CUET Chemistry Question Paper 2024 Set B with solution

1. Camphor in nitrogen gas is a type of solution:

1. Gas – Gas
2. Solid – Gas
3. Liquid – Gas
4. Solid – Liquid

Solution:

Camphor in nitrogen gas represents a solution where a solid (camphor) is dispersed in a gas (nitrogen). Therefore, it is classified as a solid-gas solution.

Answer: (2) Solid – Gas

Quick Tip

In a solid-gas solution, a solid substance is dispersed in a gaseous medium, like camphor in nitrogen gas.

---

2. Identify the correct order of organic compounds in the following chemical reaction:

$$\underline{?} + Mg \xrightarrow{\text{Dry Ether}} \underline{?} \xrightarrow{H_2O} \underline{?} \xrightarrow{Cl_2,\Delta} \underline{?}$$

- (A) CH_3MgBr
- (B) CH_3Br
- (C) CH_3Cl
- (D) CH_4

Choose the correct answer from the options given below:

1. (B), (A), (D), (C)
2. (A), (C), (B), (D)
3. (B), (A), (C), (D)

4. (C), (B), (D), (A)

Solution:

The correct sequence of the organic compounds in this reaction is based on their increasing reactivity in a given series. Grignard reagent (CH_3MgBr) is followed by alkyl halides (CH_3Br and CH_3Cl), and finally, methane (CH_4) is the least reactive. Hence, the order is:

Answer: (3) (B), (A), (C), (D)

Quick Tip

Reactivity of organic compounds depends on the bond strength and the ability of the compound to donate or accept electrons.

---

3. Consider the following statements regarding osmotic pressure:

- (A) Molar mass of a protein can be determined using the osmotic pressure method.
- (B) The osmotic pressure is proportional to the molarity.
- (C) Reverse osmosis occurs when a pressure larger than osmotic pressure is applied to the concentrated solution side.
- (D) Edema occurs due to retention of water in tissue cells as a result of osmosis.

Choose the correct statements with reference to osmotic pressure:

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

Solution:

All the statements are correct regarding osmotic pressure: - (A) The molar mass of macromolecules like proteins can be determined using osmotic pressure. - (B) Osmotic pressure is directly proportional to molarity (concentration). - (C) Reverse osmosis occurs when external pressure greater than the osmotic pressure is applied to the concentrated solution. - (D) Edema is a condition where excess water is retained in tissues due to osmosis.

Answer: (3) (A), (B), (C) and (D)

Quick Tip

Osmotic pressure is an important colligative property, and it plays a crucial role in biological processes such as water regulation in cells and reverse osmosis for water purification.

---

4. Vapour pressures of pure liquids 'A' and 'D' at 50°C are 500 mm Hg and 800 mm Hg respectively. The binary solution of 'A' and 'D' boils at 50°C and 700 mm Hg pressure. The mole percentage of 'D' in the solution is:

1. 33.33 mole percent
2. 66.67 mole percent
3. 25.75 mole percent
4. 75.25 mole percent

Solution:

According to Raoult's Law, the total vapour pressure of the solution can be written as:

$$P_{\text{total}} = P_A x_A + P_D x_D$$

Where: - $P_A = 500$ mm Hg is the vapour pressure of pure A. - $P_D = 800$ mm Hg is the vapour pressure of pure D. - $P_{\text{total}} = 700$ mm Hg is the total pressure of the solution. - x_A and x_D are the mole fractions of A and D, respectively.

Since $x_A + x_D = 1$, we can substitute and solve:

$$700 = 500x_A + 800x_D$$

Substituting $x_A = 1 - x_D$:

$$700 = 500(1 - x_D) + 800x_D$$

$$700 = 500 - 500x_D + 800x_D$$

$$700 = 500 + 300x_D$$

$$200 = 300x_D$$

$$x_D = \frac{200}{300} = \frac{2}{3} = 0.6667$$

Thus, the mole fraction of D is 66.67

Answer: (2) 66.67 mole percent

Quick Tip

Raoult's Law relates the vapour pressure of a solution to the mole fractions and vapour pressures of its components. For binary solutions, the total vapour pressure is a linear combination of the pure component pressures.

