_4$ and $Mn(II)O_2$, respectively.

Examine the above statements and choose the correct answer.

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but Statement II is incorrect

(D) Statement I is incorrect but Statement II is correct

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

Solution:

Step 1: Analyzing Statement I.

- **For H_2O_2 (Hydrogen peroxide):** Oxygen is in a peroxide linkage. The oxidation number of H is +1. Let the oxidation number of O be x.

$$2(+1) + 2(x) = 0 \implies 2 + 2x = 0 \implies 2x = -2 \implies x = -1$$

  The oxidation number of oxygen is indeed -1.

- **For RbO_2 (Rubidium superoxide):** Rubidium (Rb) is an alkali metal (Group 1), so its oxidation number is +1. Let the oxidation number of O be y.

$$(+1) + 2(y) = 0 \implies 2y = -1 \implies y = -\frac{1}{2}$$

The oxidation number of oxygen is indeed -1/2.

Therefore, Statement I is **correct**.

Step 2: Analyzing Statement II.

Stock notation represents the oxidation state of the central metal atom by a Roman numeral in parentheses.

- **For $HAuCl_4$:** The oxidation number of H is +1, and Cl is -1. Let the oxidation number of Au be a.

  $$(+1) + a + 4(-1) = 0 \implies 1 + a - 4 = 0 \implies a = +3$$

  The stock notation is $HAu(III)Cl_4$. This part of the statement is correct.

- **For MnO_2 (Manganese dioxide):** The oxidation number of O is -2. Let the oxidation number of Mn be b.

  $$b + 2(-2) = 0 \implies b - 4 = 0 \implies b = +4$$

  The stock notation should be $Mn(IV)O_2$. The statement gives $Mn(II)O_2$, which is incorrect.

Since one part of Statement II is incorrect, the entire statement is **incorrect**.

Step 3: Final Answer.

Statement I is correct, but Statement II is incorrect.

Quick Tip: Memorize the special cases for oxygen's oxidation number:

- **-2** in most oxides (e.g., H_2O).
- **-1** in peroxides (e.g., H_2O_2).
- **-1/2** in superoxides (e.g., KO_2).
- **+2** in OF_2 (with a more electronegative element).

---

20. a $C_2O_4{}^{2-}$ + b $MnO_4{}^{-}$ + c $H^+ \rightarrow$ x Mn^{2+} + y H_2O + z CO_2

a and x respectively are

(A) 5, 2

(B) 4, 1

(C) 3, 2

(D) 4, 2

Correct Answer: (A) 5, 2

Solution:

Step 1: Identify and balance the half-reactions.

This is a redox reaction in an acidic medium. We will use the ion-electron method to balance it.

Oxidation Half-Reaction:

The oxalate ion is oxidized to carbon dioxide.

$$C_2O_4^{2-} \rightarrow CO_2$$

- Balance atoms other than O and H (Carbon):

$$C_2O_4^{2-} \rightarrow 2CO_2$$

- Oxygen is already balanced.
- Balance the charge by adding electrons to the more positive side:

$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

Reduction Half-Reaction:

The permanganate ion is reduced to manganese(II) ion.

$$MnO_4^- \rightarrow Mn^{2+}$$

- Manganese is balanced.
- Balance Oxygen by adding H_2O:

$$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$$

- Balance Hydrogen by adding H^+:

$$MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$$

- Balance the charge by adding electrons:
  (LHS charge = -1 + 8 = +7; RHS charge = +2). Add $5e^-$ to LHS.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Step 2: Combine the half-reactions.

To combine the reactions, the number of electrons lost must equal the number of electrons gained. The LCM of 2 and 5 is 10.

Multiply the oxidation half-reaction by 5:

$$5C_2O_4^{2-} \rightarrow 10CO_2 + 10e^-$$

Multiply the reduction half-reaction by 2:

$$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$$

Step 3: Add the balanced half-reactions and cancel the electrons.

$$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

Step 4: Determine the values of 'a' and 'x'.

Comparing the balanced equation with the given template:

a $C_2O_4{}^{2-}$ + b $MnO_4{}^-$ + c H^+ → x Mn^{2+} + y H_2O + z CO_2

We find that the coefficient for $C_2O_4{}^{2-}$ is $\mathbf{a = 5}$.

The coefficient for Mn^{2+} is $\mathbf{x = 2}$.

Step 5: Final Answer.

The values of a and x are 5 and 2, respectively.

Quick Tip: For balancing redox reactions, the ion-electron method is systematic.

1. Split into half-reactions.
2. Balance atoms other than O and H.
3. Balance O with H_2O.
4. Balance H with H^+ (in acidic medium).
5. Balance charge with e^-.
6. Equalize e^- in both half-reactions and add them up.

Always double-check that both atoms and charge are balanced in the final equation.

---

21. Which of the following will not act as an oxidising agent?

(A) CrO_3

(B) MoO_3

(C) CrO_4^{2-}

(D) $Cr_2O_7^{2-}$

Correct Answer: (C) CrO_4^{2-}

Solution:

Step 1: Understanding Oxidation States:

In all the given options, the central metal (Cr or Mo) is in its maximum oxidation state of +6.

- In CrO_3, Cr is +6.
- In MoO_3, Mo is +6.
- In CrO_4^{2-}, Cr is +6.

- In $Cr_2O_7^{2-}$, Cr is +6.

Step 2: Analyzing the Effect of the Medium:

Chromium(VI) species exist in a pH-dependent equilibrium:

$$2CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$$

- In **acidic medium**, the equilibrium shifts toward the dichromate ion ($Cr_2O_7^{2-}$). Dichromate is a very powerful oxidizing agent in acidic conditions ($E^\circ \approx +1.33\,V$).
- In **alkaline (basic) medium**, the equilibrium shifts toward the chromate ion (CrO_4^{2-}). In this medium, the chromate ion is highly stable and its reduction potential is much lower ($E^\circ \approx -0.13\,V$).

Step 3: Logical Justification:

Because the chromate ion (CrO_4^{2-}) is the stable form in basic solutions and its reduction potential is negative, it does not act as an oxidizing agent under those conditions. In contrast, dichromate and chromic anhydride (CrO_3) are classic, strong oxidants used in synthetic organic and analytical chemistry. While MoO_3 is also a weak oxidant due to the stability of higher oxidation states in heavier transition metals, the specific choice of chromate as "non-oxidizing" is a common distinction made based on its stability in basic media.

Step 4: Final Answer:

Therefore, based on its stability and low reduction potential in its preferred medium, CrO_4^{2-} is the correct choice.

Quick Tip: Remember that the oxidizing power of Cr(VI) is highly pH-dependent. Dichromate is the active oxidizing species in acidic solution, whereas chromate is the stable, non-oxidizing species in basic solution. Always associate dichromate with acidic medium for redox reactions.

---

22. The highest oxidation state of manganese in fluoride is +4 (MnF_4), but the highest oxidation state in oxides is +7 (Mn_2O_7), because

(A) Fluorine is more electronegative than oxygen

(B) Fluorine possesses d-orbitals

(C) Fluorine stabilises lower oxidation state

(D) In covalent compounds, fluorine can form single bond only, while oxygen forms double bond

Correct Answer: (D) In covalent compounds, fluorine can form single bond only, while oxygen forms double bond

Solution:

Step 1: Understanding the Concept.

The question addresses why oxygen can stabilize a higher oxidation state of manganese (+7) compared to fluorine (+4), despite fluorine being more electronegative.

Step 2: Analyzing the Options.

(A) Fluorine is more electronegative than oxygen: This is true, but it doesn't explain the observation. Higher electronegativity would suggest fluorine should be better at stabilizing high positive oxidation states, which contradicts the given data.

(B) Fluorine possesses d-orbitals: This is false. Fluorine is in the second period and does not have accessible d-orbitals.

(C) Fluorine stabilises lower oxidation state: This is a restatement of the observation, not an explanation for it. The question is asking *why* this is the case.

(D) In covalent compounds, fluorine can form single bond only, while oxygen forms double bond: This is the key reason.

- Fluorine, being monovalent, can only form a single covalent bond (Mn-F). To achieve a +7 oxidation state, manganese would need to bond with seven fluorine atoms, leading to significant steric hindrance and inter-electronic repulsion, making MnF_7 highly unstable. The highest known stable fluoride is MnF_4.
- Oxygen is divalent and has the ability to form multiple bonds (double bonds, Mn=O). This allows manganese to achieve a high oxidation state without needing to coordinate with a large number of atoms. In Mn_2O_7, each manganese atom is bonded to three oxygen atoms via double bonds and shares one oxygen atom with the other manganese, allowing it to reach the +7 state.

The ability of oxygen to form π-bonds with d-orbitals of the transition metal is crucial for stabilizing high oxidation states.

Step 3: Final Answer.

The ability of oxygen to form multiple bonds, unlike fluorine which can only form single bonds, allows it to stabilize higher oxidation states in metals like manganese.

Quick Tip: When comparing the ability of oxygen and fluorine to stabilize high oxidation states of transition metals, remember that oxygen's ability to form multiple (double) bonds often outweighs fluorine's higher electronegativity. This is a common trend for many transition metals.

---

23. The calculated spin only magnetic moment of Cr^{2+} ion is

(A) 3.87 BM

(B) 4.90 BM

(C) 5.92 BM

(D) 2.84 BM

Correct Answer: (B) 4.90 BM

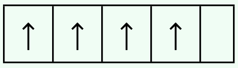
Solution:

Step 1: Determine the electronic configuration of Cr^{2+}.

- The atomic number of Chromium (Cr) is 24.
- Its neutral electronic configuration is exceptional: $[Ar]\ 3d^5\ 4s^1$.
- To form the Cr^{2+} ion, we remove two electrons. The first electron is removed from the outermost shell (4s), and the second is removed from the next shell (3d).
- So, the electronic configuration of Cr^{2+} is $[Ar]\ 3d^4$.

Step 2: Determine the number of unpaired electrons (n).

The 3d subshell has 5 orbitals. According to Hund's rule, the 4 electrons in the 3d subshell will occupy separate orbitals with parallel spins.



There are 4 unpaired electrons. So, n = 4.

Step 3: Key Formula for Spin-only Magnetic Moment.

The spin-only magnetic moment (μ) is calculated using the formula:

$$\mu = \sqrt{n(n+2)}$$

where 'n' is the number of unpaired electrons. The unit is Bohr Magneton (BM).

Step 4: Calculate the magnetic moment.

Substitute n = 4 into the formula:

$$\mu = \sqrt{4(4+2)} = \sqrt{4 \times 6} = \sqrt{24}$$

Now, we estimate the value: $\sqrt{16} = 4$ and $\sqrt{25} = 5$. So $\sqrt{24}$ is just below 5. Calculating it more precisely: $\sqrt{24} \approx 4.8989...$ BM.

Step 5: Final Answer.

The calculated value is approximately 4.90 BM.

Quick Tip: You can quickly estimate the magnetic moment. The value $\sqrt{n(n+2)}$ is always slightly less than n+1. For n=4, the value is just under 5. For n=3, it's just under 4 (3.87). This can help you select the correct option without a calculator.

---

24. Which of the following is the most stable complex?

(A) $[Fe(CO)_5]$

(B) $[Fe(CN)_6]^{4-}$

(C) $[Fe(C_2O_4)_3]^{3-}$

(D) $[Fe(H_2O)_6]^{3+}$

Correct Answer: (B) $[Fe(CN)_6]^{4-}$

Solution:

Step 1: Understanding Complex Stability.

The stability of a coordination complex is described by its stability constant (K) or formation constant (β). A higher value of the stability constant indicates a more stable complex. Several factors influence stability, including the nature of the metal ion, the nature of the ligand, and the chelate effect.

Step 2: Analyzing the Ligands and the Chelate Effect.

- **(A) $[Fe(CO)_5]$:** The ligand is Carbonyl (CO), a strong field ligand that forms strong σ and π bonds (synergic bonding). The complex is stable, but the oxidation state of Fe is 0.
- **(B) $[Fe(CN)_6]^{4-}$:** The ligand is Cyanide (CN^-), a very strong field ligand. The oxidation state of Fe is +2. Cyanide complexes are known to have very high stability constants.
- **(C) $[Fe(C_2O_4)_3]^{3-}$:** The ligand is Oxalate (${C_2O_4}^{2-}$), which is a bidentate ligand. Bidentate or polydentate ligands form rings with the central metal ion, a phenomenon known as the **chelate effect**. Chelation significantly increases the stability of a complex compared to complexes with analogous monodentate ligands. The oxidation state of Fe is +3.
- **(D) $[Fe(H_2O)_6]^{3+}$:** The ligand is Aqua (H_2O), which is a weak field ligand. The oxidation state of Fe is +3. Aqua complexes are generally less stable compared to those with strong field ligands or chelating ligands.

