JEE Main 2023 April 12 Shift 1 Question Paper with Solutions

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

General Instructions

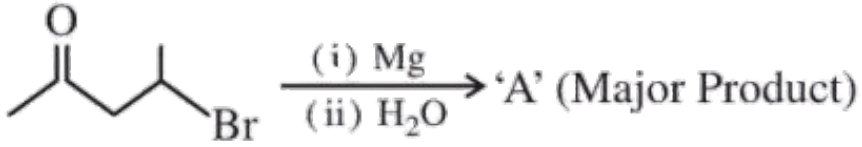
Read the following instructions very carefully and strictly follow them:

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

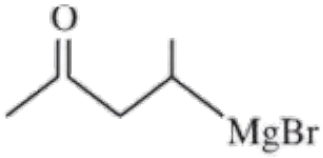
CHEMISTRY

Section-A

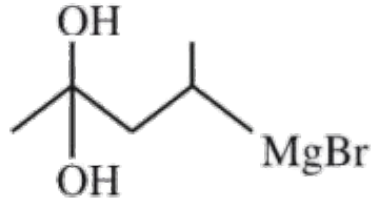
61. The compound shown below undergoes the following reactions:

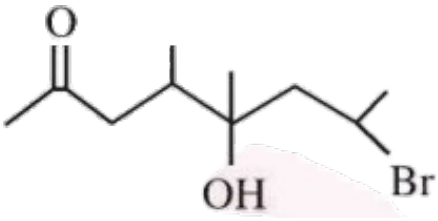


A is

(1) 

(2) 

(3) 

(4) 

Correct Answer: (4)

Solution: The reaction shown involves the conversion of an alkyl bromide to an alcohol in two steps.

1. First, the reaction with magnesium (Mg) in dry ether will convert the alkyl bromide to a Grignard reagent:

$$C_6H_5Br + Mg \xrightarrow{\text{ether}} C_6H_5MgBr$$

This results in the formation of the Grignard reagent, which is an organomagnesium compound.

2. In the second step, the Grignard reagent reacts with water (H_2O):

$$C_6H_5MgBr + H_2O \rightarrow C_6H_5OH + MgBr$$

The final product is phenol (C6H5OH), formed by the addition of a hydroxyl group (OH) to the carbon atom that was originally bonded to the bromine atom.

Thus, the major product is the phenol, which is option (4).

Therefore, the correct answer is $\boxed{4}$.

Quick Tip

When an alkyl halide reacts with magnesium in ether, it forms a Grignard reagent. This reacts with water to produce an alcohol as the major product.

---

62. Four gases A, B, C, and D have critical temperatures 5.3, 33.2, 126.0, and 154.3 K respectively.

For their adsorption on a fixed amount of charcoal, the correct order is:

(1) C > B > D > A.

(2) C > D > B > A.

(3) D > C > A > B.

(4) D > C > B > A.

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

Solution:

The extent of adsorption of gases on a fixed amount of charcoal is generally proportional to the critical temperature of the gas. The critical temperature is the temperature above which a gas cannot be liquefied, no matter how much pressure is applied.

Gases with higher critical temperatures tend to have stronger intermolecular forces and thus higher adsorption on a surface like charcoal. This is because at higher critical temperatures, the molecules have stronger interactions and are more easily adsorbed.

From the given critical temperatures:

Gas D has the highest critical temperature (154.3 K),

Gas C has the second-highest critical temperature (126.0 K),

Gas B has a lower critical temperature (33.2 K),

Gas A has the lowest critical temperature (5.3 K).

Thus, the correct order of adsorption (highest to lowest) is:

$$D > C > B > A.$$

Quick Tip

The extent of adsorption on a solid surface generally increases with the critical temperature of the gas. Higher critical temperatures result in stronger intermolecular interactions, leading to greater adsorption.

---

63. Given below are two statements:

Assertion A: 5f electrons can participate in bonding to a far greater extent than 4f electrons.

Reason R: 5f orbitals are not as buried as 4f orbitals.

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

(1) Both A and R are true but R is NOT the correct explanation of A.

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

(3) A is false but R is true.

(4) A is true but R is false.

Correct Answer: (2) Both A and R are true and R is the correct explanation of A.

Solution:

The 5f orbitals are less buried than the 4f orbitals. Therefore, electrons in 5f orbitals experience less nuclear attraction compared to electrons in 4f orbitals. This allows electrons in 5f orbitals to participate more readily in bonding. Hence, Statement A is true, and Reason R correctly explains the greater bonding capacity of 5f electrons.

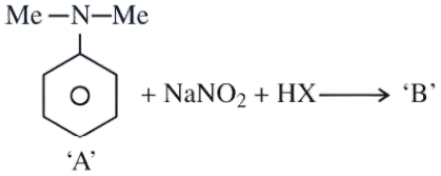
Thus, the correct answer is that both statements are true, and R is the correct explanation of A.

Quick Tip

In transition metals, the 5f orbitals are less shielded than the 4f orbitals, making them more available for bonding. This is why 5f electrons can participate in bonding more than 4f electrons.

---

64. The incorrect statement regarding the reaction given below is:



(1) The electrophile involved in the reaction is NO^+

(2) 'B' is N-nitroso ammonium compound

(3) The reaction occurs at low temperature

(4) The product 'B' formed in the above reaction is p-nitroso compound at low temperature

Correct Answer: (2) 'B' is N-nitroso ammonium compound

Solution:

The given reaction involves the nitrosation of an amine group using sodium nitrite ($NaNO_2$) and an acid (HX).