---

5. For the following reaction:

$$2\mathrm{A}_2\,(\mathrm{g}) + \frac{1}{4}\mathrm{X}\,(\mathrm{g}) \rightarrow 2\mathrm{A}_2\mathrm{X}\,(\mathrm{g})$$

If the volume is increased to double its value by decreasing the pressure on it. If the reaction is first order with respect to X and second order with respect to A_2, the rate of reaction will:

1. Decrease by eight times of its initial value
2. Increase by eight times of its initial value
3. Increase by four times of its initial value
4. Remain unchanged

Solution:

The rate law for this reaction is:

$$\text{Rate} = k[\mathrm{A}_2]^2[\mathrm{X}]$$

When the volume is doubled, the concentration of gases will halve, meaning that both $[\mathrm{A}_2]$ and [X] will be halved. Thus, the new rate will be:

$$\text{New rate} = k\left(\frac{[\mathrm{A}_2]}{2}\right)^2\left(\frac{[\mathrm{X}]}{2}\right) = k \cdot \frac{[\mathrm{A}_2]^2}{4} \cdot \frac{[\mathrm{X}]}{2} = \frac{1}{8} \cdot \text{initial rate}$$

Hence, the rate decreases by eight times.

Answer: (1) Decrease by eight times of its initial value

Quick Tip

When volume doubles, concentrations are halved. For second and first-order reactions, this drastically reduces the rate.

---

6. The total number of sigma bonds present in P_4O_{10} are:

1. 6
2. 7
3. 16
4. 17

Solution:

In the structure of P_4O_{10}, each phosphorus atom forms sigma bonds with three other phosphorus atoms and oxygen atoms. The total number of sigma bonds in P_4O_{10} is 16.

Answer: (3) 16

Quick Tip

To calculate the number of sigma bonds in a molecule, consider single bonds as sigma bonds and count bonds directly connecting atoms.

---

7. In the electrolysis of alumina to obtain aluminium metal, cryolite is added mainly to:

1. Lower the melting point of alumina
2. Dissolve the alumina in the molten cryolite
3. Remove the impurities of alumina
4. Increase the electrical conductivity

Solution:

Cryolite is added during the electrolysis of alumina to reduce the melting point of alumina, making the process more energy-efficient.

Answer: (1) Lower the melting point of alumina

Quick Tip

Cryolite lowers the melting point of alumina, reducing energy requirements for its electrolysis.

---

8. Identify the order of reaction if its rate constant is $k = 2 \times 10^{-2}\,\mathbf{s}^{-1}$:

1. Zero order
2. First order
3. Second order
4. Half order

Solution:

The unit of the rate constant is s^{-1}, which corresponds to a first-order reaction.

Answer: (2) First order

Quick Tip

The units of the rate constant can help you determine the order of a reaction. For first-order reactions, the unit is s^{-1}.

---

9. For a complex reaction, the order of reaction is equal to:

1. Sum of stoichiometric coefficients in the balanced chemical reaction
2. The molecularity of overall reaction
3. Order of the fastest step of the reaction
4. The molecularity of the slowest step of the reaction

Solution:

For a complex reaction, the overall order of the reaction is determined by the molecularity of the slowest step, also called the rate-determining step. The slowest step limits the overall reaction rate and thus defines the reaction order.

Answer: (4) The molecularity of the slowest step of the reaction

Quick Tip

In complex reactions, the slowest step (rate-determining step) controls the reaction rate, and its molecularity determines the order of the reaction.

10. A molecule X associates in a given solvent as per the following equation:

$$X \rightleftharpoons (X)_n$$

For a given concentration of X, the van't Hoff factor was found to be 0.80 and the fraction of associated molecules was 0.3. The correct value of 'n' is:

(1) 2

(2) 3

(3) 1

(4) 5

Solution:

The van't Hoff factor i is related to the association factor n by the formula:

$$i = \frac{1}{n}$$

Given that $i = 0.80$, we can find the value of n as follows:

$$n = \frac{1}{0.80} = 1.25$$

Since the fraction of molecules associated is 0.3, the remaining fraction that is unassociated is 0.7. Therefore, $n = 3$ is the correct value for the association factor.

Answer: (2) 3

Quick Tip

For association or dissociation problems, remember that the van't Hoff factor is the ratio of actual particles in solution to the expected particles and can be used to calculate the association or dissociation factor.