Step 3: Comparing the Stability.

We need to compare the stability of these complexes.

- Comparing (C) and (D): The oxalate complex (C) is a chelate and will be much more stable than the aqua complex (D) due to the chelate effect.
- Comparing (B) and (C): We are comparing a complex with a very strong monodentate ligand (CN^-) and a complex with a chelating ligand (${C_2O_4}^{2-}$). While the chelate effect is powerful, the cyanide ligand is exceptionally strong and forms extremely stable complexes. The stability constant for $[Fe(CN)_6]^{4-}$ is extremely large ($\log \beta \approx 35$). The stability constant for $[Fe(C_2O_4)_3]^{3-}$ is also high due to chelation ($\log \beta \approx 20$), but significantly lower than that of the cyanide complex.

- Comparing (A) and (B): Metal carbonyls are stable due to synergic bonding. However, hexacyanoferrate(II) is renowned for its exceptional thermodynamic stability in aqueous solution.

Overall, the complex $[Fe(CN)_6]^{4-}$ is known to be one of the most stable iron complexes due to the strong ligand field and high charge density of the CN^- ligand.

Step 4: Final Answer.

The most stable complex among the given options is $[Fe(CN)_6]^{4-}$.

Quick Tip: When comparing complex stability, consider these factors in order: 1. **Chelate Effect:** Complexes with polydentate (chelating) ligands are significantly more stable than those with similar monodentate ligands. 2. **Ligand Strength:** Strong field ligands (like CN^-, CO) generally form more stable complexes than weak field ligands (like H_2O, halogens). 3. **Metal Ion Charge/Size:** Higher charge and smaller size of the central metal ion generally lead to greater stability.

---

25. How many ions per molecule are produced from the complex $[Co(NH_3)_6]Cl_3$ in solution?

(A) 6

(B) 4

(C) 3

(D) 2

Correct Answer: (B) 4

Solution:

Step 1: Understanding the Dissociation of Coordination Compounds.

When a coordination compound is dissolved in a solvent like water, it dissociates into its constituent ions. The coordination sphere (the part in the square brackets) remains as a single, intact complex ion, while the counter ions outside the brackets dissociate.

Step 2: Analyzing the given complex.

The complex is $[Co(NH_3)_6]Cl_3$.

- The coordination sphere is $[Co(NH_3)_6]^{3+}$. This is one complex cation.

- The counter ions are the three chloride ions, Cl^-.

Step 3: Writing the dissociation equation.

When one formula unit of the complex dissolves in water, it dissociates as follows:

$$[Co(NH_3)_6]Cl_3(s) \xrightarrow{\text{Water}} [Co(NH_3)_6]^{3+}(aq) + 3Cl^-(aq)$$

Step 4: Counting the total number of ions produced.

From the dissociation equation, we can see that one formula unit produces:

- 1 complex cation: $[Co(NH_3)_6]^{3+}$
- 3 simple anions: Cl^-

Total number of ions = 1 + 3 = 4 ions.

Step 5: Final Answer.

A total of 4 ions are produced per molecule of the complex in solution.

Quick Tip: To find the number of ions produced by a coordination compound, simply count the complex ion (the part in square brackets) as one ion and then add the number of counter ions outside the brackets.

---

26. Given below are two statements:

Statement I: The M – C σ bond is formed by the donation of lone pair of electrons on the carbonyl carbon into a vacant d-orbital of the metal

Statement II: The M – C π bond is formed by the donation of a pair of electrons from a filled d-orbital of metal into the vacant antibonding π^* orbital of carbon monoxide.

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

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but Statement II is incorrect

(D) Statement I is incorrect but Statement II is correct

Correct Answer: (A) Both Statement I and Statement II are correct

Solution:

Step 1: Understanding Synergic Bonding in Metal Carbonyls.

The bonding between a metal atom and a carbon monoxide (carbonyl) ligand is a special type of bonding called synergic bonding. It consists of two components: a sigma (σ) bond and a pi (π) bond.

Step 2: Analyzing Statement I.

This statement describes the formation of the sigma bond. The carbon atom in the CO molecule has a lone pair of electrons. This lone pair is donated into a suitable vacant orbital of the metal atom (which can be a d-orbital, or a hybrid orbital). This forms a standard coordinate covalent bond, which is a σ bond. The direction of electron donation is from the ligand (CO) to the metal (M). So, M ← CO. Statement I accurately describes this process. Thus, Statement I is **correct**.

Step 3: Analyzing Statement II.

This statement describes the formation of the pi bond, also known as back-bonding. The metal atom has filled d-orbitals. The CO ligand has vacant antibonding pi-star (π^*) orbitals. A pair of electrons from a filled d-orbital of the metal is donated back into a vacant π^* orbital of the CO ligand. This creates a π bond. The direction of electron donation is from the metal (M) to the ligand (CO). So, M → CO. Statement II accurately describes this back-donation. Thus, Statement II is **correct**.

Step 4: Conclusion.

Both statements correctly describe the two components of synergic bonding in metal carbonyls. The sigma bond strengthens the pi bond and vice-versa, leading to a strong overall M-C bond.

Step 5: Final Answer.

Both Statement I and Statement II are correct.

Quick Tip: Visualize synergic bonding as a "give and take" relationship.

- **Ligand gives (σ bond):** CO donates its lone pair to the metal's empty orbital.
- **Metal gives back (π bond):** The metal donates electrons from its filled d-orbital to CO's empty π^* orbital.

This dual bonding mechanism is why CO is a strong field ligand and forms very stable complexes.

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27. Match List - I with List - II

	List - I (Complex)		**List - II (Geometry)**
(a)	$[Co(NH_3)_6]^{3+}$	(i)	Trigonal bipyramidal
(b)	$[NiCl_4]^{2-}$	(ii)	Octahedral
(c)	$[Ni(CN)_4]^{2-}$	(iii)	Tetrahedral
(d)	$[Fe(CO)_5]$	(iv)	Square planar

Choose the correct answer from the options given below.

(A) a - ii, b – iii, c – iv, d - i

(B) a - ii, b - i, c - iii, d – iv

(C) a – iii, b – ii, c – iv, d – i

(D) a – i, b – iii, c – iv, d – ii

Correct Answer: (A) a - ii, b – iii, c – iv, d - i

Solution:

Step 1: Determine the geometry of each complex.

(a) $[Co(NH_3)_6]^{3+}$:

- Co atomic number = 27. Co^{3+} configuration: [Ar] $3d^6$.
- NH_3 is a strong field ligand, so it will cause pairing of electrons. The 6 electrons will occupy three d-orbitals.
- Hybridization involves two empty 3d orbitals, one 4s, and three 4p orbitals, leading to d^2sp^3 hybridization.
- The geometry for coordination number 6 is **Octahedral**.
- So, **a** → **ii**.

(b) $[NiCl_4]^{2-}$:

- Ni atomic number = 28. Ni^{2+} configuration: [Ar] $3d^8$.
- Cl^- is a weak field ligand. No pairing of electrons will occur.
- Hybridization involves one 4s and three 4p orbitals, as the 3d orbitals are not empty. This leads to sp^3 hybridization.
- The geometry for sp^3 hybridization is **Tetrahedral**.
- So, **b** → **iii**.

(c) $[Ni(CN)_4]^{2-}$:

- Ni^{2+} configuration: [Ar] $3d^8$.
- CN^- is a strong field ligand. It will force the two unpaired electrons in the 3d orbitals to pair up, leaving one 3d orbital empty.
- Hybridization involves the one empty 3d orbital, one 4s, and two 4p orbitals, leading to dsp^2 hybridization.
- The geometry for dsp^2 hybridization is **Square planar**.
- So, **c** → **iv**.

(d) $[Fe(CO)_5]$:

- Fe atomic number = 26. Fe(0) configuration: [Ar] $3d^6$ $4s^2$.
- CO is a strong field ligand. In the complex, the 8 valence electrons of Fe rearrange and pair up in the 3d orbitals.
- The complex has coordination number 5. The hybridization is dsp^3.
- The geometry for coordination number 5 (dsp^3) is **Trigonal bipyramidal**.
- So, **d** → **i**.

Step 2: Compile the matches.

The correct matches are: a → ii, b → iii, c → iv, d → i.

Step 3: Final Answer.

This combination corresponds to option (A).

Quick Tip: For coordination number 4, the geometry depends on the ligand.

- **Strong field ligands** with d^8 metals (like Ni^{2+}) cause pairing and lead to dsp^2 (square planar) geometry.
- **Weak field ligands** with d^8 metals do not cause pairing and lead to sp^3 (tetrahedral) geometry.

For coordination number 5, the most common geometry is trigonal bipyramidal. For coordination number 6, the geometry is almost always octahedral.

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28. Match List - I with List – II

	List - I (Vitamins)		List - II (Deficiency Diseases)
(a)	B_1	(i)	Convulsions
(b)	B_2	(ii)	RBC deficiency in haemoglobin
(c)	B_6	(iii)	Retarded growth
(d)	B_{12}	(iv)	Burning sensation of the skin

Choose the correct answer from the options given below.

(A) a – ii, b – iv, c – iii, d – i

(B) a – iii, b – iv, c – i, d – ii

(C) a – i, b – ii, c – iii, d – iv

(D) a – iv, b – iii, c – ii, d – i

Correct Answer: (B) a – iii, b – iv, c – i, d – ii (Note: There might be overlap in symptoms, this is based on common textbook associations. For instance, B1 deficiency causes Beriberi, which involves nerve and growth issues.)

Solution:

Step 1: Match each vitamin with its known deficiency disease.

(a) Vitamin B_1 (Thiamine): Deficiency of Thiamine causes the disease Beriberi, which affects the nervous system and heart. It can also lead to stunted or **retarded growth** in children. So, a plausible match is **(iii)**.

(b) Vitamin B_2 (Riboflavin): Deficiency of Riboflavin can cause cheilosis (cracks at the corners of the mouth), skin disorders, and a **burning sensation of the skin** or tongue. So, a plausible match is **(iv)**.

(c) Vitamin B_6 (Pyridoxine): Deficiency of Pyridoxine can lead to neurological symptoms, including depression, confusion, and **convulsions**. So, a plausible match is **(i)**.

(d) Vitamin B_{12} (Cobalamin): Deficiency of Vitamin B_{12} causes pernicious anemia, which is a type of megaloblastic anemia characterized by a **deficiency of red blood cells (RBC)**. So, a plausible match is **(ii)**.

Step 2: Compile the matches.

The most likely correct matches are:

- a → iii
- b → iv
- c → i
- d → ii

Step 3: Final Answer.

This combination corresponds to option (B).

Quick Tip: Creating flashcards for vitamins, their chemical names, and their deficiency diseases is an effective way to memorize this information, which is frequently tested.

- B1 (Thiamine) → Beriberi
- B2 (Riboflavin) → Cheilosis, skin issues
- B6 (Pyridoxine) → Convulsions, nerve issues
- B12 (Cobalamin) → Pernicious Anemia

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29. Consider the following statements:

Statement I: All monosaccharides are reducing sugars.

Statement II: Sucrose can reduce ammoniacal silver nitrate solution.

Choose the correct answer from the options given below.

(A) Both Statement I and Statement II are correct

(B) Both Statement I and Statement II are incorrect

(C) Statement I is correct but Statement II is incorrect

(D) Statement I is incorrect but Statement II is correct

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

Solution:

Step 1: Analyzing Statement I.

Reducing sugars are carbohydrates that can act as reducing agents because they have a free aldehyde group or a free ketone group. All monosaccharides (like glucose, fructose, galactose) exist in equilibrium with their open-chain forms, which contain either an aldehyde group (aldoses) or a ketone group that can isomerize to an aldehyde (ketoses). This free carbonyl group allows them to be oxidized by mild oxidizing agents like Tollens' reagent or Fehling's solution. Therefore, **all monosaccharides are reducing sugars**. Statement I is **correct**.

Step 2: Analyzing Statement II.

Sucrose is a disaccharide made up of two monosaccharide units: α-glucose and β-fructose. The glycosidic bond in sucrose is formed between the anomeric carbon of glucose (C1) and the anomeric carbon of fructose (C2). These anomeric carbons contain the potentially free aldehyde and ketone groups, respectively. Since both are involved in the glycosidic linkage, neither unit can open up to form a free carbonyl group. Therefore, sucrose does not have reducing properties. The reaction with ammoniacal silver nitrate solution is the Tollens' test, which is a test for reducing sugars. Since sucrose is a non-reducing sugar, it will not give a positive Tollens' test, meaning it **cannot reduce** the solution. Statement II is **incorrect**.