The nitrosonium ion (NO^+) is the electrophile involved in this reaction, attacking the nitrogen of the amine group, leading to the formation of a nitroso product.

The product formed is a nitroso compound, not an N-nitroso ammonium compound. An N-nitroso ammonium compound would imply that both the nitroso group and ammonium group are attached to the same nitrogen atom, which is not the case here.

Thus, option (2) is the incorrect statement.

$\boxed{(2)'B'isN-nitrosoammoniumcompound.}$

Quick Tip

In diazotization reactions, the nitrosonium ion (NO^+) acts as the electrophile and reacts with amines to form nitroso compounds.

---

65. Match List I with List II

LIST I Complex		LIST II CFSE(Δ_0)	
A.	$[Cu(NH_3)_6]^{2+}$	I.	-0.6
B.	$[Ti(N_2O)_6]^{3+}$	II.	-2.0
C.	$[Fe(CN)_6]^{3-}$	III.	-1.2
D.	$[NiF_6]^{4-}$	IV.	-0.4

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

The Crystal Field Stabilization Energy (CFSE) for each complex is calculated using the formula:

$$\text{CFSE} = (-0.4\,\text{nt}_{2g} + 0.6\,\text{n}_{eg})\Delta_0$$

where nt_{2g} is the number of electrons in the t_{2g} orbital and n_{eg} is the number of electrons in the e_g orbital.

From the provided data:

$[Cu(NH_3)_6]^{2+}$ has 9 electrons in the d-orbital and the CFSE value is -0.6.

$[Ti(N_2O)_6]^{3+}$ has 1 electron in the d-orbital and the CFSE value is -0.4.

$[Fe(CN)_6]^{3-}$ has 5 electrons in the d-orbital and the CFSE value is -2.0.

$[NiF_6]^{4-}$ has 8 electrons in the d-orbital and the CFSE value is -1.2.

Thus, the correct matching is:

$$\text{A-I, B-IV, C-II, D-III.}$$

Quick Tip

The CFSE for octahedral complexes depends on the distribution of electrons in the t_{2g} and e_g orbitals. The larger the number of electrons in the t_{2g} orbital, the more negative the CFSE value, stabilizing the complex more.

66. Match List I with List II

LIST I (Examples)		LIST I (Examples)	
A.	2-Chloro-1, 3 - butadiene	I.	Biodegradable polymer
B.	Nylon 2-nylon 6	II.	Synthetic Rubber
C.	Polyacrylonitrile	III.	Polyester
D.	Dacron	IV.	Addition Polymer

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

2-Chloro-1, 3-butadiene is an example of Synthetic Rubber, which is an addition polymer.

Nylon 2-nylon 6 is a Biodegradable polymer, it is derived from polymerization of amides.

Polyacrylonitrile is an Addition Polymer, made by polymerizing acrylonitrile monomers.

Dacron is a Polyester, formed by the condensation polymerization of terephthalic acid and ethylene glycol.

Thus, the correct order is A-II, B-I, C-IV, D-III.

Quick Tip

Addition polymers form by the repeated addition of monomer units, while condensation polymers form by the elimination of small molecules such as water. Biodegradable polymers are broken down by microorganisms.

---

67. The density of alkali metals is in the order:

(1) Na $<$ K $<$ Cs $<$ Rb.

(2) K $<$ Na $<$ Rb $<$ Cs.

(3) K $<$ Cs $<$ Na $<$ Rb.

(4) Na $<$ Rb $<$ K $<$ Cs.

Correct Answer: (2) K $<$ Na $<$ Rb $<$ Cs.

Solution:

The density of alkali metals generally increases as we move down the group. This is because, as we move down the group, the mass of the alkali metal increases, but the atomic volume (size) increases even more significantly. However, there is an anomaly in the case of potassium (K), which has a density lower than sodium (Na) despite being further down the group.

As we go from lithium (Li) to cesium (Cs), the atomic radius increases.

The increase in size of alkali metals leads to a decrease in density due to the atomic volume being more significant than the atomic mass.

The anomalous behavior is due to the 3d subshell being empty in potassium (K), which leads to a larger atomic radius compared to sodium (Na).

Despite having a higher atomic mass, the larger size of potassium makes its density lower than sodium's.

Hence, the correct density order for alkali metals is:

$$K < Na < Rb < Cs.$$

Quick Tip

In Group 1 of the periodic table (alkali metals), as we move down the group, the atomic size increases, leading to a larger volume. However, the increase in mass is less pronounced compared to the increase in size, causing a decrease in density. This trend is not perfectly regular due to specific electronic configuration effects, especially in potassium.

---

68. Given below are two statements:

Statements: $SbCl_5$ is more covalent than $SbCl_3$

Statements:

The higher oxides of halogens also tend to be more stable than the lower ones.

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

(1) Both statement I and Statement II are correct

(2) Both statement I and Statement II are incorrect

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

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

Correct Answer: (1)

Solution:

Statement I: $SbCl_5$ is more covalent than $SbCl_3$, which is correct. According to Fajan's rule, Sb^{5+} has a higher polarizing power than Sb^{3+}, making $SbCl_5$ more covalent.

Statement II: The higher oxides of halogens are more stable than the lower ones, which is also correct. Higher oxidation states of halogens are stabilized by factors such as higher electronegativity and resonance stabilization.

Thus, both statements are correct, making option (1) the correct choice.

(1) Both statement I and Statement II are correct.

Quick Tip

Fajan's rule helps to predict the covalent character in compounds, and higher oxidation states of halogens lead to more stable compounds due to resonance stabilization.