11. The oxidation number of Co in complex $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$ is:

(1) 3

(2) 4

(3) 2

(4) 5

Solution:

To determine the oxidation number of Co in the complex $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$, we know: - SO_4^{2-} has a charge of -2, and there are 3 sulfate ions, contributing a total of -6. - The complex must be neutral, so the total charge from the $2[Co(H_2NCH_2CH_2NH_2)_3]^{2+}$ must be $+6$.

Since there are 2 Co ions, the oxidation state of each Co must be $+3$.

Therefore, the oxidation number of Co is $+3$.

Answer: (2) 4

Quick Tip

For oxidation number calculations, first account for the charges of known ligands and anions, then ensure the sum equals the overall charge of the complex.

---

12. The correct structure of dipeptide, Gly-Ala (glycyl alanine) is:

1. H_2N - CH_2 - CO - NH - $CH(CH_3)$ - COOH
2. HOOC - CH_2 - NH - CO - $CH(CH_3)$ - NH_2
3. HOOC - $CH(CH_3)$ - NH - CO - CH_2 - NH_2
4. H_2N - $CH(CH_3)$ - CO - NH - CH_2 - COOH

Solution:

The dipeptide Gly-Ala (glycyl alanine) is formed by joining glycine (Gly) and alanine (Ala). Glycine has the structure H_2N-CH_2-COOH, and alanine has the structure H_2N-$CH(CH_3)$-COOH. The correct dipeptide structure involves the amino group (NH_2) of glycine forming a peptide bond with the carboxyl group (COOH) of alanine. Thus, the correct structure is:

$$H_2N - CH_2 - CO - NH - CH(CH_3) - COOH$$

Answer: (1) H_2N - CH_2 - CO - NH - $CH(CH_3)$ - COOH

Quick Tip

A dipeptide is formed when the carboxyl group of one amino acid forms a peptide bond with the amino group of another. In Gly-Ala, glycine (Gly) is on the N-terminal, and alanine (Ala) is on the C-terminal.

---

13. The total number of ions produced from the compound $[Cr(NH_3)_6]Cl_3$ in aqueous solution is:

(1) 2

(2) 3

(3) 4

(4) 5

Solution:

The compound $[Cr(NH_3)_6]Cl_3$ dissociates in water as:

$$[Cr(NH_3)_6]Cl_3 \rightarrow [Cr(NH_3)_6]^{3+} + 3Cl^-$$

Thus, it produces **4 ions** (1 cation and 3 anions).

Answer: 4 (Option 3)

Quick Tip

In dissociation problems, always count the number of ions produced from the dissociated species (both cations and anions).

Question 14. Arrange the following in decreasing order of number of molecules contained in:

(A) 16 g of O_2

(B) 16 g of CO_2

(C) 16 g of CO

(D) 16 g of H_2

Choose the correct order:

(1) (A), (B), (C), (D)

(2) (D), (C), (A), (B)

(3) (B), (A), (D), (C)

(4) (C), (B), (D), (A)

Solution:

To compare the number of molecules, use the formula:

$$\text{Number of moles} = \frac{\text{mass}}{\text{molar mass}}$$

- O_2 has a molar mass of 32 g/mol, so moles of $O_2 = \frac{16}{32} = 0.5$ moles.

- CO_2 has a molar mass of 44 g/mol, so moles of $CO_2 = \frac{16}{44} \approx 0.36$ moles.

- CO has a molar mass of 28 g/mol, so moles of $CO = \frac{16}{28} \approx 0.57$ moles.

- H_2 has a molar mass of 2 g/mol, so moles of $H_2 = \frac{16}{2} = 8$ moles.

Thus, the decreasing order is $H_2 > CO > O_2 > CO_2$.

Answer: 2 (D), (C), (A), (B)

Quick Tip

For comparing the number of molecules, always calculate the moles using the formula: moles $= \frac{\text{mass}}{\text{molar mass}}$.

---

15. The Cu metal crystallises into fcc lattice with a unit cell edge length of 361 pm. The radius of Cu atom is:

(1) 127 pm

(2) 181 pm

(3) 157 pm

(4) 108 pm

Solution:

In a face-centered cubic (fcc) lattice, the relation between the unit cell edge length a and the atomic radius r is:

$$r = \frac{a}{2\sqrt{2}}$$

Substituting $a = 361\,\text{pm}$:

$$r = \frac{361}{2\sqrt{2}} \approx 127\,\text{pm}$$

Answer: (3) 157 pm

Quick Tip

For fcc lattices, use the relation $r = \frac{a}{2\sqrt{2}}$ to find the atomic radius, where a is the edge length of the unit cell.