Step 3: Final Answer.

Statement I is correct, and Statement II is incorrect.

Quick Tip: To identify a reducing sugar, check for a hemiacetal group in its cyclic structure. A hemiacetal group (a carbon bonded to both an -OH and an -OR group) indicates that the ring can open to form a free aldehyde. In sucrose, the anomeric carbons are linked in an acetal/ketal linkage, so there are no hemiacetal groups.

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30. Incorrect statement about α-amino acids of proteins among the following is

(A) Methionine is an essential amino acid

(B) Glycine doesn't exhibit enantiomerism

(C) Glycylalanylglutamine has three amide linkages

(D) Zwitterion of valine exhibits amphoteric behaviour

Correct Answer: (C) Glycylalanylglutamine has three amide linkages

Solution:

Step 1: Evaluate each statement.

(A) Methionine is an essential amino acid: Essential amino acids are those that cannot be synthesized by the human body and must be obtained from the diet. Methionine is one of the nine essential amino acids. This statement is **correct**.

(B) Glycine doesn't exhibit enantiomerism: Enantiomerism (optical activity) occurs in molecules that have a chiral center - a carbon atom bonded to four different groups. The structure of glycine is H_2N-CH_2-COOH. The α-carbon is bonded to two hydrogen atoms, one amino group, and one carboxyl group. Since it is not bonded to four *different* groups, it is not chiral. Therefore, glycine does not exhibit enantiomerism. This statement is **correct**.

(C) Glycylalanylglutamine has three amide linkages: This is a tripeptide, meaning it is formed from three amino acids: Glycine, Alanine, and Glutamine. A peptide bond (which is an amide linkage) is formed between each pair of adjacent amino acids.

- A bond forms between Glycine and Alanine. (1st amide linkage)
- A bond forms between Alanine and Glutamine. (2nd amide linkage)

A tripeptide has **two** peptide (amide) linkages connecting the three amino acid residues. Glutamine itself has an amide group in its side chain, but the question asks about the amide *linkages* forming the peptide backbone. The statement says there are three amide linkages, which is incorrect. This statement is **incorrect**.

(D) Zwitterion of valine exhibits amphoteric behaviour: A zwitterion is a molecule that has both a positive charge (on the -NH_3^+ group) and a negative charge (on the -COO^- group). This structure can react with both acids (by accepting a proton at the -COO^- group) and bases (by donating a proton from the -NH_3^+ group). A substance that can act as both an acid and a base is called amphoteric. This statement is **correct**.

Step 2: Final Answer.

The incorrect statement is (C).

Quick Tip: For a polypeptide chain, the number of peptide (amide) linkages is always one less than the number of amino acid residues. A dipeptide has one linkage, a tripeptide has two, a tetrapeptide has three, and so on. Number of linkages = n - 1, where n is the number of amino acids.

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31. Match List I with List II and select the correct options

List - I (Functional group)		List - II (Functional group reagent)	
(a)	Secondary Alcohol	(i)	Neutral ferric chloride test
(b)	$C_6H_5NH_2$ (Aniline)	(ii)	Azo dye test
(c)	CH_3CH_2CHO (Propanal)	(iii)	Ceric ammonium nitrate test
(d)	Phenol	(iv)	Tollen's reagent test

Codes:

(A) a – iv, b – i, c – ii, d – iii

(B) a - iii, b - ii, c - iv, d - i

(C) a – iii, b – ii, c – i, d – iv

(D) a – ii, b – iii, c – iv, d - i

Correct Answer: (B) a - iii, b - ii, c - iv, d - i

Solution:

Step 1: Match each functional group with its characteristic test.

(a) Secondary Alcohol (e.g., propan-2-ol shown in the image): Alcohols give a positive test with **Ceric Ammonium Nitrate (CAN)**. The solution turns from yellow to red. So, **a → iii**.

(b) $C_6H_5NH_2$ (Aniline, a primary aromatic amine): Primary aromatic amines undergo a diazotization reaction (with $NaNO_2/HCl$ at 0°C) followed by coupling with a phenol (like β-naphthol) to form a brightly colored **azo dye** (orange-red precipitate). This is the basis of the azo dye test. So, **b → ii**.

(c) CH_3CH_2CHO (Propanal, an aldehyde): Aldehydes are readily oxidized and give a positive test with **Tollen's reagent** (ammoniacal silver nitrate solution). They reduce Ag^+ ions to metallic silver, forming a silver mirror on the inside of the test tube. So, **c → iv**.

(d) Phenol: Phenols have a weakly acidic hydroxyl group directly attached to a benzene ring. They give a characteristic coloration (usually violet, but can be blue or green) with a **neutral ferric chloride ($FeCl_3$) solution** due to the formation of a colored iron-phenoxide complex. So, **d → i**.

Step 2: Compile the matches.

The correct matches are:

- a → iii
- b → ii
- c → iv
- d → i

Step 3: Final Answer.

This combination corresponds to option (B).

Quick Tip: It is essential to memorize the common functional group tests in organic chemistry.

- **Phenols**: Neutral $FeCl_3$ test (violet color).
- **Aldehydes**: Tollen's test (silver mirror) or Fehling's test (red ppt).
- **Alcohols**: Ceric Ammonium Nitrate (red color) or Lucas test (turbidity for 1°, 2°, 3°).
- **Primary Aromatic Amines**: Azo dye test (colored dye).

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32. When salt BA is treated with Conc. H_2SO_4, reddish brown gas is liberated. The aqueous solution of BA gives pale yellow precipitate with $AgNO_3$ solution. Which of the following anion(A) is present in the salt BA?

(A) Cl^-

(B) $CO_3{}^{2-}$

(C) $SO_4{}^{2-}$

(D) Br^-

Correct Answer: (D) Br^-

Solution:

Step 1: Analyze the first observation.

Test: Salt + Conc. $H_2SO_4 \rightarrow$ Reddish brown gas.

This is a characteristic test for the bromide ion (Br^-). The concentrated sulfuric acid first oxidizes HBr (formed initially) to bromine gas (Br_2), which has a reddish-brown color. The reactions are:

$$Br^- + H_2SO_4 \rightarrow HBr + HSO_4^-$$

$$2HBr + H_2SO_4 \rightarrow Br_2(\text{red-brown gas}) + SO_2 + 2H_2O$$

Nitrate ion ($NO_3{}^-$) also gives a reddish-brown gas (NO_2) with conc. H_2SO_4, especially upon adding copper turnings, but the second test will confirm the anion.

Step 2: Analyze the second observation.

Test: Aqueous solution of salt + $AgNO_3$ solution → Pale yellow precipitate.

This test with silver nitrate is used to identify halide ions.

- **AgCl** (from Cl^-) is a curdy **white** precipitate.
- **AgBr** (from Br^-) is a **pale yellow** precipitate, which is sparingly soluble in ammonium hydroxide.
- **AgI** (from I^-) is a bright **yellow** precipitate, which is insoluble in ammonium hydroxide.

The observation of a pale yellow precipitate strongly indicates the presence of the bromide ion (Br^-).

Step 3: Conclusion.

Both tests are consistent with the presence of the bromide ion (Br^-) as the anion A^-.

Step 4: Final Answer.

The anion present in the salt BA is Br^-.

Quick Tip: Remember the colors of silver halide precipitates for qualitative analysis:

- **AgCl**: White
- **AgBr**: Pale Yellow (Cream)
- **AgI**: Bright Yellow

Also, remember the key confirmatory tests for anions with concentrated H_2SO_4. The reddish-brown gas (Br_2) is a classic indicator for bromide.

---

33. Which of the following represents de Broglie equation?

(A) $\lambda = \frac{h}{\sqrt{mv}}$

(B) $\lambda = \frac{h}{mv}$

(C) $\lambda = \frac{h}{mp}$

(D) $\lambda = \frac{\mu}{p}$

Correct Answer: (B) $\lambda = \frac{h}{mv}$

Solution:

Step 1: Understanding the de Broglie Hypothesis.

In 1924, Louis de Broglie proposed that all matter exhibits wave-like properties. He suggested that a particle with momentum (p) has an associated wavelength (λ). This is known as the wave-particle duality of matter.

Step 2: The de Broglie Equation.

The equation that relates the wavelength (λ) of a particle to its momentum (p) is:

$$\lambda = \frac{h}{p}$$

Where:

- λ is the de Broglie wavelength.
- h is Planck's constant (6.626×10^{-34} J·s).
- p is the momentum of the particle.

Step 3: Expressing Momentum.

Momentum (p) of a particle is defined as the product of its mass (m) and its velocity (v):

$$p = mv$$

Step 4: Substituting Momentum in the de Broglie Equation.

By substituting the expression for momentum into the de Broglie equation, we get the most common form of the equation:

$$\lambda = \frac{h}{mv}$$

Step 5: Evaluating the Options.

- (A) $\lambda = \frac{h}{\sqrt{mv}}$: Incorrect.
- (B) $\lambda = \frac{h}{mv}$: Correct. This is the de Broglie equation.
- (C) $\lambda = \frac{h}{mp}$: Incorrect. This would imply $\lambda = \frac{h}{m(mv)} = \frac{h}{m^2v}$.
- (D) $\lambda = \frac{\mu}{p}$: Incorrect. It uses a different symbol (μ) instead of Planck's constant (h).

Step 6: Final Answer.

The correct representation of the de Broglie equation is $\lambda = \frac{h}{mv}$.

Quick Tip: The de Broglie equation $\lambda = h/p$ is fundamental. Since p=mv, the two forms $\lambda = h/p$ and $\lambda = h/mv$ are equivalent and frequently used. Remember that this equation links a particle property (momentum) to a wave property (wavelength).

---

34. Which of the following is the CORRECT statement about Ψ^2?

(A) Ψ^2 represents atomic orbit

(B) Probability density of the electron at that point

(C) $\Psi^2 \neq 0$ for nodes

(D) Ψ^2 has no physical meaning

Correct Answer: (B) Probability density of the electron at that point

Solution:

Step 1: Understanding Ψ and Ψ^2.

In quantum mechanics, the state of an electron in an atom is described by a wave function, represented by the Greek letter psi (Ψ). The wave function Ψ itself is a mathematical function (a solution to the Schrödinger equation) and does not have a direct physical meaning. However, its square, Ψ^2, does have a very important physical significance.

Step 2: Evaluating the Options.

(A) Ψ^2 represents atomic orbit: An atomic orbital is the three-dimensional region of space around the nucleus where the probability of finding an electron is maximum (typically >90%). Ψ^2 is the probability density at a single point, not the entire region (orbital). So, this is incorrect.

(B) Probability density of the electron at that point: According to Max Born's interpretation of the wave function, the value of Ψ^2 at any given point in space is proportional to the probability of finding the electron at that point. More precisely, $\Psi^2 dV$ represents the probability of finding the electron in a small volume element dV. Therefore, Ψ^2 is known as the probability density. This statement is **correct**.

(C) $\Psi^2 \neq 0$ for nodes: A node is a point or a surface where the probability of finding an electron is zero. By definition, at a node, $\Psi = 0$, and consequently, $\Psi^2 = 0$. This statement claims the opposite and is therefore incorrect.

(D) Ψ^2 has no physical meaning: This is incorrect. As explained in (B), Ψ^2 has a clear and crucial physical meaning: it represents the probability density of finding an electron. It is Ψ itself that has no direct physical meaning.

Step 3: Final Answer.

The correct statement is that Ψ^2 represents the probability density of the electron at a point.

Quick Tip: Distinguish carefully between the wave function (Ψ) and the probability density (Ψ^2).

- Ψ: Wave function. Can be positive, negative, or zero. No direct physical meaning.
- Ψ^2: Probability density. Must be positive or zero. Represents the probability of finding an electron per unit volume at a specific point.

An orbital is the region where the total probability ($\int \Psi^2 dV$) is high.

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35. A: Entropy of a perfect crystalline solid at absolute zero approaches zero.

B: For spontaneity of a reaction, $T\Delta S > \Delta H$.

Among the two statements given above, identify the correct answer from the options given below.

(A) Both 'A' and 'B' are true

(B) 'A' is true but 'B' is false

(C) Both 'A' and 'B' are false

(D) 'A' is false but 'B' is true

Correct Answer: (A) Both 'A' and 'B' are true

Solution:

Step 1: Analyzing Statement A.

Statement A says, "Entropy of a perfect crystalline solid at absolute zero approaches zero." This is a direct statement of the **Third Law of Thermodynamics**. The law states that as the temperature of a system approaches absolute zero (0 K), the entropy of the system approaches a minimum value. For a perfect crystalline substance, this minimum entropy is zero, as there is only one possible arrangement of atoms (one microstate, W=1, and $S = k \ln W = 0$). Therefore, Statement A is **true**.