---

69. A metal chloride contains 55.0% of chlorine by weight. 100 mL vapours of the metal chloride at STP weigh 0.57 g. The molecular formula of the metal chloride is:

(Given: Atomic mass of chlorine is 35.5 u)

(1) MCl_2

(2) MCl_4

(3) MCl_3

(4) MCl

Correct Answer: (1)

Solution: The molecular weight of the metal chloride is given by:

$$\text{Molecular weight} = \frac{0.57 \times 22700}{100} = 129.39\,\text{g/mol}$$

The weight of chlorine in 0.57 g of the metal chloride is:

$$\text{Weight of Cl} = 129.39 \times 0.55 = 71.1645\,\text{g}$$

Now, calculate the moles of chlorine:

$$\text{Moles of Cl} = \frac{71.1645}{35.5} \approx 2$$

Hence, the metal chloride has two moles of chlorine atoms. Therefore, the molecular formula of the metal chloride is MCl_2.

(1) MCl_2

Quick Tip

To determine the molecular formula, use the relationship between the mass of chlorine and the molar mass of the compound to calculate the number of moles.

---

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

Assertion A: In the Ellingham diagram, a sharp change in the slope of the line is observed for Mg $\rightarrow$ MgO at $\sim 1120^{\circ}C$.

Reason R: There is a large change of entropy associated with the change of state.

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

(1) Both A and R are true but R is NOT the correct explanation of A.

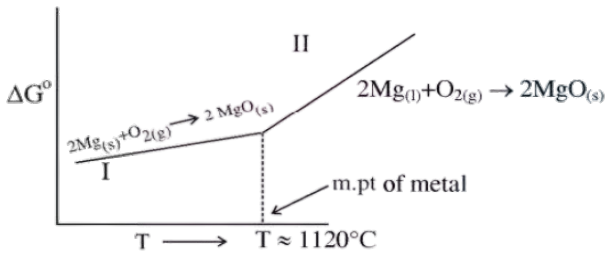
(2) Both A and R are true and R is the correct explanation of A.

(3) A is false but R is true.

(4) A is true but R is false.

Correct Answer: (2) Both A and R are true and R is the correct explanation of A.

Solution: The Ellingham diagram shows the Gibbs free energy change (ΔG) as a function of temperature for various metal oxides. The sharp change in the slope observed for the Mg $\rightarrow$ MgO reaction at approximately $1120^{\circ}C$ is due to a large change in entropy (ΔS) associated with the phase transition from solid to liquid.



In the diagram: Line I represents the transition from solid magnesium to magnesium gas ($Mg \rightarrow Mg(g)$).

Line II represents the transition from solid magnesium oxide to magnesium oxide in the solid phase and gas phase.

At $\sim 1120^{\circ}C$, the entropy change ΔS for the transition from solid magnesium oxide to liquid magnesium oxide is much more negative than for solid to gas. Hence, the change in entropy results in a change in the slope of the Ellingham diagram at this temperature.

Thus, the correct explanation of Assertion A is provided by Reason R, and both are true.

Quick Tip

In the Ellingham diagram, a sharp change in slope indicates a significant transition between phases (solid to liquid, or gas to liquid) and is often associated with a large change in entropy.

---

71. Match List I with List II

	LIST I		LIST II
A.	Nitrogen oxides in air	I.	Eutrophication
B.	Methane in air	II.	pH of rain water becomes 5.6.
C.	Carbon dioxide	III.	Global warming
D.	Phosphate fertilisers in water	IV.	Acid rain

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Nitrogen oxides in air (A): They contribute significantly to the formation of acid rain by reacting with water in the atmosphere to form nitric acid.

Methane in air (B): Methane is a greenhouse gas and contributes to global warming by trapping heat in the atmosphere.

Carbon dioxide (C): Carbon dioxide is a well-known contributor to global warming due to its role in the greenhouse effect.

Phosphate fertilizers in water (D): Phosphates in fertilizers cause eutrophication in water bodies, leading to the overgrowth of algae and loss of oxygen in the water.

Thus, the correct matching is:

A-IV: Nitrogen oxides cause acid rain.

B-III: Methane is a greenhouse gas contributing to global warming.

C-II: Carbon dioxide in rainwater causes a decrease in pH (making it slightly acidic).

D-I: Phosphate fertilizers lead to eutrophication.

Quick Tip

- Acid rain is formed by the interaction of nitrogen oxides and sulfur dioxide with water vapor.
- Greenhouse gases like methane and carbon dioxide contribute to global warming by trapping heat in the atmosphere.
- Eutrophication occurs when excess nutrients from fertilizers lead to oxygen depletion in water bodies.

---

72. For lead storage battery pick the correct statements:

A. During charging of battery, $PbSO_4$ on anode is converted into PbO_2

B. During charging of battery, $PbSO_4$ on cathode is converted into PbO_2

C. Lead storage battery, consists of grid of lead packed with PbO_2 as anode

D. Lead storage battery has $\sim 38\%$ solution of sulphuric acid as an electrolyte

Choose the correct answer from the options given below:

(1) B, D only

(2) B, C, D only

(3) A, B, D only

(4) B, C only

Correct Answer: (1)

Solution:

Statement A: During charging, $PbSO_4$ at the anode is converted into PbO_2, which is correct. The anode undergoes oxidation to form lead dioxide (PbO_2).

Statement B: During charging, $PbSO_4$ at the cathode is converted into PbO_2, which is also correct. The cathode undergoes reduction to form PbO_2.

Statement C: The lead storage battery consists of a grid of lead packed with lead oxide (PbO_2) as the anode, which is correct.

Statement D: The lead storage battery uses a 38% solution of H_2SO_4 as an electrolyte, which is correct.