---

16. If 75% of a first-order reaction gets completed in 32 minutes, the time taken for 50% completion of this reaction is:

(1) 16 minutes

(2) 78 minutes

(3) 8 minutes

(4) 4 minutes

Solution:

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

$$t = \frac{0.693}{k}$$

For 75% completion, the time is related to k as follows:

$$t_{75\%} = \frac{t_{50\%}}{0.693}$$

Given that the 75% completion time is 32 minutes, the time for 50% completion is:

$$t_{50\%} = \frac{32}{0.693} \approx 8\,\text{minutes}$$

Answer: (3) 8 minutes

Quick Tip

For first-order reactions, use the half-life formula $t_{1/2} = \frac{0.693}{k}$, where k is the rate constant, to relate completion times.

---

17. Which of the following compounds will be repelled when placed in an external magnetic field?

(1) $Na_2[CuCl_4]$

(2) $Na_2[CdCl_4]$

(3) $K_4[Fe(CN)_6]$

(4) $K_3[Fe(CN)_6]$

Solution:

$K_4[Fe(CN)_6]$ contains Fe^{2+} with a low-spin configuration due to the strong-field ligand CN^-. It is diamagnetic (no unpaired electrons), meaning it will be repelled by a magnetic field.

Answer: (3) $K_4[Fe(CN)_6]$

Quick Tip

Diamagnetic compounds have no unpaired electrons and are repelled by a magnetic field. Paramagnetic compounds have unpaired electrons and are attracted to a magnetic field.

---

18. The spin-only magnetic moment of Hexacyanomanganate(II) ion is _____ BM.

(1) 5.90

(2) 1.73

(3) 4.90

(4) 3.87

Solution:

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

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

where n is the number of unpaired electrons. For Mn^{2+}, $n = 5$, so:

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92\,\text{BM}$$

Answer: (1) 5.90 BM

Quick Tip

For calculating magnetic moments, use the formula $\mu = \sqrt{n(n+2)}$, where n is the number of unpaired electrons.

---

19. The correct order of increasing boiling points of the following compounds is:

Pentan-1-ol, n-Butane, Pentanal, Ethoxyethane

(1) Ethoxyethane, Pentanal, n-Butane, Pentan-1-ol

(2) Pentanal, n-Butane, Ethoxyethane, Pentan-1-ol

(3) n-Butane, Pentanal, Ethoxyethane, Pentan-1-ol

(4) n-Butane, Ethoxyethane, Pentanal, Pentan-1-ol

Solution:

Boiling points are influenced by molecular weight, polarity, and hydrogen bonding: - n-Butane is non-polar and has the lowest boiling point. - Ethoxyethane has weak dipole-dipole interactions. - Pentanal has stronger dipole-dipole interactions. - Pentan-1-ol has hydrogen bonding, resulting in the highest boiling point.

Thus, the correct order is:

$$\text{n-Butane} < \text{Ethoxyethane} < \text{Pentanal} < \text{Pentan-1-ol}$$

Answer: (4) n-Butane, Ethoxyethane, Pentanal, Pentan-1-ol

Quick Tip

For boiling point trends, consider the type of bonding (hydrogen bonding, dipole-dipole, van der Waals forces) and molecular structure.

---

20. In the following reaction, identify the product D.

$$C_6H_5OH \xrightarrow{\text{Zn dust}} A \xrightarrow{CH_3Cl+\text{anhy. } AlCl_3} B \xrightarrow{K_2Cr_2O_7+H_2SO_4} C \xrightarrow{H_2SO_4+HNO_3} D$$

(1) o-Nitrobenzoic acid

(2) p-Nitrobenzoic acid

(3) o,p-Dinitrobenzoic acid

(4) m-Nitrobenzoic acid

Solution:

Step-by-step analysis of the given reaction:

- The first step is the reduction of phenol (C_6H_5OH) to benzene (A) using Zn dust. - In the second step, Friedel-Crafts alkylation of benzene (A) with methyl chloride (CH_3Cl) in the presence of anhydrous $AlCl_3$ gives toluene (B). - In the third step, oxidation of toluene (B) with potassium dichromate ($K_2Cr_2O_7$) in acidic medium (H_2SO_4) forms benzoic acid (C). - Finally, nitration of benzoic acid (C) with a mixture of sulfuric acid (H_2SO_4) and nitric acid (HNO_3) leads to m-nitrobenzoic acid (D).