Step 2: Analyzing Statement B.

Statement B gives a condition for the spontaneity of a reaction: $T\Delta S > \Delta H$. The spontaneity of a process at constant temperature and pressure is determined by the change in Gibbs free energy (ΔG). The relationship is:

$$\Delta G = \Delta H - T\Delta S$$

For a process to be spontaneous, the change in Gibbs free energy must be negative ($\Delta G < 0$). So, for spontaneity:

$$\Delta H - T\Delta S < 0$$

Rearranging this inequality:

$$\Delta H < T\Delta S$$

or

$$T\Delta S > \Delta H$$

This exactly matches the condition given in Statement B. Therefore, Statement B is **true**.

Step 3: Final Answer.

Both statements A and B are true.

Quick Tip: Remember the key thermodynamic principles:

- **Third Law:** $S \to 0$ as $T \to 0$ K for a perfect crystal.
- **Spontaneity (Gibbs Free Energy):** A reaction is spontaneous if $\Delta G < 0$. Always start from the fundamental equation $\Delta G = \Delta H - T\Delta S$ to derive the conditions for spontaneity.

36. Which of the following is a correct statement for a thermodynamic system?

(A) The internal energy changes in all processes

(B) Internal energy and entropy are state functions

(C) Work is a state function

(D) The work done in an adiabatic process is always zero

Correct Answer: (B) Internal energy and entropy are state functions

Solution:

Step 1: Understanding State Functions and Path Functions.

- **State Function:** A property of a system that depends only on the current state of the system (e.g., temperature, pressure, volume, internal energy, entropy), not on the path taken to reach that state. The change in a state function depends only on the initial and final states.
- **Path Function:** A property that depends on the path taken between two states (e.g., heat, work).

Step 2: Evaluating each statement.

(A) The internal energy changes in all processes: This is incorrect. For example, in an isothermal process involving an ideal gas, the internal energy (which depends only on temperature for an ideal gas) remains constant ($\Delta U = 0$). Also, in a cyclic process, the system returns to its initial state, so the change in any state function, including internal energy, is zero.

(B) Internal energy and entropy are state functions: This is correct. Both internal energy (U) and entropy (S) are properties that depend only on the state of the system, not on how the system arrived at that state. Their changes (ΔU and ΔS) are determined solely by the initial and final states.

(C) Work is a state function: This is incorrect. Work (w) is a classic example of a path function. The amount of work done to get from state A to state B depends on the specific path followed.

(D) The work done in an adiabatic process is always zero: This is incorrect. An adiabatic process is one in which no heat is exchanged with the surroundings (q=0).

According to the first law of thermodynamics, $\Delta U = q + w$. For an adiabatic process, this becomes $\Delta U = w$. Since the internal energy can change (e.g., by changing temperature), the work done is generally not zero. Work is only zero in a free expansion into a vacuum.

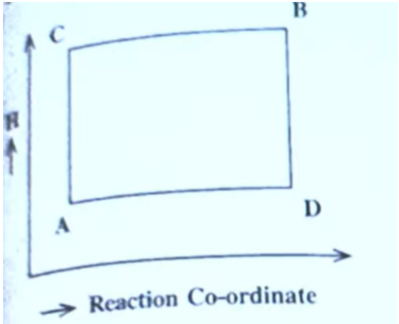
Step 3: Final Answer.

The correct statement is that internal energy and entropy are state functions.

Quick Tip: Remember the main state functions in thermodynamics: Pressure (P), Volume (V), Temperature (T), Internal Energy (U), Enthalpy (H), Entropy (S), and Gibbs Free Energy (G). The two main path functions are Heat (q) and Work (w).

---

37. A gas can be taken from A to B via two different paths ACB and ADB. When path ACB is used, 60J of heat flows into the system and 30J of work is done by the system. If path ADB is used, work done by the system is 10J. The heat flow into the system in path ADB is



(A) 80J

(B) 20J

(C) 100J

(D) 40J

Correct Answer: (D) 40J

Solution:

Step 1: Understanding the First Law of Thermodynamics and State Functions.

The first law of thermodynamics states that the change in internal energy (ΔU) of a system is equal to the heat (q) added to the system minus the work (w) done by the system.

$$\Delta U = q - w$$

(Note: The sign convention w = work done *by* the system is used here). Internal energy (U) is a state function. This means that the change in internal energy (ΔU) between two states (A and B) is independent of the path taken. Therefore, $\Delta U_{ACB} = \Delta U_{ADB}$.

Step 2: Calculate the change in internal energy for path ACB.
For path ACB:

- Heat flow into the system, $q_{ACB} = +60$ J
- Work done by the system, $w_{ACB} = +30$ J

Using the first law:

$$\Delta U_{ACB} = q_{ACB} - w_{ACB} = 60\text{ J} - 30\text{ J} = 30\text{ J}$$

Step 3: Use the property of state functions to find the heat flow for path ADB.
Since internal energy is a state function, the change in internal energy from A to B is the same for both paths.

$$\Delta U_{ADB} = \Delta U_{ACB} = 30\text{ J}$$

For path ADB:

- Work done by the system, $w_{ADB} = +10$ J
- Heat flow, $q_{ADB} = ?$

Using the first law for path ADB:

$$\Delta U_{ADB} = q_{ADB} - w_{ADB}$$

$$30\text{ J} = q_{ADB} - 10\text{ J}$$

$$q_{ADB} = 30\text{ J} + 10\text{ J} = 40\text{ J}$$

Step 4: Final Answer.
The heat flow into the system in path ADB is 40 J.

Quick Tip: This type of problem is a direct application of the fact that internal energy (U) is a state function. The key is to calculate ΔU using the path for which complete information is given, and then use that value of ΔU to find the missing variable for the other path.

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38. For the reversible reaction, $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$. When the partial pressure is measured in atmosphere, the value of K_p at 500°C is 1.44×10^{-5}. The value of K_c when the concentration is expressed in mol L^{-1} is:

(A) $\frac{1.44\times10^{-5}}{(0.082\times500)^{-2}}$

(B) $\frac{1.44\times10^{-5}}{(8.314\times773)^{-2}}$

(C) $\frac{1.44\times10^{-5}}{(0.082\times773)^{2}}$

(D) $\frac{1.44\times10^{-5}}{(0.082\times773)^{-2}}$

Correct Answer: (D) $\frac{1.44\times10^{-5}}{(0.082\times773)^{-2}}$

Solution:

Step 1: Understanding the Question:

The question asks to find the numerical expression for the equilibrium constant in terms of molarity (K_c) given the equilibrium constant in terms of partial pressure (K_p) and the temperature.

Step 2: Key Formula or Approach:

The relationship between K_p and K_c for a gaseous reaction is:

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

Where:

- R is the universal gas constant (use $0.0821\,\mathrm{L\cdot atm\cdot K^{-1}mol^{-1}}$ to match units).
- T is the absolute temperature in Kelvin.
- Δn_g is the change in the number of moles of gaseous products and reactants (moles of products − moles of reactants).

Step 3: Detailed Explanation:

1. **Calculate Δn_g:**

The balanced chemical equation is: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$.

$$\Delta n_g = (2) - (1+3) = 2 - 4 = -2$$

2. **Convert Temperature to Kelvin:**

$$T = 500^\circ\text{C} + 273 = 773\,\text{K}$$

3. **Rearrange the formula to solve for K_c:**

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

Substituting the values ($K_p = 1.44 \times 10^{-5}$, $R \approx 0.082$, $T = 773$, and $\Delta n_g = -2$):

$$K_c = \frac{1.44 \times 10^{-5}}{(0.082 \times 773)^{-2}}$$

Step 4: Final Answer:

Comparing this result with the given options, it exactly matches option (D). (Note: Option C is incorrect because it uses a positive exponent of 2 in the denominator, which would correspond to $\Delta n_g = +2$).

Quick Tip: Always double-check the sign of Δn_g. For the Haber process (ammonia synthesis), Δn_g is always -2. Also, remember that in K_p/K_c relations, temperature must always be in Kelvin.

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39. For the following gaseous reversible reaction: $3A_{(g)} + B_{(g)} \rightleftharpoons A_3B_{(g)}$ (ΔH = -q kJ), The amount of product $A_3B_{(g)}$ is affected by

(A) Temperature alone

(B) Pressure alone

(C) Both temperature and pressure

(D) Temperature, pressure and catalyst

Correct Answer: (C) Both temperature and pressure

Solution:

Step 1: Understanding Le Chatelier's Principle.

Le Chatelier's principle states that if a change of condition (like temperature, pressure, or concentration) is applied to a system in equilibrium, the system will shift in a direction that counteracts the change. We need to see how temperature and pressure changes will affect the equilibrium position.

Step 2: Effect of Temperature.

The reaction is given as exothermic (ΔH = -q kJ, meaning heat is released).

$$3\text{A}_{(g)} + \text{B}_{(g)} \rightleftharpoons \text{A}_3\text{B}_{(g)} + \text{Heat}$$

According to Le Chatelier's principle:

- **Increasing the temperature** will favor the endothermic (reverse) reaction to absorb the added heat. The equilibrium will shift to the **left**, decreasing the amount of product A_3B.
- **Decreasing the temperature** will favor the exothermic (forward) reaction to release heat. The equilibrium will shift to the **right**, increasing the amount of product A_3B.

Since temperature changes the equilibrium position, the amount of product is affected by temperature.

Step 3: Effect of Pressure.

The effect of pressure depends on the change in the number of moles of gas (Δn_g).

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

$$\Delta n_g = (1) - (3 + 1) = 1 - 4 = -3$$

Since $\Delta n_g \neq 0$, pressure will affect the equilibrium. According to Le Chatelier's principle:

- **Increasing the pressure** will favor the side with fewer moles of gas to relieve the pressure. The equilibrium will shift to the **right**, increasing the amount of product A_3B.
- **Decreasing the pressure** will favor the side with more moles of gas. The equilibrium will shift to the **left**, decreasing the amount of product A_3B.

Since pressure changes the equilibrium position, the amount of product is affected by pressure.

Step 4: Effect of a Catalyst.
A catalyst increases the rate of both the forward and reverse reactions equally. It helps the system reach equilibrium faster but **does not change** the position of the equilibrium. Therefore, a catalyst does not affect the amount of product at equilibrium.

Step 5: Final Answer.
The amount of product is affected by both temperature and pressure, but not by a catalyst. Therefore, option (C) is the best answer.

Quick Tip: To quickly determine the effects on equilibrium:

- **Temperature:** Check if ΔH is positive (endothermic) or negative (exothermic). Increasing T favors the endothermic direction.
- **Pressure:** Calculate Δn_g. If $\Delta n_g \neq 0$, increasing P favors the side with fewer gas moles.
- **Catalyst:** Never changes the equilibrium position, only the rate at which it is reached.

---

40. A 0.15 mole of pyridinium chloride has been added to 500 cm^3 of 0.2M pyridine solution (a base). Assuming there is no change in volume upon mixing, the pH of the resulting solution is
(Note: K_b for pyridine is 1.5×10^{-9})

(A) 5

(B) 6

(C) 7

(D) 8

Correct Answer: (A) 5

Solution:

Step 1: Understanding the System.

We are mixing pyridine (C_5H_5N, a weak base) with its conjugate acid, pyridinium chloride ($C_5H_5NH^+Cl^-$). This combination forms a **basic buffer** solution.

Step 2: Calculate the concentrations of the base and its conjugate acid.

Volume of solution = 500 cm^3 = 0.5 L.

Concentration of pyridine (Base): $[\text{Base}] = [C_5H_5N] = 0.2$ M (given).

Concentration of pyridinium chloride (Salt/Conjugate Acid): Moles of salt = 0.15 mol.

$$[\text{Salt}] = [C_5H_5NH^+] = \frac{\text{moles}}{\text{volume}} = \frac{0.15 \text{ mol}}{0.5 \text{ L}} = 0.3 \text{ M}$$

Step 3: Key Formula for Buffer pH (Henderson-Hasselbalch Equation).

For a basic buffer, we can calculate the pOH using the Henderson-Hasselbalch equation:

$$\text{pOH} = \text{pK}_b + \log\left(\frac{[\text{Salt}]}{[\text{Base}]}\right)$$

And then find pH using pH + pOH = 14.

Step 4: Calculate pK_b.