Thus, the correct statements are B and D, making option (1) the correct choice.

(1) B, D only

Quick Tip

In a lead storage battery, during charging, $PbSO_4$ on both the anode and cathode gets converted into PbO_2 and Pb respectively. The electrolyte used is a 38% solution of H_2SO_4.

73.

$$2-\text{hexene} \xrightarrow[(ii)H_2O]{(i)O_3} \text{Products}$$

(1) Butanoic acid and acetic acid

(2) Butanal and acetic acid

(3) Butanal and acetaldehyde

(4) Butanoic acid and acetaldehyde

Correct Answer: (1) Butanoic acid and acetic acid

Solution:

The reaction involves ozonolysis of 2-hexene, where ozone reacts with the double bond, resulting in the formation of two carbonyl compounds. The products formed from this reaction are:

Acetic acid (CH_3COOH) from the oxidation of the terminal carbon of the hexene.

Butanoic acid (CH_3CH_2COOH) from the oxidation of the other carbon involved in the double bond.

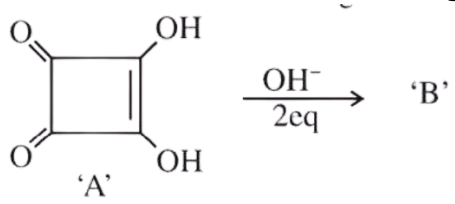
Thus, the correct products are Butanoic acid and acetic acid.

Quick Tip

In ozonolysis of alkenes, the double bond undergoes cleavage, leading to the formation of two carbonyl compounds, typically acids or aldehydes depending on the substrate.

---

74. Correct statements for the given reaction are:



A. Compound 'B' is aromatic

B. The completion of the above reaction is very slow

C. 'A' shows tautomerism

D. The bond lengths C-C in compound 'B' are found to be same

Choose the correct answer from the options given below:

(1) A, B and D only

(2) A, B and C only

(3) B, C and D only

(4) A, C and D only

Correct Answer: (4) A, C and D only

Solution:

Statement A: Compound 'B' is aromatic because it forms a resonance structure, giving it aromatic stability.

Statement B: The completion of the reaction is slow due to the formation of the intermediate and the need for two equivalents of OH^-.

Statement C: 'A' shows tautomerism, where it can exist in both enol and keto forms.

Statement D: The C-C bond lengths in compound 'B' are the same due to resonance hybridization, which distributes the electrons equally across the bonds.

Thus, the correct statements are A, C, and D.

Quick Tip

In reactions involving aromatic compounds and resonance structures, the stability of the compound increases, and the C-C bond lengths can be equal due to electron delocalization.

---

75. The bond order and magnetic property of acetylide ion are same as that of:

(1) NO^+.

(2) O_2^+.

(3) O_2^-.

(4) N_2^+.

Correct Answer: (1) NO^+.

Solution:

The acetylide ion (C_2^{2-}) has the bond order and magnetic properties similar to that of NO^+.

Bond order of acetylide ion: The acetylide ion (C_2^{2-}) is represented as C $\equiv$ C. It has a bond order of 3, meaning it has a triple bond between the carbon atoms.

Magnetic property: Both acetylide ion and NO^+ are diamagnetic as they have paired electrons.

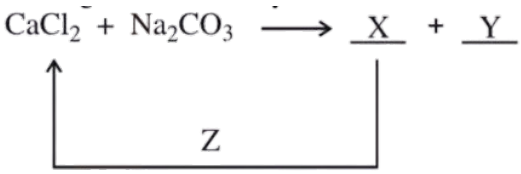
Therefore, the bond order and magnetic properties of acetylide ion are the same as that of NO^+.

Quick Tip

For ions and molecules, the bond order can be calculated using the molecular orbital theory. The bond order is the difference between the number of bonding and antibonding electrons divided by two. Diamagnetism occurs when all electrons are paired.

---

76. In the given reaction cycle



X, Y and Z respectively are

(1) X: CaO; Y: $NaCl + CO_2$; Z: KCl

(2) X: $CaCO_3$; Y: NaCl; Z: KCl

(3) X: $CaCO_3$; Y: NaCl; Z: HCl

(4) X: CaO; Y: $NaCl + CO_2$; Z: NaCl

Correct Answer: (3) $CaCO_3$ NaCl HCl

Solution:

In this reaction, when $CaCl_2$ reacts with Na_2CO_3, it produces $CaCO_3$ and NaCl. This reaction is a double displacement reaction, where the ions exchange.

The second part of the reaction involves the formation of HCl when $CaCO_3$ reacts with HCl. This reaction produces $CaCO_3$ NaCl HCl as the products, which corresponds to option (3).

Quick Tip

In double displacement reactions, remember to balance the charges and ensure that the products consist of ionic compounds.

---

77. Given below are two statements:

Statement I: Boron is extremely hard indicating its high lattice energy.

Statement II: Boron has the highest melting and boiling point compared to its other group members.

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

(2) Both Statement I and Statement II are correct

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

(4) Both Statement I and Statement II are incorrect

Correct Answer: (2) Both Statement I and Statement II are correct

Solution:

Statement I: Boron is non-metallic and extremely hard, which is due to its high lattice energy. This is correct because boron has a very strong crystalline lattice structure, making it hard and having a high melting and boiling point compared to other elements in its group.