Thus, the product D is **m-Nitrobenzoic acid**. Therefore, the correct option is:

Answer: (4) m-Nitrobenzoic acid

Quick Tip

In reactions involving nitration of benzoic acid, the carboxyl group is meta-directing, leading to substitution at the meta position relative to the carboxyl group.

21. The gold number range of some of the lyophilic colloids is given below:

A: 0.005–0.01, B: 0.15–0.25, C: 0.04–1.0, D: 15–25

Which among these can be used as a better protective colloid?

1. A
2. B
3. C
4. D

Solution:

The gold number is inversely related to the protective power of a colloid. A lower gold number indicates a better protective colloid. In this case, option A has the lowest gold number (0.005–0.01), making it the best protective colloid.

Answer: (1) A

Quick Tip

The lower the gold number, the better the colloid can protect against the coagulation of gold sol particles. Always look for the smallest gold number to find the best protective colloid.

---

22. Reaction of aniline with conc. HNO_3 and conc. H_2SO_4 at 298 K will produce 47% of

(1) p-Nitroaniline

(2) o-Nitroaniline

(3) m-Nitroaniline

(4) 2,4-Dinitroaniline

Solution: The reaction of aniline with a mixture of concentrated nitric acid (HNO_3) and sulfuric acid (H_2SO_4) leads to nitration. Under these conditions, nitration occurs primarily at the ortho and para positions relative to the amino group. The given conditions (298 K) result in the major product being 47% of para-nitroaniline.

Answer: (1) p-Nitroaniline.

Quick Tip

For nitration reactions, aniline usually undergoes substitution at the ortho and para positions due to the activating effect of the amino group (-NH_2).

---

23. What will be the increasing order of basic strength of the following compounds?

$$C_2H_5NH_2, \quad (C_2H_5)_2NH, \quad (C_2H_5)_3N, \quad C_6H_5NH_2$$

1. $C_2H_5NH_2 < (C_2H_5)_2NH < (C_2H_5)_3N < C_6H_5NH_2$
2. $C_6H_5NH_2 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$
3. $(C_2H_5)_3N < (C_2H_5)_2NH < C_6H_5NH_2 < C_2H_5NH_2$
4. $(C_2H_5)_2NH < (C_2H_5)_3N < C_2H_5NH_2 < C_6H_5NH_2$

Solution:

The basic strength of amines depends on the availability of the lone pair of electrons on nitrogen for donation. Alkyl groups increase the electron density on nitrogen due to their +I (inductive effect), while the phenyl group (in aniline) withdraws electrons due to its -R (resonance effect). Therefore, the correct order of basic strength is option (2):

$$C_6H_5NH_2 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$$

Answer: (2) $C_6H_5NH_2 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$

Quick Tip

Aromatic amines (like aniline) are generally less basic than aliphatic amines due to resonance, which delocalizes the lone pair on nitrogen into the ring.

---

24. Which of the following compounds will give the Hell-Volhard-Zelinsky reaction?

1. $R - CH_2 - COOH$
2. $R_3C - CHO$
3. R_2CO

4. H – COOH

Solution:

The Hell-Volhard-Zelinsky reaction is specific to carboxylic acids with α-hydrogen atoms. These hydrogens are required for the halogenation to occur at the α-carbon. Out of the given compounds, only option (1)

$$R - CH_2 - COOH$$

has an α-hydrogen and will undergo this reaction.

Answer: (1) $R - CH_2 - COOH$

Quick Tip

The Hell-Volhard-Zelinsky reaction only works with carboxylic acids that have at least one α-hydrogen atom. If there's no α-hydrogen, the reaction cannot proceed.