$K_b = 1.5 \times 10^{-9}$.

$$\text{pK}_b = -\log(K_b) = -\log(1.5 \times 10^{-9})$$

$$\text{pK}_b = -(\log(1.5) + \log(10^{-9})) = -(\log(1.5) - 9) = 9 - \log(1.5)$$

Given $\log(1.5) \approx 0.18$.

$$\text{pK}_b \approx 9 - 0.18 = 8.82$$

Step 5: Calculate pOH.

$$\text{pOH} = 8.82 + \log\left(\frac{0.3}{0.2}\right) = 8.82 + \log(1.5)$$

$$\text{pOH} = 8.82 + 0.18 = 9.0$$

Step 6: Calculate pH.

$$\text{pH} = 14 - \text{pOH} = 14 - 9.0 = 5.0$$

Step 7: Final Answer.

The pH of the resulting buffer solution is 5.

Quick Tip: For any buffer solution problem, first identify if it's an acidic buffer (weak acid + its salt) or a basic buffer (weak base + its salt). Then, apply the appropriate Henderson-Hasselbalch equation:

- **Acidic Buffer:** $\text{pH} = \text{pK}_a + \log([\text{Salt}]/[\text{Acid}])$
- **Basic Buffer:** $\text{pOH} = \text{pK}_b + \log([\text{Salt}]/[\text{Base}])$

Always remember to convert pOH to pH if the question asks for pH of a basic buffer.

---

41. Which of the following is CORRECT with respect to the property mentioned against it?

(A) Osmotic pressure at 298K : 0.1M NaCl solution $<$ 0.1M Urea solution

(B) Concentration of NaCl in the solution : 2ppm $>$ 2M

(C) ΔT_b : 0.02M Urea solution $>$ 0.02M NaCl solution

(D) Vapour pressure at 298K : Salt water $<$ Pure water

Correct Answer: (D) Vapour pressure at 298K : Salt water $<$ Pure water

Solution:

Step 1: Understanding Colligative Properties and Van't Hoff Factor (i).

Colligative properties (osmotic pressure, elevation in boiling point, depression in freezing point, relative lowering of vapour pressure) depend on the number of solute particles in a solution. For electrolytes like NaCl, we must consider their dissociation using the Van't Hoff factor (i).

- For NaCl, which dissociates into Na^+ and Cl^-, the theoretical Van't Hoff factor is i=2.
- For Urea, a non-electrolyte, i=1.

The effective concentration for colligative properties is i × Molarity.

Step 2: Evaluating each statement.

(A) Osmotic pressure (π) = iCRT:

- For 0.1M NaCl: effective concentration $= \text{i} \times 0.1\text{ M} = 2 \times 0.1\text{ M} = 0.2\text{ M}$.
- For 0.1M Urea: effective concentration $= \text{i} \times 0.1\text{ M} = 1 \times 0.1\text{ M} = 0.1\text{ M}$.

Since osmotic pressure is proportional to the effective concentration, the osmotic pressure of 0.1M NaCl solution should be greater than that of 0.1M Urea solution. The statement says the opposite, so it is incorrect.

(B) Concentration of NaCl in the solution: 2ppm > 2M:

- 2 ppm (parts per million) is a very dilute concentration (e.g., 2 mg of solute per 1 kg of solution).
- 2M (2 Molar) means 2 moles of solute per 1 litre of solution. Molar mass of NaCl ≈ 58.5 g/mol. So, 2M NaCl is $2 \times 58.5 = 117$ g of NaCl per litre.

Clearly, 2M is a much, much higher concentration than 2ppm. The statement is incorrect.

(C) Elevation in boiling point (ΔT_b) = iK_bm:

- For 0.02M Urea: effective concentration $\approx 1 \times 0.02\text{ M} = 0.02\text{ M}$.
- For 0.02M NaCl: effective concentration $\approx 2 \times 0.02\text{ M} = 0.04\text{ M}$.

Since ΔT_b is proportional to the effective concentration, the boiling point elevation for NaCl solution will be greater than for Urea solution. The statement says the opposite, so it is incorrect.

(D) Vapour pressure at 298K: Salt water < Pure water: This refers to the lowering of vapour pressure, a colligative property. According to Raoult's law, when a non-volatile solute (like salt) is dissolved in a solvent (like water), the vapour pressure of the solution is lower than that of the pure solvent. This is because the solute particles occupy some of the surface area, reducing the rate of evaporation of the solvent molecules. This statement is **correct**.

Step 3: Final Answer.

The correct statement is (D).

Quick Tip: For all colligative properties, remember that adding a non-volatile solute to a solvent will:

- Lower the freezing point.
- Elevate the boiling point.
- Lower the vapour pressure.
- Increase the osmotic pressure.

Also, always account for the Van't Hoff factor (i) for electrolytes.

---

42. Match List - I (Laws) with the List - II (Mathematical expressions):

List - I		**List - II**	
(a)	Henry's law	(i)	$P_1 = x_1 {P_1}^0$
(b)	Raoult's law	(ii)	$p = K_H x$
(c)	First law of thermodynamics	(iii)	$\Lambda_m^0 = \nu_+ \lambda_+^0 + \nu_- \lambda_-^0$
(d)	Kohlrausch's law	(iv)	$\Delta U = q + w$

Codes:

(A) a - i, b – ii, c - iii, d - iv

(B) a - ii, b – i, c - iii, d - iv

(C) a - ii, b – i, c – iv, d – iii

(D) a – i, b – ii, c – iv, d - iii

Correct Answer: (C) a - ii, b – i, c – iv, d – iii

Solution:

Step 1: Match each law with its mathematical expression.

(a) Henry's law: This law relates the partial pressure of a gas above a liquid to the concentration of the gas dissolved in the liquid. The mathematical form is $p = K_H x$, where p is the partial pressure of the gas, x is its mole fraction in the solution, and K_H is Henry's law constant. This matches with **(ii)**. So, **a** → **ii**.

(b) Raoult's law: This law states that for a solution of volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction. The expression is $P_1 = x_1 P_1^0$, where P_1 is the partial pressure of component 1, x_1 is its mole fraction, and ${P_1}^0$ is the vapour pressure of the pure component. This matches with **(i)**. So, **b** → **i**.

(c) First law of thermodynamics: This law is a statement of the conservation of energy. It states that the change in internal energy of a system (ΔU) is equal to the heat supplied to the system (q) plus the work done on the system (w). The equation is $\Delta U = q + w$. This matches with **(iv)**. So, **c** $\rightarrow$ **iv**.

(d) Kohlrausch's law: This law of independent migration of ions states that the limiting molar conductivity of an electrolyte (Λ_m^0) can be represented as the sum of the individual contributions of the anion and cation of the electrolyte. The expression is $\Lambda_m^0 = \nu_+\lambda_+^0 + \nu_-\lambda_-^0$, where ν_+ and ν_- are the number of cations and anions per formula unit, and λ_+^0 and λ_-^0 are their limiting molar conductivities. This matches with **(iii)**. So, **d** $\rightarrow$ **iii**.

Step 2: Compile the matches.

The correct matches are: a $\rightarrow$ ii, b $\rightarrow$ i, c $\rightarrow$ iv, d $\rightarrow$ iii.

Step 3: Final Answer.

This combination corresponds to option (C).

Quick Tip: It is crucial to be precise with the notation in physical chemistry laws:

- **Raoult's Law ($P_1 = x_1 P_1{}^0$):** The superscript '0' denotes the pure component.
- **Henry's Law ($p = K_H x$):** K_H is the constant for the gas-solvent pair.
- **Kohlrausch's Law:** Λ_m^0 refers to limiting molar conductivity (at infinite dilution).
- **First Law of Thermodynamics:** Pay attention to the sign convention for work (w). $\Delta U = q + w$ means w is work done *on* the system. $\Delta U = q - w$ means w is work done *by* the system. Both forms are valid if the convention is stated.

---

43. When 0.0106 mole of acetic acid was dissolved in 1 kg of water, the freezing point depression for this strength of acid was 0.0205 K. If the calculated freezing point depression is 0.0197 K, Van't Hoff factor (i) and degree of dissociation of acetic acid respectively are

(A) 0.041 and 1.041

(B) 1.041 and 0.1041

(C) 0.041 and 0.041

(D) 1.041 and 0.041

Correct Answer: (D) 1.041 and 0.041

Solution:

Step 1: Calculate the Van't Hoff factor (i).

The Van't Hoff factor (i) is the ratio of the observed colligative property to the calculated (theoretical) colligative property for a non-electrolyte.

$$i = \frac{\text{Observed colligative property}}{\text{Calculated colligative property}}$$

In this case, the colligative property is the depression in freezing point (ΔT_f).

- Observed $\Delta T_f = 0.0205$ K
- Calculated ΔT_f (assuming no dissociation, i=1) $= 0.0197$ K

$$i = \frac{0.0205 \text{ K}}{0.0197 \text{ K}} \approx 1.0406 \approx 1.041$$

Step 2: Relate the Van't Hoff factor (i) to the degree of dissociation (α).

Acetic acid (CH_3COOH) is a weak electrolyte that partially dissociates in water:

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

The relationship between i, α, and the number of ions produced (n) is given by:

$$i = 1 + (n-1)\alpha$$

For acetic acid, it dissociates into two ions (CH_3COO^- and H^+), so n = 2.

$$i = 1 + (2-1)\alpha = 1 + \alpha$$

Step 3: Calculate the degree of dissociation (α).

Rearranging the formula:

$$\alpha = i - 1$$

Substitute the value of i we calculated:

$$\alpha = 1.041 - 1 = 0.041$$

Step 4: Final Answer.

The Van't Hoff factor (i) is 1.041, and the degree of dissociation (α) is 0.041.

Quick Tip: Remember the two key formulas for Van't Hoff factor problems: 1. Definition: $i = \frac{\text{Observed Value}}{\text{Calculated Value}}$ 2. Relation with dissociation: $i = 1+(n-1)\alpha$ For association, the formula is $i = 1+(\frac{1}{n}-1)\alpha$. Be sure to correctly identify n (number of particles formed per formula unit).

---

44. The relative lowering of vapour pressure produced by dissolving 18 g of urea (Molar mass = 60 g mol^{-1}) in 100 g of water is

(A) 0.025

(B) 0.5

(C) 0.05

(D) 0.25

Correct Answer: (C) 0.05

Solution:

Step 1: Key Formula for Relative Lowering of Vapour Pressure (RLVP).

According to Raoult's law, the relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute (x_{solute}).

$$\text{RLVP} = \frac{P^0 - P}{P^0} = x_{solute}$$

Where:

$$x_{solute} = \frac{\text{moles of solute}}{\text{moles of solute} + \text{moles of solvent}}$$

Step 2: Calculate the moles of solute (urea) and solvent (water).

Moles of urea (n_1):

- Mass of urea = 18 g

- Molar mass of urea = 60 g/mol

$$n_1 = \frac{\text{mass}}{\text{molar mass}} = \frac{18\text{ g}}{60\text{ g/mol}} = 0.3\text{ mol}$$

Moles of water (n_2):

- Mass of water = 100 g
- Molar mass of water (H_2O) = 18 g/mol

$$n_2 = \frac{\text{mass}}{\text{molar mass}} = \frac{100\text{ g}}{18\text{ g/mol}} \approx 5.55\text{ mol}$$

Step 3: Calculate the mole fraction of the solute (urea).

$$x_{urea} = \frac{n_1}{n_1 + n_2} = \frac{0.3}{0.3 + 5.55} = \frac{0.3}{5.85}$$

$$x_{urea} \approx 0.05128$$

Step 4: Final Answer.

The relative lowering of vapour pressure is equal to the mole fraction of the solute, which is approximately 0.05.

Quick Tip: For dilute solutions, the mole fraction of the solute can be approximated as $x_{solute} \approx \frac{n_{solute}}{n_{solvent}}$. Let's check this approximation here: $\frac{0.3}{5.55} \approx 0.054$. This is also close to 0.05. This approximation is useful for quick calculations in multiple-choice questions.

---

45. During the electrolysis of acidified water, 16 g of O_2 gas is formed at anode. The volume of H_2 gas liberated at cathode under STP conditions is

(A) 22.4 L

(B) 11.2 L

(C) 2.24 L

(D) 1.12 L

Correct Answer: (A) 22.4 L

Solution:

Step 1: Write the half-reactions for the electrolysis of water.

At Anode (Oxidation):

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$

At Cathode (Reduction):

$$4H^+(aq) + 4e^- \rightarrow 2H_2(g)$$

(Alternatively, using water: $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$) From these balanced half-reactions, we see that for every 1 mole of O_2 produced, 2 moles of H_2 are produced. The molar ratio is $H_2 : O_2 = 2 : 1$.

Step 2: Calculate the moles of O_2 produced.

- Mass of $O_2 = 16$ g
- Molar mass of $O_2 = 32$ g/mol

$$\text{Moles of } O_2 = \frac{\text{mass}}{\text{molar mass}} = \frac{16 \text{ g}}{32 \text{ g/mol}} = 0.5 \text{ mol}$$

Step 3: Calculate the moles of H_2 produced.