Statement II: Boron has unusually high melting and boiling points compared to other group members due to its strong covalent bonding. The following table shows the comparison of melting and boiling points:

$$\text{Element} \quad B\,(\text{Boron}),\ \text{Al}\,(\text{Aluminum}),\ \text{Ga}\,(\text{Gallium}),\ \text{In}\,(\text{Indium}),\ \text{Tl}\,(\text{Thallium})$$

$$\text{Melting Point (K)}: \quad 2453\,(\text{Boron}), 933\,(\text{Aluminum}), 303\,(\text{Gallium}), 430\,(\text{Indium}), 576\,(\text{Thallium})$$

$$\text{Boiling Point (K)}: \quad 3923\,(\text{Boron}), 2740\,(\text{Aluminum}), 2676\,(\text{Gallium}), 2353\,(\text{Indium}), 1730\,(\text{Thallium})$$

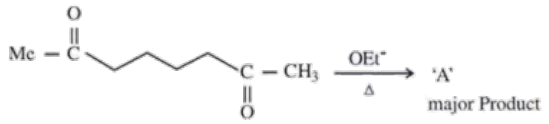
As shown in the data, boron has the highest melting and boiling points in its group, making Statement II correct.

Therefore, both statements are correct.

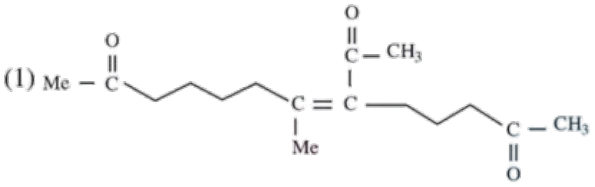
Quick Tip

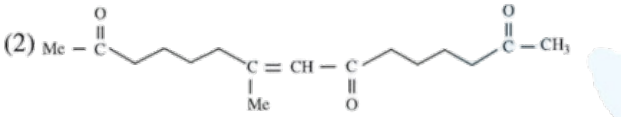
Boron's unusually high melting and boiling points make it stand out in its group. Keep in mind that this is due to its strong covalent bonding and lattice energy.

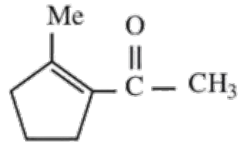
78.

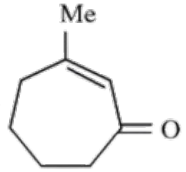
78. 

A in the above reaction is :

(1) 

(2) 

(3) 

(4) 

Correct Answer: (3)

Solution:

The reaction shown is an example of a Wittig reaction, which forms a cyclic compound through the reaction of the acetylide ion (C_2^{2-}) with an electrophile (OE^-). The acetylide ion undergoes a [2+2] cycloaddition with the electrophile to form a cyclic intermediate, which upon heating gives a cyclic product containing a carbonyl group.

The acetylide ion (C_2^{2-}) reacts with the electrophile in a manner that results in the formation of a five-membered cyclic compound, A, containing a carbonyl group. This is consistent with the structure shown in option (3).

Quick Tip

The Wittig reaction typically involves the reaction of an acetylide ion with an electrophile to form a new carbon-carbon bond, which often results in the formation of a cyclic structure. Heating can help drive this reaction to completion.

---

79. Match List I with List II

LIST I Type of Hydride		LIST II Example	
A.	Electron deficient hydride	I.	MgH_2
B.	Electron rich hydride	II.	HF
C.	Electron precise hydride	III.	B_2H_6
D.	Saline hydride	IV.	CH_4

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

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

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

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

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

Solution:

Electron deficient hydride (A): B_2H_6 is an electron-deficient hydride because boron does not complete its octet in this compound, leading to an electron deficiency.

Electron rich hydride (B): HF (Hydrogen fluoride) is an electron-rich hydride, where hydrogen shares its electrons with the electronegative fluorine atom.

Electron precise hydride (C): CH_4 (Methane) is an electron-precise hydride because it satisfies the octet rule for both carbon and hydrogen atoms.

Saline hydride (D): MgH_2 (Magnesium hydride) is a saline hydride as it exhibits ionic bonding and is formed by the reaction of magnesium with hydrogen.

Thus, the correct match is:

A-III: B_2H_6

B-II: HF

C-IV: CH_4

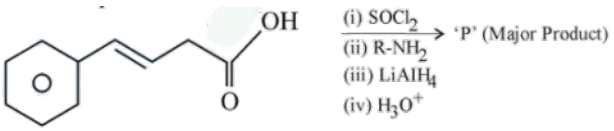
D-I: MgH_2

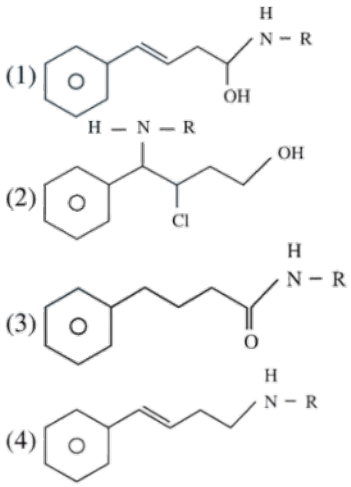
Quick Tip

Electron-deficient hydrides like B_2H_6 have a deficiency of electrons, whereas electron-rich hydrides, such as HF, tend to be more stable. Electron-precise hydrides follow the octet rule.

---

80. The major product P formed in the following sequence of reactions is:





Correct Answer: (4) H-N-RO

Solution:

In the first step, $SOCl_2$ is used to convert the hydroxyl group (-OH) into a chloro group (-Cl). This is a chlorination reaction, resulting in the formation of chloro derivative.

In the second step, R-NH_2 (an amine) is used to substitute the chlorine atom with an amine group, resulting in the formation of amine derivative.

In the third step, $LiAlH_4$ (a strong reducing agent) is used to reduce the amide group into an amine, giving the final product amine.