---

25. Arrange the following acids in increasing order of their acidic strengths:

$$HCOOH, \quad FCH_2COOH, \quad NO_2CH_2COOH, \quad ClCH_2COOH$$

1. $HCOOH < FCH_2COOH < NO_2CH_2COOH < ClCH_2COOH$
2. $HCOOH < NO_2CH_2COOH < ClCH_2COOH < FCH_2COOH$
3. $NO_2CH_2COOH < HCOOH < ClCH_2COOH < FCH_2COOH$
4. $HCOOH < ClCH_2COOH < FCH_2COOH < NO_2CH_2COOH$

Solution:

Acidic strength depends on the electron-withdrawing ability of substituents attached to the carboxylic acid group. The stronger the electron-withdrawing group, the stronger the acid. The nitro group (NO_2) is a stronger electron-withdrawing group than fluorine (F), chlorine (Cl), or hydrogen (H). Therefore, the correct order is:

$$HCOOH < FCH_2COOH < ClCH_2COOH < NO_2CH_2COOH$$

Answer: (4) $HCOOH < ClCH_2COOH < FCH_2COOH < NO_2CH_2COOH$

Quick Tip

When comparing acidic strengths, look for the presence of electron-withdrawing groups. The more electronegative and stronger the withdrawing group, the more acidic the compound becomes.

---

26. In the following compounds, what is the increasing order of their reactivity towards nucleophilic addition reactions?

Benzaldehyde, p-Tolualdehyde, p-Nitrobenzaldehyde, Acetophenone

1. Benzaldehyde < p-Tolualdehyde < p-Nitrobenzaldehyde < Acetophenone
2. Acetophenone < Benzaldehyde < p-Tolualdehyde < p-Nitrobenzaldehyde
3. Acetophenone < p-Tolualdehyde < Benzaldehyde < p-Nitrobenzaldehyde
4. Benzaldehyde < Acetophenone < p-Tolualdehyde < p-Nitrobenzaldehyde

Solution:

The reactivity towards nucleophilic addition reactions is influenced by the electron-withdrawing or electron-donating groups attached to the carbonyl carbon. Strong electron-withdrawing groups increase the electrophilicity of the carbonyl carbon, making the compound more reactive. In this case, the order of reactivity is:

Benzaldehyde < Acetophenone < p-Tolualdehyde < p-Nitrobenzaldehyde

Therefore, the correct answer is (4).

Answer: (4) Benzaldehyde < Acetophenone < p-Tolualdehyde < p-Nitrobenzaldehyde

Quick Tip

Electron-withdrawing groups increase the reactivity of carbonyl compounds in nucleophilic addition reactions, while electron-donating groups decrease it.

---

27. The Gattermann-Koch reaction is used in the industrial preparation of benzaldehyde. The electrophile involved in this reaction is

1. CO^+

2. HCl + CO_2 + anhydrous $AlCl_3$

3. HCO^+

4. CO + anhydrous $AlCl_3$

Solution:

The Gattermann-Koch reaction involves the formation of benzaldehyde from benzene using CO and HCl in the presence of anhydrous $AlCl_3$ as a catalyst. The electrophile generated in the reaction is CO^+, which reacts with benzene.

Answer: (1) CO^+

Quick Tip

In the Gattermann-Koch reaction, carbon monoxide (CO) forms the key electrophile (CO^+) that gets added to the benzene ring to form benzaldehyde.

---

28. Formaldehyde undergoes Cannizzaro reaction because

- (A) It has alpha-hydrogen atom.
- (B) It does not have alpha-hydrogen atom.
- (C) It does not undergo self-oxidation and reduction on heating with concentrated alkali.
- (D) It undergoes self-oxidation and reduction on heating with concentrated alkali.

Choose the correct answer from the options given below:

1. (B) and (D) only

2. (A) and (C) only

3. (B) and (C) only

4. (A) and (D) only

Solution:

The Cannizzaro reaction is a redox reaction that occurs with aldehydes lacking an alpha-hydrogen. In this reaction, one molecule of the aldehyde gets oxidized to a carboxylate, while another gets reduced to an alcohol. Formaldehyde does not have an alpha-hydrogen, which makes it undergo this reaction.

Answer: (1) (B) and (D) only

Quick Tip

For Cannizzaro reaction to occur, the aldehyde must not have any alpha-hydrogen atoms. Aldehydes with alpha-hydrogens usually undergo aldol reactions instead.

---

29. In the reaction, $(CH_3)_3C - O - CH_3 + HI \rightarrow$ Products, CH_3OH and $(CH_3)_3CCl$ are the products and not CH_3I and $(CH_3)_3COH$. It is because,

- (A) In step 2 of the reaction, the departure of leaving group (HO–CH_3) creates less stable carbocation.
- (B) In step 2 of the reaction, the departure of leaving group (HO–CH_3) creates more stable carbocation.
- (C) The reaction follows an S_N1 mechanism.
- (D) The reaction follows S_N2 mechanism.