Using the molar ratio from Step 1:

$$\text{Moles of } H_2 = 2 \times \text{Moles of } O_2 = 2 \times 0.5 \text{ mol} = 1 \text{ mol}$$

Step 4: Calculate the volume of H_2 at STP.

At Standard Temperature and Pressure (STP), 1 mole of any ideal gas occupies a volume of 22.4 liters.

$$\text{Volume of } H_2 = \text{moles} \times \text{molar volume at STP} = 1 \text{ mol} \times 22.4 \text{ L/mol} = 22.4 \text{ L}$$

Step 5: Final Answer.

The volume of H_2 gas liberated at the cathode is 22.4 L.

Quick Tip: A quick way to solve this is to remember that during the electrolysis of water, the volume of hydrogen produced is always double the volume of oxygen produced ($V_{H2} = 2V_{O2}$). Moles of O_2 = $16/32 = 0.5$ mol. Volume of O_2 at STP $= 0.5 \times 22.4 = 11.2$ L. Volume of H_2 $= 2 \times$ Volume of O_2 $= 2 \times 11.2$ L $= 22.4$ L.

---

46. $\Lambda_m^o(NH_4OH)$ is equal to

(A) $\Lambda_m^o(NH_4OH) + \Lambda_m^o(NH_4Cl)$ - $\Lambda_m^o(HCl)$

(B) $\Lambda_m^o(NH_4Cl) + \Lambda_m^o(NaOH)$ - $\Lambda_m^o(NaCl)$

(C) $\Lambda_m^o(NH_4Cl) + \Lambda_m^o(NaCl)$ - $\Lambda_m^o(NaOH)$

(D) $\Lambda_m^o(NaOH) + \Lambda_m^o(NaCl)$ - $\Lambda_m^o(NH_4Cl)$

Correct Answer: (B) $\Lambda_m^o(NH_4Cl) + \Lambda_m^o(NaOH)$ - $\Lambda_m^o(NaCl)$

Solution:

Step 1: Understanding Kohlrausch's Law and its Application.

Kohlrausch's law of independent migration of ions states that the limiting molar conductivity of an electrolyte (Λ_m^0) is the sum of the limiting ionic conductivities of its constituent ions. This law is particularly useful for determining the Λ_m^0 of weak electrolytes (like NH_4OH), which cannot be found by extrapolating a graph of Λ_m vs. $\sqrt{C}$. We can calculate it using the Λ_m^0 values of strong electrolytes.

Step 2: Expressing the target Λ_m^0 in terms of ionic conductivities.

We want to find $\Lambda_m^0(NH_4OH)$. According to Kohlrausch's law:

$$\Lambda_m^0(NH_4OH) = \lambda^0(NH_4^+) + \lambda^0(OH^-)$$

Our goal is to combine the Λ_m^0 values of strong electrolytes in a way that results in this expression.

Step 3: Analyzing the options.

Let's express the Λ_m^0 of the strong electrolytes in each option in terms of their ionic conductivities. We need to combine them to get $\lambda^0(NH_4^+) + \lambda^0(OH^-)$. Consider option (B): $\Lambda_m^o(NH_4Cl)$ + $\Lambda_m^o(NaOH)$ - $\Lambda_m^o(NaCl)$

- $\Lambda_m^o(NH_4Cl) = \lambda^0(NH_4^+) + \lambda^0(Cl^-)$

- $\Lambda_m^o(\text{NaOH}) = \lambda^0(\text{Na}^+) + \lambda^0(\text{OH}^-)$
- $\Lambda_m^o(\text{NaCl}) = \lambda^0(\text{Na}^+) + \lambda^0(\text{Cl}^-)$

Now, let's perform the combination:

$$[\lambda^0(\text{NH}_4^+) + \lambda^0(\text{Cl}^-)] + [\lambda^0(\text{Na}^+) + \lambda^0(\text{OH}^-)] - [\lambda^0(\text{Na}^+) + \lambda^0(\text{Cl}^-)]$$

$$= \lambda^0(\text{NH}_4^+) + \lambda^0(\text{Cl}^-) + \lambda^0(\text{Na}^+) + \lambda^0(\text{OH}^-) - \lambda^0(\text{Na}^+) - \lambda^0(\text{Cl}^-)$$

The $\lambda^0(\text{Cl}^-)$ and $\lambda^0(\text{Na}^+)$ terms cancel out, leaving:

$$= \lambda^0(\text{NH}_4^+) + \lambda^0(\text{OH}^-)$$

This is exactly equal to $\Lambda_m^0(\text{NH}_4\text{OH})$.

Step 4: Final Answer.

The correct combination is given in option (B).

Quick Tip: To solve these problems quickly, think like building with Lego blocks. You want the ions from your target weak electrolyte ($NH_4{}^+$ and OH^-). 1. Pick a strong electrolyte that provides the cation you need: NH_4Cl provides $NH_4{}^+$. 2. Pick a strong electrolyte that provides the anion you need: NaOH provides OH^-. 3. Now you have extra ions you don't want (Cl^- and Na^+). To remove them, subtract the Λ_m^0 of the strong electrolyte made from these unwanted ions: NaCl. So, you get: (NH_4Cl) + (NaOH) - (NaCl).

---

47. Given below are the half-cell reactions:

$Mn^{2+} + 2e^- \rightarrow Mn$ (E° = -1.18 V)

$Mn^{3+} + e^- \rightarrow Mn^{2+}$ (E° = +1.51 V)

The E°_{cell} for $3\,Mn^{2+} \rightarrow Mn + 2Mn^{3+}$ will be __________

(A) - 2.69 V, the reaction will not occur (Non-Spontaneous)

(B) 2.69 V, the reaction will occur (Spontaneous)

(C) - 0.33 V, the reaction will not occur (Non-Spontaneous)

(D) - 0.33 V, the reaction will occur (Spontaneous)

Correct Answer: (A) - 2.69 V, the reaction will not occur (Non-Spontaneous)

Solution:

Step 1: Identify the half-reactions as they occur in the overall reaction.

The overall reaction is: 3 $Mn^{2+} \rightarrow Mn + 2Mn^{3+}$. Let's break this down into oxidation and reduction half-reactions:

- **Reduction:** One Mn^{2+} ion is gaining 2 electrons to become Mn.

$$\mathrm{Mn^{2+}} + 2e^- \rightarrow \mathrm{Mn} \quad E^\circ_{red} = -1.18 \text{ V}$$

- **Oxidation:** Two Mn^{2+} ions are losing electrons to become two Mn^{3+} ions.

$$2\mathrm{Mn^{2+}} \rightarrow 2\mathrm{Mn^{3+}} + 2e^-$$

  This is the reverse of the second given half-reaction. When we reverse a half-reaction, we change the sign of its E°. The given reduction is: $Mn^{3+} + e^- \rightarrow Mn^{2+}$ ($E^\circ = +1.51$ V). So, the oxidation half-reaction is: $Mn^{2+} \rightarrow Mn^{3+} + e^-$ (E°_{ox} = -1.51 V).

Step 2: Calculate the standard cell potential (E°_{cell}).

The standard cell potential is the sum of the standard reduction potential and the standard oxidation potential.

$$E^\circ_{cell} = E^\circ_{reduction} + E^\circ_{oxidation}$$

Note: E° is an intensive property, so we do not multiply it by the stoichiometric coefficients. We just add the potentials for the identified half-reactions.

$$E^\circ_{cell} = (-1.18 \text{ V}) + (-1.51 \text{ V}) = -2.69 \text{ V}$$

Step 3: Determine the spontaneity of the reaction.

The spontaneity of an electrochemical reaction is determined by the sign of E°_{cell}.

- If $E^\circ_{cell} > 0$, the reaction is spontaneous under standard conditions ($\Delta G^\circ < 0$).
- If $E^\circ_{cell} < 0$, the reaction is non-spontaneous under standard conditions ($\Delta G^\circ > 0$).

Since E°_{cell} = -2.69 V, which is negative, the reaction is **non-spontaneous** and will not occur as written.

Step 4: Final Answer.

The E°_{cell} is -2.69 V, and the reaction is non-spontaneous.

Quick Tip: To calculate E°_{cell}, you can use either of these two equivalent formulas: 1. $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$ (where both potentials are reduction potentials). 2. $E^\circ_{cell} = E^\circ_{reduction} + E^\circ_{oxidation}$ (where you reverse the sign of the potential for the oxidation half-reaction). The second method is often less prone to errors. Remember that a negative E°_{cell} means the reaction is not spontaneous in the forward direction.

---

48. The conductivity of centimolar solution of KCl at 298 K is 0.021 Ohm^{-1} cm^{-1} and the resistance of the cell containing the solution at 298 K is 60 Ω. The value of cell constant (G*) is

(A) 3.28 cm^{-1}

(B) 1.26 cm^{-1}

(C) 3.34 cm^{-1}

(D) 1.34 cm^{-1}

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

Solution:

Step 1: Key Formula relating conductivity, resistance, and cell constant.

The relationship between these three quantities is:

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

The cell constant is defined as the ratio of the distance between the electrodes (l) to their area of cross-section (A), $G^* = l/A$.

Step 2: Identify the given values.

- Conductivity $(\kappa) = 0.021\ \Omega^{-1}\ \text{cm}^{-1}$
- Resistance $(R) = 60\ \Omega$
- Cell Constant $(G^*) = ?$

The concentration ("centimolar", which is 0.01 M) is extra information and not needed for this specific calculation.

Step 3: Rearrange the formula and calculate the cell constant.

From the formula $\kappa = \frac{G^*}{R}$, we can rearrange to solve for G*:

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

Substitute the given values:

$$G^* = (0.021\ \Omega^{-1}\text{cm}^{-1}) \times (60\ \Omega)$$

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

The units are consistent: $\Omega^{-1}\ \text{cm}^{-1} \times \Omega = \text{cm}^{-1}$.

Step 4: Final Answer.

The value of the cell constant is $1.26\ \text{cm}^{-1}$.

Quick Tip: Remember the fundamental relationships in conductivity measurements:

- Resistance $R = \rho \frac{l}{A}$
- Conductance $G = \frac{1}{R}$
- Resistivity ρ
- Conductivity $\kappa = \frac{1}{\rho}$
- Cell Constant $G^* = \frac{l}{A}$

From these, you can derive the key working equation: $\kappa = G \times G^* = \frac{G^*}{R}$.

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49. Which one of the following graph is not applicable for a 1st order reaction (R → P)?

(A) A graph of [R] vs t with a downward sloping curve.

(B) A graph of ln[R] vs t with a downward sloping straight line.

(C) A graph of $\log_{10}$[R] vs t with an upward sloping straight line.

(D) A graph of $\log_{10}([R]_0/[R])$ vs t with an upward sloping straight line through the origin.

Correct Answer: (C) A graph of $\log_{10}[R]$ vs t with an upward sloping straight line.

Solution:

Step 1: Key Formula - The Integrated Rate Law for a First-Order Reaction.

The integrated rate law for a first-order reaction can be expressed in several forms:

1. $[R] = [R]_0 e^{-kt}$
2. $\ln[R] = \ln[R]_0 - kt$
3. $\log_{10}[R] = \log_{10}[R]_0 - \frac{k}{2.303}t$
4. $k = \frac{2.303}{t}\log_{10}\left(\frac{[R]_0}{[R]}\right) \implies \log_{10}\left(\frac{[R]_0}{[R]}\right) = \frac{k}{2.303}t$

where [R] is the concentration of reactant at time t, $[R]_0$ is the initial concentration, and k is the rate constant.

Step 2: Analyze each graph based on the integrated rate laws.

(A) [R] vs t: From equation (1), $[R] = [R]_0 e^{-kt}$, the concentration of the reactant decreases exponentially with time. This corresponds to a downward sloping curve. This graph is applicable. (The image shows an upward arrow from [R], which is confusing, but the concept of a curve is correct).

(B) ln[R] vs t: From equation (2), $\ln[R] = -kt + \ln[R]_0$. This is in the form of a linear equation y = mx + c, where y = ln[R], x = t, the slope m = -k, and the y-intercept c = $\ln[R]_0$. Since the slope (-k) is negative, this is a downward sloping straight line. This graph is applicable.

(C) $\log_{10}$[R] vs t: From equation (3), $\log_{10}[R] = -\left(\frac{k}{2.303}\right)t + \log_{10}[R]_0$. This is also in the form y = mx + c, where y = $\log[R]$, x = t, and the slope m = $-\frac{k}{2.303}$. The slope is negative. The graph should be a downward sloping straight line. The option shows an upward sloping line. This graph is **not applicable**.