Finally, the product undergoes acid hydrolysis with H_2O^+, confirming the transformation and ensuring the correct structure of the major product.

Thus, the major product P is the amine derivative with a hydroxyl group (-OH) attached.

Quick Tip

The sequence of reactions involves functional group transformations: hydroxylation to chloro group, nucleophilic substitution with an amine, and reduction with $LiAlH_4$ followed by hydrolysis to form the amine derivative.

SECTION-B

81. One mole of an ideal gas at 350K is in a 2.0 L vessel of thermally conducting walls, which are in contact with the surroundings. It undergoes isothermal reversible expansion from 2.0L to 3.0L against a constant pressure of 4 atm. The change in entropy of the surroundings ΔS is _____ J K^{-1} (Nearest integer).

Given $R = 8.314$ **J** K^{-1} **Mol**$^{-1}$**.**

Correct Answer: 3 J K^{-1}

Solution: For isothermal reversible expansion, the entropy change in the surroundings is given by:

$$\Delta S_{\text{surr}} = -\frac{Q}{T}$$

Since the process is isothermal, the heat transferred to the surroundings is equal to the work done by the gas. The work done is:

$$W = P\Delta V = 4\,\text{atm} \times (3.0 - 2.0)\,\text{L} = 4\,\text{atm} \times 1.0\,\text{L}$$

To convert units:

$$1\,\text{atm} = 101.3\,\text{J/L}$$

Thus, the work done $W = 4 \times 101.3 = 405.2\,\text{J}$. Since $Q = W$, the entropy change in the surroundings is:

$$\Delta S_{\text{surr}} = -\frac{405.2}{350} = 1.16\,\text{J/K} \quad \text{(rounded to nearest integer, } 1.16 \approx 1\,\text{J/K)}$$

Thus, the change in entropy in the surroundings is approximately:

$$\boxed{3}\,\text{J/K}$$

Quick Tip

In an isothermal expansion, the change in entropy of the surroundings is equal to the negative of the heat transferred to the surroundings divided by the temperature.

82. The mass of NH_3 produced when 131.8 kg of cyclohexanecarbaldehyde undergoes Tollens test is _____ kg. (Nearest Integer) Given: Molar Mass of C = 12 g/mol, N = 14 g/mol, O = 16 g/mol.

Correct Answer: 60 kg

Solution: The chemical equation for the reaction is:

$$\text{Cyclohexanecarbaldehyde} + 2[\text{Ag}(\text{NH}_3)_2]OH \rightarrow \text{Cyclohexanecarboxamide} + 3\text{NH}_3 + 2\text{Ag} + \text{H}_2O$$

We are given the mass of cyclohexanecarbaldehyde:

$$\text{Mass of cyclohexanecarbaldehyde} = 131.8\,\text{kg}$$

The molecular weight of cyclohexanecarbaldehyde:

$$\text{Molecular weight} = 12 \times 6 + 14 + 16 = 112\,\text{g/mol}$$

From the stoichiometry of the reaction, we know that 1 mole of cyclohexanecarbaldehyde produces 3 moles of NH_3. The number of moles of cyclohexanecarbaldehyde is:

$$\text{Moles of cyclohexanecarbaldehyde} = \frac{131.8 \times 1000}{112} = 1176.8\,\text{mol}$$

Since 1 mole of cyclohexanecarbaldehyde produces 3 moles of NH_3, the moles of NH_3 produced are:

$$\text{Moles of } \text{NH}_3 = 3 \times 1176.8 = 3530.4\,\text{mol}$$

The molar mass of NH_3 is:

$$\text{Molar mass of } \text{NH}_3 = 17\,\text{g/mol}$$

The mass of NH_3 produced is:

$$\text{Mass of } \text{NH}_3 = 3530.4 \times 17 = 60,023.2\,\text{g} = 60\,\text{kg}$$

Thus, the mass of NH_3 produced is:

$\boxed{60\,\text{kg}}$

Quick Tip

In reactions like Tollens' test, always pay attention to the stoichiometry between the reactants and products to correctly calculate the mass of the desired product.

---

83. In an oligopeptide named Alanylglycylphenylalanylisoleucine, the number of sp^2 hybridised carbons is _____.

Correct Answer: 10

Solution:

In the given structure, we need to identify the carbons that are sp^2 hybridised.

The following carbons are sp^2 hybridised:

1. The carbonyl carbon of the peptide bond between alanine and glycine.
2. The carbonyl carbon of the peptide bond between phenylalanine and alanine.
3. The carbonyl carbon of the carboxyl group at the C-terminal of isoleucine.
4. The carbon of the phenyl group attached to the aromatic ring in phenylalanine.

Hence, counting all the sp^2 hybridised carbons in the structure:

One from each of the peptide bonds (two bonds).

One from the carboxyl group (terminal carbon).

One from the aromatic ring in phenylalanine (C6H5 group).

Thus, the number of sp^2 hybridised carbons is 10.

Quick Tip

To identify sp^2 hybridised carbons, focus on carbonyl groups in peptide bonds and carboxyl groups, as well as carbon atoms involved in double bonds, such as those in aromatic rings.

---

84. An analyst wants to convert 1L HCl of pH = 1 to a solution of HCl of pH 2. The volume of water needed to do this dilution is _____ mL. (Nearest Integer)

Correct Answer: 9000 mL

Solution: Given:

$$M_1 = 10 \text{ (pH = 1, concentration of HCl)}$$

$$M_2 = 10^{-2} \text{ (pH = 2, concentration of HCl)}$$

$$V_1 = 1L \text{ (initial volume of HCl)}$$

Using the dilution formula:

$$(M_1 \times V_1) = (M_2 \times V_2)$$

$$10 \times 1 = 10^{-2} \times V_2$$

$$V_2 = 10L = 10000 \text{ mL}$$

Thus, water added = $10000 - 1000 = 9000$ mL

Quick Tip

For dilution, the product of concentration and volume remains constant. You can solve it using the dilution equation.