Solution:

In this reaction, the intermediate formed is a tertiary carbocation due to the departure of the HO-CH_3 group, which creates a stable tertiary carbocation. Since the reaction involves the formation of a carbocation, it proceeds via the S_N1 mechanism, where a more stable carbocation intermediate is favored.

Answer: (2) (B) and (C)

Quick Tip

The S_N1 mechanism involves a two-step process with a carbocation intermediate, and the stability of the carbocation is a key factor in determining the reaction pathway.

---

30. Aniline does not undergo Friedel-Crafts reaction because

1. (A) It forms salt with the Lewis acid catalyst, $AlCl_3$.
2. (B) Nitrogen of aniline acquires negative charge.
3. (C) Nitrogen of aniline acquires positive charge.

4. (D) Nitrogen acts as a strong deactivating group in the further reaction.

Choose the correct answer from the options given below:

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

Solution:

Aniline does not undergo the Friedel-Crafts reaction because the nitrogen atom, being a strong electron-donating group, forms a salt with the Lewis acid catalyst ($AlCl_3$), rendering it inactive for further electrophilic substitution. Additionally, the nitrogen acquires a positive charge, making it strongly deactivating for the reaction.

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

Quick Tip

The amino group (-NH_2) in aniline acts as a deactivator in the Friedel-Crafts reaction because it forms a complex with the catalyst, hindering the process.

---

31. Although chlorine is an electron-withdrawing group, yet it is ortho- and para-directing in electrophilic aromatic substitution reaction because

- (A) Chlorine withdraws electrons through inductive effect.
- (B) Chlorine destabilizes the intermediate carbocation formed during electrophilic substitution.
- (C) Chlorine accepts electrons through resonance.
- (D) Chlorine releases electrons through resonance.

Choose the correct answer from the options given below:

1. (A), (B) and (D) only
2. (A), (B) and (C) only

3. (A), (C) and (D) only

4. (B), (C) and (D) only

Solution:

Chlorine is an electron-withdrawing group due to its high electronegativity, which withdraws electrons through the inductive effect. However, chlorine also has lone pairs that participate in resonance, donating electron density to the ring at the ortho and para positions. This resonance effect makes chlorine an ortho- and para-directing group in electrophilic substitution reactions.

Answer: (2) (A), (B) and (C) only

Quick Tip

Even though chlorine is electron-withdrawing by the inductive effect, its lone pair donation through resonance makes it an ortho- and para-directing group in aromatic substitution reactions.

---

32. In Etard reaction, the final product is

1. Aromatic aldehyde

2. Aromatic chloride

3. Aromatic amine

4. Aromatic alcohol

Solution:

The Etard reaction is an oxidation process in which a methyl group (-CH_3) attached to an aromatic ring is converted into an aldehyde (-CHO) using chromyl chloride (CrO_2Cl_2). This reaction selectively oxidizes the methyl group without further oxidation to a carboxylic acid, producing an aromatic aldehyde.

Answer: (1) Aromatic aldehyde

Quick Tip

The Etard reaction is a selective oxidation that stops at the aldehyde stage, making it a useful method for preparing aromatic aldehydes from methyl groups on aromatic rings.

33. Match List-I with List-II:

List-I	List-II
(A) Amino acids linked in a specific sequence	(I) Primary structure of proteins
(B) Regular folding of a specific sequence of amino acids due to H-bonding	(II) Secondary structure of proteins
(C) Fibrous proteins	(III) Quaternary structure of proteins
(D) Spatial arrangement of two or more polypeptide chains	(IV) Tertiary structure of proteins

Choose the correct answer from the options given below:

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

Solution:

- (A) Amino acids linked in a specific sequence represent the primary structure of proteins (I). - (B) Regular folding due to H-bonding refers to the secondary structure of proteins (II). - (C) Fibrous proteins are related to the quaternary structure of proteins (III). - (D) Spatial arrangement of multiple polypeptide chains refers to the tertiary structure (IV).

Thus, the correct matching is:

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

Answer: (1) (I)

Quick Tip

Protein structure is organized into four levels: primary (sequence of amino acids), secondary (folding due to H-bonding), tertiary (3D arrangement of a single chain), and quaternary (arrangement of multiple chains).