(D) $\log_{10}([R]_0/[R])$ vs t: From equation (4), $\log_{10}\left(\frac{[R]_0}{[R]}\right) = \left(\frac{k}{2.303}\right)t$. This is in the form y = mx, where y = $\log([R]_0/[R])$, x = t, and the slope m = $\frac{k}{2.303}$. Since the slope is positive, this is an upward sloping straight line passing through the origin. This graph is applicable.

Step 3: Final Answer.

The graph of log$[R]$ vs t should be a straight line with a negative slope. The graph shown in option (C) has a positive slope and is therefore not applicable to a first-order reaction.

Quick Tip: Memorize the linear plots for different reaction orders:

- **Zero Order:** [R] vs. t is a straight line with slope = -k.
- **First Order:** ln[R] vs. t is a straight line with slope = -k.
- **Second Order:** 1/[R] vs. t is a straight line with slope = k.

Knowing these plots is the fastest way to solve such graphical questions.

---

50. For a reaction having three steps, the overall rate constant is K = $\frac{k_1 k_3}{k_2}$. The values of E_{a1}, E_{a2}, and E_{a3} (activation energies stepwise) are 40, 50 and 60 kJ mol^{-1} respectively. Then the overall E_a (activation energy) of the reaction is

(A) 30 kJ mol^{-1}

(B) 40 kJ mol^{-1}

(C) 50 kJ mol^{-1}

(D) 60 kJ mol^{-1}

Correct Answer: (C) 50 kJ mol^{-1}

Solution:

Step 1: Relate the overall rate constant to the Arrhenius equation.

The Arrhenius equation relates the rate constant (k) to the activation energy (E_a):

$$k = Ae^{-E_a/RT}$$

We can apply this relationship to the overall rate constant K and the individual rate constants k_1, k_2, and k_3.

$$K = A_{overall}e^{-E_{a,overall}/RT}$$

$$k_1 = A_1 e^{-E_{a1}/RT}$$

$$k_2 = A_2 e^{-E_{a2}/RT}$$

$$k_3 = A_3 e^{-E_{a3}/RT}$$

Step 2: Substitute the Arrhenius expressions into the given overall rate constant equation.

The given relation is:

$$K = \frac{k_1 k_3}{k_2}$$

Substituting the Arrhenius forms:

$$Ae^{-E_a/RT} = \frac{(A_1 e^{-E_{a1}/RT})(A_3 e^{-E_{a3}/RT})}{(A_2 e^{-E_{a2}/RT})}$$

Assuming $A = \frac{A_1 A_3}{A_2}$, we can focus on the exponential parts:

$$e^{-E_a/RT} = \frac{e^{-E_{a1}/RT} \cdot e^{-E_{a3}/RT}}{e^{-E_{a2}/RT}}$$

Using the rule $e^a \cdot e^b = e^{a+b}$ and $e^a/e^b = e^{a-b}$:

$$e^{-E_a/RT} = e^{(-E_{a1}/RT)+(-E_{a3}/RT)-(-E_{a2}/RT)}$$

$$e^{-E_a/RT} = e^{(-E_{a1}-E_{a3}+E_{a2})/RT}$$

Step 3: Equate the exponents to find the overall activation energy (E$_a$).

For the equality to hold, the exponents must be equal:

$$-\frac{E_a}{RT} = \frac{-E_{a1} - E_{a3} + E_{a2}}{RT}$$

Multiplying by -RT, we get:

$$E_a = E_{a1} + E_{a3} - E_{a2}$$

Step 4: Substitute the given values and calculate E$_a$.

We are given:

- $E_{a1} = 40$ kJ mol^{-1}
- $E_{a2} = 50$ kJ mol^{-1}
- $E_{a3} = 60$ kJ mol^{-1}

$$E_a = (40) + (60) - (50)$$

$$E_a = 100 - 50 = 50 \text{ kJ mol}^{-1}$$

Step 5: Final Answer.

The overall activation energy of the reaction is 50 kJ mol^{-1}.

Quick Tip: A quick shortcut for such problems is to remember the relationship between the overall activation energy and the individual activation energies based on the rate constant expression. If $K = \frac{k_1 k_3}{k_2}$, then the overall activation energy is $E_a = E_{a1} + E_{a3} - E_{a2}$. Essentially, activation energies from the numerator are added, and those from the denominator are subtracted.

---

51. For a 1st order change R → P, the concentration of Reactant R changes from 0.1 M to 0.025 M in 40 minutes. The rate of reaction when the concentration of R is 0.01 M is

(A) 1.73×10^{-5} M min^{-1}

(B) 3.47×10^{-4} M min^{-1}

(C) 3.47×10^{-5} M min^{-1}

(D) 1.73×10^{-4} M min^{-1}

Correct Answer: (B) 3.47×10^{-4} M min^{-1}

Solution:

Step 1: Understanding the Question:

The question asks for the rate of a first-order reaction at a specific concentration (0.01 M). To find this, we first need to determine the rate constant (k) using the time taken for a given change in concentration.

Step 2: Key Formula or Approach:

For a first-order reaction:

1. Integrated rate law: $k = \frac{2.303}{t} \log\left(\frac{[R]_0}{[R]_t}\right)$
2. Rate law: $\text{Rate} = k[R]$
3. Relation between k and half-life $t_{1/2}$: $k = \frac{0.693}{t_{1/2}}$

Step 3: Detailed Explanation:

1. Finding the Rate Constant (k):

Initial concentration, $[R]_0 = 0.1$ M.

Final concentration after 40 min, $[R]_t = 0.025$ M.

Notice that $\frac{[R]_t}{[R]_0} = \frac{0.025}{0.1} = \frac{1}{4}$.

Since the concentration becomes one-fourth, two half-lives have passed in 40 minutes ($0.1 \to 0.05 \to 0.025$).

Therefore, $2 \times t_{1/2} = 40 \text{ min} \implies t_{1/2} = 20$ min.

Now, calculate the rate constant k:

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{20 \text{ min}} = 0.03465 \text{ min}^{-1}$$

2. Calculating the Rate of Reaction:

We need the rate when $[R] = 0.01$ M.

$$\text{Rate} = k \times [R]$$

$$\text{Rate} = 0.03465 \text{ min}^{-1} \times 0.01 \text{ M}$$

$$\text{Rate} = 0.0003465 \text{ M min}^{-1} = 3.465 \times 10^{-4} \text{ M min}^{-1}$$

Rounding to three significant figures, we get 3.47×10^{-4} M min^{-1}.

Step 4: Final Answer:

The rate is 3.47×10^{-4} M min^{-1}, which corresponds to option (B).

Quick Tip: For first-order reactions, always check if the concentration change is a power of 2 (like $1/2, 1/4, 1/8$). If it is, you can skip the logarithmic formula and find the half-life directly by dividing the total time by the number of half-lives.

---

52. The activation energy for the reaction X → Y is 150 kJ mol^{-1}. The change in enthalpy for the above reaction is -135 kJ mol^{-1}. Then the activation energy for Y → X is

(A) 280 kJ mol^{-1}

(B) 285 kJ mol^{-1}

(C) 270 kJ mol^{-1}

(D) 15 kJ mol^{-1}

Correct Answer: (B) 285 kJ mol^{-1}

Solution:

Step 1: Understanding the relationship between activation energies and enthalpy change.

For a reversible reaction, the activation energy of the forward reaction ($E_{a,f}$), the activation energy of the reverse reaction ($E_{a,b}$), and the enthalpy change of the reaction (ΔH) are related. This can be visualized with a reaction profile diagram. The relationship is:

$$\Delta H = E_{a,f} - E_{a,b}$$

Where:

- ΔH is the enthalpy change of the forward reaction.
- $E_{a,f}$ is the activation energy of the forward reaction (X → Y).
- $E_{a,b}$ is the activation energy of the backward/reverse reaction (Y → X).

Step 2: Identify the given values.

- Activation energy for the forward reaction, $E_{a,f} = 150$ kJ mol^{-1}
- Enthalpy change, $\Delta H = -135$ kJ mol^{-1} (The reaction is exothermic).
- We need to find the activation energy for the reverse reaction, $E_{a,b}$.

Step 3: Rearrange the formula and calculate $E_{a,b}$.

$$E_{a,b} = E_{a,f} - \Delta H$$

Substitute the given values:

$$E_{a,b} = (150 \text{ kJ mol}^{-1}) - (-135 \text{ kJ mol}^{-1})$$

$$E_{a,b} = 150 + 135 = 285 \text{ kJ mol}^{-1}$$

Step 4: Final Answer.

The activation energy for the reverse reaction (Y → X) is 285 kJ mol^{-1}.

Quick Tip: Drawing a simple energy profile diagram can help you visualize the relationship and avoid sign errors. 1. Draw the energy level for reactants (X). 2. Since ΔH is negative (exothermic), draw the energy level for products (Y) lower than X. The difference is 135. 3. Draw the transition state peak. The energy barrier from X to the peak is $E_{a,f} = 150$. 4. The activation energy for the reverse reaction, $E_{a,b}$, is the energy barrier from Y to the peak. 5. From the diagram, you can see that $E_{a,b} = E_{a,f} + |\Delta H| = 150 + 135 = 285$.

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53. The intermediates in heteropolar reactions are

(A) Free radicals only

(B) Cations only

(C) Anions only

(D) Both anions and cations

Correct Answer: (D) Both anions and cations

Solution:

Step 1: Understanding Bond Fission.

Chemical reactions involve the breaking of existing bonds and the formation of new bonds. The breaking of a covalent bond, known as bond fission, can occur in two ways:

1. **Homolytic Fission (Homolysis):** The shared pair of electrons is distributed equally between the two separating atoms. This results in the formation of neutral species with

an unpaired electron, called **free radicals**. These reactions are typically initiated by heat, light, or peroxides and are called homopolar reactions.
Example: $A : B \rightarrow A \cdot + \cdot B$

2. **Heterolytic Fission (Heterolysis):** The shared pair of electrons is transferred completely to one of the atoms. This results in the formation of a positively charged ion (**cation**) and a negatively charged ion (**anion**). This type of fission occurs in polar bonds and is often facilitated by polar solvents. Reactions involving these charged intermediates are called **heteropolar reactions** or ionic reactions.
Example: $A : B \rightarrow A^{+} + : B^{-}$ (if B is more electronegative)

Step 2: Identifying Intermediates in Heteropolar Reactions.
As defined above, heteropolar reactions proceed through heterolytic bond fission. This process generates charged intermediates. Depending on which atom takes the electron pair, either a cation or an anion (or both, in different steps of a mechanism) can be formed as intermediates. For example, in electrophilic addition to an alkene, a carbocation is formed. In nucleophilic substitution, a carbocation (S_N1) or a transition state with developing charges is formed. In reactions involving carbanions, an anion is the intermediate. Therefore, the intermediates in heteropolar reactions are charged species, which can be either cations or anions.

Step 3: Final Answer.
The intermediates in heteropolar reactions are both anions and cations.

Quick Tip: Associate the prefixes with the type of fission and intermediates:

- **HOMO-** (meaning "same"): Homolytic fission → electrons split the **same** way → forms neutral **free radicals**.
- **HETERO-** (meaning "different"): Heterolytic fission → electrons split a **different** way → forms charged **ions** (cations and anions).

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54. Statement I: Nitrogen in pyridine cannot be estimated by Kjeldahl's method
Statement II: Nitrogen in pyridine changes to ammonium sulphate when heated with conc.

H_2SO_4 in Kjeldahl's method.

Read the above given statements and choose the correct answer from the given options.

(A) Statement I is true but Statement II is false

(B) Both Statement I and Statement II are false

(C) Both Statement I and Statement II are true

(D) Statement I is false but Statement II is true

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

Solution:

Step 1: Analyzing Statement I.

Kjeldahl's method is a classical method for the quantitative determination of nitrogen in organic compounds. However, it has limitations. The method is not applicable to compounds where the nitrogen atom is part of a heterocyclic ring (like pyridine), or in nitro (-NO_2) and azo (-N=N-) groups. This is because the nitrogen in these compounds is very stable and is not completely converted to ammonium sulfate under the conditions of the digestion step. Therefore, the statement that nitrogen in pyridine cannot be estimated by Kjeldahl's method is **true**.

Step 2: Analyzing Statement II.

This statement claims that the nitrogen in pyridine *does* change to ammonium sulfate when heated with concentrated H_2SO_4. This contradicts the reason why Kjeldahl's method fails for pyridine. The nitrogen atom in the pyridine ring is part of an aromatic system, which makes it very resistant to the acid digestion. It does not get converted to ammonium sulfate. Therefore, Statement II is **false**.

Step 3: Conclusion.