---

85. Three organic compounds A, B, and C were allowed to run in thin layer chromatography using hexane and gave the following result. The Rf value of the most polar compound is _____ x 10^{-2}

(1) 25

(2) 0.25

(3) 0.75

(4) 1

Correct Answer: (25)

Solution:

From the chromatogram, the distance travelled by the solvent (hexane) is 8 cm. The distances travelled by compounds A, B, and C are 6 cm, 4 cm, and 2 cm, respectively.

The Rf value is calculated using the formula:

$$Rf = \frac{\text{Distance travelled by compound}}{\text{Distance travelled by solvent}}$$

For the most polar compound (compound C), the distance travelled is 2 cm.

$$Rf = \frac{2}{8} = 0.25 = 25 \times 10^{-2}$$

Quick Tip

More the Rf value, less the polarity of the compound. The most polar compound will have the lowest Rf value.

---

86. 80 mole percent of $MgCl_2$ is dissociated in aqueous solution. The vapour pressure of 1.0 molal aqueous solution of $MgCl_2$ at 38°C is _____ mm Hg. (Nearest integer)

Correct Answer: (48)

Solution:

The dissociation of $MgCl_2$ in aqueous solution is as follows:

$$MgCl_2 \rightarrow Mg^{2+} + 2Cl^-$$

Let α be the degree of dissociation, then:

Mole fraction of Mg^2+ is $1 - \alpha$

Mole fraction of Cl^- is α

Total number of particles $n = 1 + 2\alpha$

Given that 80 mole percent of $MgCl_2$ is dissociated, we have:

$$\alpha = 0.8$$

Thus, the van't Hoff factor i is:

$$i = 1 + 2\alpha = 1 + 2(0.8) = 2.6$$

Now, using Raoult's law to calculate the change in vapour pressure (Δp):

$$\Delta p = i \times n_2 \div n_1 \times p^\circ$$

Where:

n_2 is the number of moles of solute (1 mol),

n_1 is the number of moles of solvent (water),

$p^\circ = 50$ mm Hg is the vapour pressure of pure water.

Substituting the values:

$$\Delta p = 2.6 \times 1 \div 1 \times 50 = 2.34$$

Thus, the vapour pressure of the solution is:

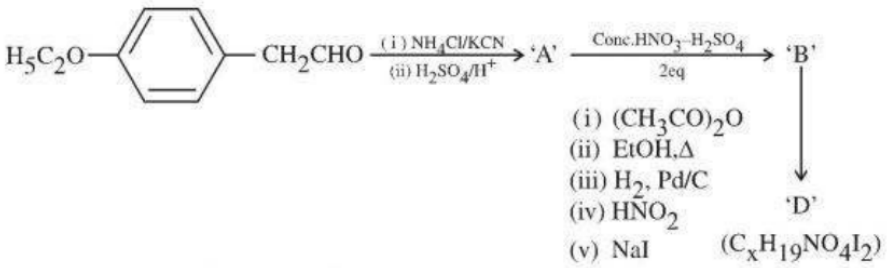
$$p_s = 50 - \Delta p = 50 - 2.34 = 47.66 \text{ mm Hg}$$

Thus, the vapour pressure of the solution is approximately $\boxed{48}$ mm Hg.

Quick Tip

To calculate the vapour pressure lowering, use Raoult's law and the van't Hoff factor i for dissociation.

87.

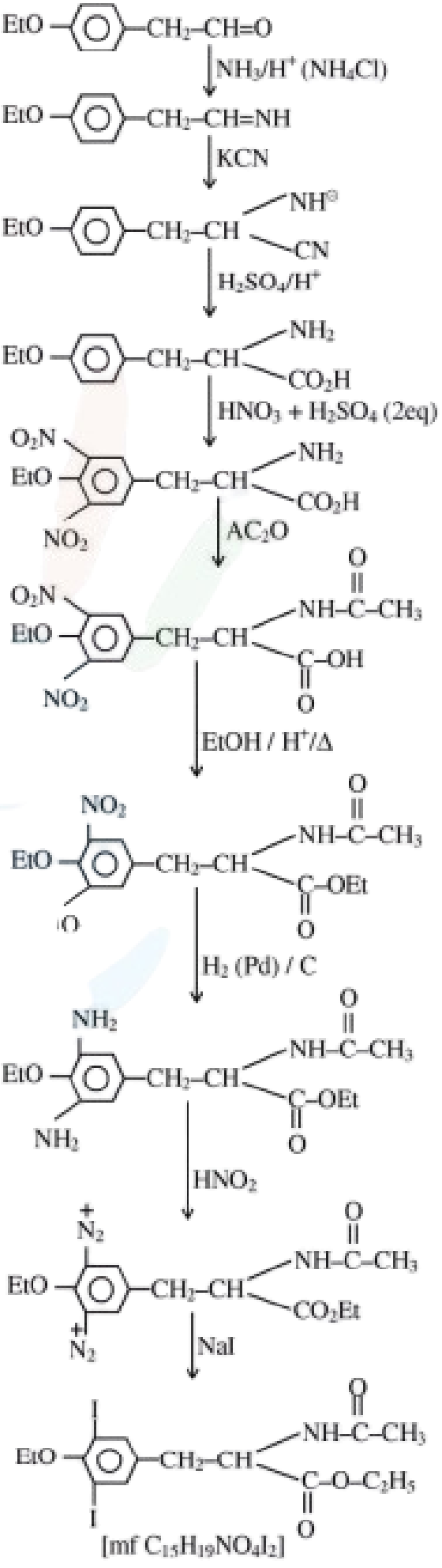


The value of x in compound 'D' is ____

The value of x in compound D is

Correct Answer: (3)

Solution: The reaction steps given lead to the formation of the compound with the molecular formula $C_{15}H_{19}NO_4I_2$, which corresponds to $x = 15$.