Statement I is true because Kjeldahl's method has limitations and does not work for heterocyclic compounds like pyridine. Statement II is false because the reason the method fails is precisely that the nitrogen is *not* converted to ammonium sulfate.

Step 4: Final Answer.

Statement I is true but Statement II is false.

Quick Tip: Remember the key limitations of the Kjeldahl method for nitrogen estimation. It fails for compounds containing:

- Nitrogen in a ring (e.g., Pyridine, Quinoline).
- Nitro groups (-NO_2).
- Azo groups (-N=N-).

This is a frequently tested exception in qualitative and quantitative analysis.

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55. The number of chain isomers possible for the hydrocarbon with molecular formula C_5H_{12} is

(A) 4

(B) 3

(C) 2

(D) 1

Correct Answer: (B) 3

Solution:

Step 1: Understanding the Question:

The question asks for the number of chain isomers for the alkane with the molecular formula C_5H_{12}, which is pentane. Chain isomers are structural isomers that differ in the arrangement of their carbon skeleton.

Step 2: Detailed Explanation:

To find all chain isomers, we systematically vary the carbon chain length and add branches:

1. **n-Pentane:** The five carbon atoms are arranged in a single continuous straight chain.

Structure: $CH_3-CH_2-CH_2-CH_2-CH_3$

2. **Isopentane (2-Methylbutane):** The parent chain consists of four carbon atoms, with one methyl ($-CH_3$) group branched off the second carbon.

Structure: $CH_3-CH(CH_3)-CH_2-CH_3$

3. **Neopentane (2,2-Dimethylpropane):** The parent chain consists of three carbon atoms, with two methyl groups branched off the central carbon atom.

Structure: $CH_3 - C(CH_3)_2 - CH_3$

Further branching is not possible for five carbon atoms without repeating one of these structures or violating valency rules.

Step 3: Final Answer:

Thus, there are exactly three chain isomers for the molecular formula C_5H_{12}, which corresponds to option (B).

Quick Tip: For alkanes, the number of structural isomers increases as the number of carbon atoms increases. It is helpful to remember the counts for smaller alkanes:

- Butane (C_4): 2 isomers
- Pentane (C_5): 3 isomers
- Hexane (C_6): 5 isomers
- Heptane (C_7): 9 isomers

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56. The compound with molecular formula $C_{20}H_{42}$ is

(A) Decane

(B) Dodecane

(C) Eicosane

(D) Hicosane

Correct Answer: (C) Eicosane

Solution:

Step 1: Identify the type of hydrocarbon.

The molecular formula is $C_{20}H_{42}$. This fits the general formula for alkanes, C_nH_{2n+2}. For n=20, 2n+2 $= 2(20) + 2 = 40 + 2 = 42$. So, the compound is a 20-carbon alkane.

Step 2: Recall the IUPAC nomenclature for alkanes.

The root name of an alkane indicates the number of carbon atoms in its longest chain. We need to identify the root name for a 20-carbon chain.

- (A) **Decane**: "Deca-" means 10. So, $C_{10}H_{22}$.
- (B) **Dodecane**: "Do-" (2) + "deca-" (10) means 12. So, $C_{12}H_{26}$.
- (C) **Eicosane**: "Eicosa-" is the Greek prefix for 20. So, $C_{20}H_{42}$.
- (D) **Hicosane**: This is a common misspelling of Eicosane.

Step 3: Final Answer.

The correct name for the alkane with the molecular formula $C_{20}H_{42}$ is Eicosane.

Quick Tip: Memorize the IUPAC root names for carbon chains, especially beyond ten carbons, as they are often tested.

- 11: Undecane
- 12: Dodecane
- 13: Tridecane
- 20: Eicosane
- 30: Triacontane

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57. C-Cl bond in methyl chloride compared to C-Cl bond in chlorobenzene is

(A) Longer and stronger

(B) Shorter and stronger

(C) Shorter and weaker

(D) Longer and weaker

Correct Answer: (D) Longer and weaker

Solution:

Step 1: Analyze the bonding in methyl chloride (CH_3Cl).

In methyl chloride, the chlorine atom is bonded to a carbon atom that is sp^3 hybridized. The C-Cl bond is a pure single (σ) bond.

Step 2: Analyze the bonding in chlorobenzene (C_6H_5Cl).
In chlorobenzene, the chlorine atom is bonded to a carbon atom that is part of the benzene ring. This carbon atom is sp^2 hybridized. Furthermore, the lone pairs of electrons on the chlorine atom can participate in resonance with the π-electron system of the benzene ring. This resonance delocalization gives the C-Cl bond a **partial double bond character**.

Step 3: Compare the bond length and bond strength.
Bond Length:

- A single bond is longer than a double bond.
- The C(sp^2)-Cl bond in chlorobenzene has partial double bond character, making it **shorter** than the C(sp^3)-Cl single bond in methyl chloride.
- Also, an sp^2 hybrid orbital has more s-character (33.3%) than an sp^3 hybrid orbital (25%). More s-character leads to shorter and stronger bonds.

Therefore, the C-Cl bond in methyl chloride is **longer**.

Bond Strength:

- A double bond is stronger than a single bond.
- Because the C-Cl bond in chlorobenzene has partial double bond character, it is **stronger** than the pure single C-Cl bond in methyl chloride.

Therefore, the C-Cl bond in methyl chloride is **weaker**.

Step 4: Final Answer.
Combining the two comparisons, the C-Cl bond in methyl chloride is **longer and weaker** than the C-Cl bond in chlorobenzene.

Quick Tip: Remember these two key factors when comparing bonds to a benzene ring with bonds to a simple alkyl group: 1. **Hybridization:** A bond to an sp^2 carbon is shorter and stronger than a bond to an sp^3 carbon. 2. **Resonance:** Resonance can introduce partial double bond character, which shortens and strengthens the bond. Both factors work in the same direction for chlorobenzene, making its C-Cl bond shorter and stronger.

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58. The compound from which chlorobenzene cannot be prepared easily is

(A) Aniline

(B) Benzene

(C) Phenol

(D) Benzene diazonium chloride

Correct Answer: (C) Phenol

Solution:

Step 1: Evaluate the synthesis of chlorobenzene from each starting material.

(A) Aniline ($C_6H_5NH_2$): Aniline can be easily converted to chlorobenzene via the Sandmeyer reaction. First, aniline is treated with $NaNO_2$/HCl at 0-5°C to form benzene diazonium chloride. This is then treated with CuCl/HCl to yield chlorobenzene. This is a standard and easy preparation.

$$C_6H_5NH_2 \xrightarrow{NaNO_2,HCl} C_6H_5N_2^+Cl^- \xrightarrow{CuCl/HCl} C_6H_5Cl$$

(B) Benzene (C_6H_6): Chlorobenzene is prepared commercially by the direct halogenation of benzene. This is an electrophilic aromatic substitution reaction carried out by reacting benzene with chlorine in the presence of a Lewis acid catalyst like $FeCl_3$ or $AlCl_3$. This is an easy and direct method.

$$C_6H_6 + Cl_2 \xrightarrow{FeCl_3} C_6H_5Cl + HCl$$

(C) Phenol (C_6H_5OH): The C-O bond in phenol is very strong and difficult to break. This is because the lone pair of electrons on the oxygen atom participates in resonance with the benzene ring, giving the C-O bond a partial double bond character. Simple reagents used to convert aliphatic alcohols to alkyl chlorides (like HCl, $SOCl_2$, PCl_5) do not work effectively with phenol to produce chlorobenzene. The reaction is not easy and requires harsh conditions with very low yield.

(D) Benzene diazonium chloride ($C_6H_5N_2{}^+Cl^-$): This is an excellent starting material for preparing chlorobenzene. As mentioned in part (A), treatment with cuprous chloride (CuCl) in HCl (Sandmeyer reaction) or with copper powder in HCl (Gattermann reaction) easily converts it to chlorobenzene.

Step 2: Final Answer.

Due to the partial double bond character of the C-O bond, it is very difficult to prepare chlorobenzene from phenol. Therefore, this is the compound from which chlorobenzene cannot be prepared easily.

Quick Tip: The reactivity of the C-X bond (where X is a heteroatom like O, N, or a halogen) attached to a benzene ring is very different from its aliphatic counterpart. Resonance makes the bond stronger and less susceptible to nucleophilic substitution. This is why phenols are not easily converted to haloarenes.

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59. In S_N1 reaction, the alkyl halide that on hydrolysis produces racemic mixture is

(A) Tertiary butyl bromide

(B) 2-bromobutane

(C) Isopropyl bromide

(D) Methyl bromide

Correct Answer: (B) 2-bromobutane

Solution:

Step 1: Understanding Racemization in S_N1 Reactions.

The S_N1 reaction mechanism proceeds through a carbocation intermediate. If the carbocation is formed at a chiral center, the intermediate will be planar (sp^2 hybridized) and achiral. The incoming nucleophile can then attack this planar carbocation from either the front side or the back side with equal probability. This leads to the formation of both possible enantiomers in equal amounts. A 50:50 mixture of two enantiomers is called a **racemic mixture**. Therefore, for a racemic mixture to be produced, the starting alkyl halide must be **chiral**.

Step 2: Analyzing the Chirality of the given Alkyl Halides.

A molecule is chiral if it has a carbon atom bonded to four different groups. Let's examine each option.

(A) Tertiary butyl bromide ($(CH_3)_3$C-Br): The carbon atom bonded to bromine is also bonded to three identical methyl groups. It is not a chiral center. The product, tert-butanol, is also achiral.

(B) 2-bromobutane (CH_3-CH(Br)-CH_2-CH_3): The second carbon atom is bonded to four different groups: a hydrogen atom (-H), a bromine atom (-Br), a methyl group (-CH_3), and an ethyl group (-CH_2CH_3). Therefore, 2-bromobutane is **chiral**. Its hydrolysis via the S_N1 mechanism will form a planar secondary carbocation, which upon attack by H_2O will produce a racemic mixture of (R)-butan-2-ol and (S)-butan-2-ol.

(C) Isopropyl bromide ($(CH_3)_2$CH-Br): The carbon atom bonded to bromine is also bonded to two identical methyl groups. It is not a chiral center.

(D) Methyl bromide (CH_3Br): The carbon atom is bonded to three identical hydrogen atoms. It is not a chiral center. (Also, methyl halides primarily undergo S_N2 reactions).

Step 3: Final Answer.

Only 2-bromobutane is a chiral alkyl halide among the options. Therefore, its hydrolysis via an S_N1 mechanism will produce a racemic mixture.

Quick Tip: To predict racemization in a substitution reaction, check two conditions: 1. The reaction must proceed via an S_N1 mechanism (favored by $3^\circ > 2^\circ$ halides, polar protic solvents). 2. The carbon atom bearing the leaving group in the starting material must be a chiral center. If both conditions are met, racemization is the expected outcome.

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60. Match the compounds of List-I with their effects in List-II

List-I		**List-II**	
(a)	Chloramphenicol	(i)	Malaria
(b)	Thyroxine	(ii)	Anesthetic
(c)	Chloroquine	(iii)	Goiter
(d)	Chloroform	(iv)	Typhoid fever

Codes:

(A) a – i, b – ii, c – iii, d – iv

(B) a - iv, b - iii, c - i, d - ii

(C) a – i, b – iii, c – iv, d – ii

(D) a – iv, b – iii, c – ii, d - i

Correct Answer: (B) a - iv, b - iii, c - i, d - ii

Solution:

Step 1: Match each compound with its known use or associated condition.

(a) Chloramphenicol: This is a broad-spectrum antibiotic. It is effective against a variety of bacterial infections, and it is particularly used for the treatment of **Typhoid fever**. So, **a** → **iv**.

(b) Thyroxine: This is the main hormone produced by the thyroid gland. It is an iodine-containing hormone. A deficiency of iodine in the diet leads to insufficient production of thyroxine, which can cause the enlargement of the thyroid gland, a condition known as **Goiter**. So, thyroxine is related to goiter. **b** → **iii**.

(c) Chloroquine: This is a well-known synthetic drug used for the treatment and prevention of **Malaria**. So, **c** → **i**.

(d) Chloroform ($CHCl_3$): In the past, chloroform was widely used as a general **anesthetic** during surgery. Its use has been largely replaced due to its toxicity, but its historical association with anesthesia is very strong. So, **d** → **ii**.

Step 2: Compile the matches.

The correct matches are:

- a → iv
- b → iii

- c → i

- d → ii

Step 3: Final Answer.

This combination corresponds to option (B).

Quick Tip: Questions on "Chemistry in Everyday Life" are often based on direct memorization. Creating a table or flashcards linking common drugs/chemicals to their specific uses (e.g., antibiotic, antimalarial, anesthetic) or associated diseases is an effective study strategy.