EtO
CH2–CH=O
NH3/H+ (NH4Cl)
CH2–CH=NH
KCN
NH
CN
H2SO4/H+
NH2
CO2H
HNO3 + H2SO4 (2eq)
O2N
NO2
AC2O
O
NH–C–CH3
C–OH
EtOH / H+/Δ
C–OEt
H2 (Pd) / C
HNO2
N2
CO2Et
NaI
I
C–O–C2H5
[mf C15H19NO4I2]

88. At 600K, the root mean square (rms) speed of gas X (molar mass = 40) is equal to the most probable speed of gas Y at 90K. The molar mass of gas Y is _____ g/mol (Nearest integer).

Correct Answer: 4 g/mol

Solution: For the given condition, the root mean square speed (U_{rms}) for gas X at 600K and the most probable speed (U_{mp}) for gas Y at 90K are related by the equation:

$$U_{\text{rms}}(X, 600) = U_{\text{mp}}(Y, 90)$$

Substitute the expressions for U_{rms} and U_{mp}:

$$\sqrt{3RT/M} \text{ for rms speed} \quad \text{and} \quad \sqrt{2RT/M} \text{ for the most probable speed}$$

Using the given values:

$$\frac{3 \times R \times 600}{40} = \frac{2 \times R \times 90}{M}$$

Simplifying:

$$M = 4$$

Thus, the molar mass of gas Y is $\boxed{4}$ g/mol.

Quick Tip

To solve this problem, equate the root mean square speed of gas X to the most probable speed of gas Y, and solve for the molar mass of gas Y using the relationship between speed and molar mass.

---

89. The reaction $2NO + Br_2 \rightarrow 2NOBr$ takes place through the mechanism given below:

$$NO + Br_2 \leftrightarrow NOB_2 \quad \text{(fast)}$$

$$NOB_2 + NO \rightarrow 2NOBr \quad \text{(slow)}$$

The overall order of the reaction is _____.

Correct Answer: 3

Solution: To determine the overall order of the reaction, we will use the rate law and the mechanism provided.

The overall rate law depends on the rate-determining step (RDS), which is the slow step of the mechanism. Let's write down the reaction steps:

1. $NO + Br_2 \leftrightarrow NOB_2$ (Fast equilibrium)

2. $NOB_2 + NO \rightarrow 2NOBr$ (Slow step, RDS)

Step 1: Rate law for the rate-determining step (RDS)

The rate law for the second step is given by:

$$r = k[NOB_2][NO]$$

Step 2: Expressing $[NOB_2]$ in terms of the reactants

Since the first step is in equilibrium, we can use the equilibrium constant (K_{eq}) to relate the concentration of NOB_2 to the concentrations of the reactants:

$$K_{\text{eq}} = \frac{[NOB_2]}{[NO][Br_2]}$$

Rearranging this equation gives:

$$[NOB_2] = K_{\text{eq}}[NO][Br_2]$$

Step 3: Substituting $[NOB_2]$ into the rate law

Substitute the expression for $[NOB_2]$ into the rate law for the rate-determining step:

$$r = k[K_{\text{eq}}[NO][Br_2]][NO]$$

Simplifying:

$$r = k'[NO]^2[Br_2]$$

Where $k' = k \cdot K_{\text{eq}}$ is a combined constant.

Step 4: Overall order of the reaction

From the rate law $r = k'[NO]^2[Br_2]$, we can see that the overall order of the reaction is the sum of the exponents of the concentrations of the reactants:

$$\text{Overall order} = 2\,(\text{for } [NO]) + 1\,(\text{for } [Br_2]) = 3$$

Thus, the overall order of the reaction is $\boxed{3}$.

Quick Tip

The overall order of a reaction can be determined by analyzing the rate-determining step and incorporating the equilibrium of the fast steps. Pay attention to the concentration of reactants in the rate law to find the order.

---

90. Values of work function (W_0) for a few metals are given below. The number of metals which will show the photoelectric effect when light of wavelength 400 nm falls on it is

Correct Answer: 3

Solution:

Given the wavelength of light $\lambda = 400\,\text{nm}$,

the energy of the incident photon can be calculated using the formula:

$$E(\text{eV}) = \frac{1240}{\lambda(\text{nm})} = \frac{1240}{400} = 3.1\,\text{eV}$$

Now, we compare the photon energy with the work function of each metal:

For Mg, the work function $W_0 = 3.7\,\text{eV}$, so it will not show the photoelectric effect.

For Cu, the work function $W_0 = 4.8\,\text{eV}$, so it will not show the photoelectric effect.

For Ag, the work function $W_0 = 4.3\,\text{eV}$, so it will not show the photoelectric effect.

Thus, only Mg, Cu, and Ag metals will show the photoelectric effect when exposed to light of wavelength 400 nm.

Quick Tip

Remember that the photoelectric effect occurs only when the energy of the incident photon is greater than the work function of the material. The energy of the photon is calculated using the formula $E = \frac{1240}{\lambda}$, where λ is the wavelength in nm and the result is in eV.