34. Match List-I with List-II:

List-I	List-II
(A) Tollen's reagent	(I) Rochelle salt
(B) Jones reagent	(II) Conc. HCl and $ZnCl_2$
(C) Lucas reagent	(III) Ammoniacal silver nitrate
(D) Fehling solution	(IV) Chromium trioxide-sulphuric acid

Choose the correct answer from the options given below:

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

Solution:

- (A) Tollen's reagent is Ammoniacal silver nitrate (III), used for the oxidation of aldehydes to carboxylic acids. - (B) Jones reagent consists of Chromium trioxide in sulphuric acid (IV), used for oxidizing alcohols. - (C) Lucas reagent is a mixture of Concentrated HCl and $ZnCl_2$ (II), used for testing alcohols. - (D) Fehling solution is used in tests for aldehydes, containing Rochelle salt (I).

Thus, the correct matching is:

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

Answer: (1) (III)

Quick Tip

Tollen's reagent is specific for aldehydes, producing a silver mirror. Lucas reagent helps differentiate between primary, secondary, and tertiary alcohols based on reactivity.

---

35. Match List-I with List-II:

List-I	List-II
(A) Swarts Reaction	(I) $C_6H_5NH_2 + NaNO_2 + HX + Cu_2X_2 \rightarrow C_6H_5X + N_2$
(B) Finkelstein reaction	(II) $2RX + 2Na \rightarrow R\text{-}R + 2NaX$
(C) Sandmeyer's reaction	(III) $RX + AgF \rightarrow R\text{-}F + AgX$
(D) Wurtz reaction	(IV) $RX + NaI \rightarrow R\text{-}I + NaX$

Choose the correct answer from the options given below:

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

Solution:

- (A) Swarts reaction involves the halogen exchange with $RX + AgF \rightarrow R\text{-}F + AgX$ (III). - (B) Finkelstein reaction involves the halogen exchange in the presence of sodium iodide: $RX + NaI \rightarrow R\text{-}I + NaX$ (IV). - (C) Sandmeyer's reaction is used to prepare aryl halides from diazonium salts, involving $C_6H_5NH_2 + NaNO_2 + HX + Cu_2X_2 \rightarrow C_6H_5X + N_2$ (I). - (D) Wurtz reaction is the coupling of alkyl halides in the presence of sodium to form hydrocarbons: $2RX + 2Na \rightarrow R\text{-}R + 2NaX$ (II).

Thus, the correct matching is:

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

Answer: (3) (I)

Quick Tip

- Swarts reaction is used for the preparation of alkyl fluorides. - Sandmeyer's reaction is useful for the preparation of aryl halides from diazonium salts.

---

36. Match List-I with List-II:

List-I (Biomolecule)	List-II (Function/Diseases)
(A) Vitamin A	(I) Menstrual cycle
(B) Thiamine	(II) Xerophthalmia
(C) Glucocorticoids	(III) Beri-Beri
(D) Estradiol	(IV) Addison's disease

Choose the correct answer from the options given below:

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

Solution:

- (A) Vitamin A deficiency causes Xerophthalmia (II), a condition that affects the eyes and leads to dryness. - (B) Thiamine deficiency leads to Beri-Beri (III), a disease affecting the nervous system. - (C) Glucocorticoids are associated with Addison's disease (IV), a condition caused by insufficient production of these hormones. - (D) Estradiol is linked to the Menstrual cycle (I), as it is a key hormone involved in female reproductive health.

Thus, the correct matching is:

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

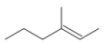
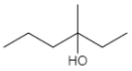
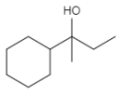
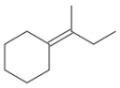
Answer: (4) (I)

Quick Tip

- Vitamin A is important for vision and deficiency can lead to eye-related issues such as xerophthalmia. - Thiamine deficiency results in Beri-Beri, which impacts muscle and nerve function.

---

37. In the following table, match the reactants given in List-I with the correct product in List-II as per the reaction of hydration of alkene under acidic conditions.

List-I (Reactants)	List-II (Products)
(A) 	(I) 
(B) 	(II) 
(C) 	(III) 
(D) 	(IV) 

Choose the correct answer from the options given below:

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

Solution:

- (A) undergoes hydration to give the product (I), which is a secondary alcohol. - (B) undergoes hydration to give product (III), leading to a tertiary alcohol. - (C) reacts to form the product (II), an alcohol formed from the hydration of an alkene. - (D) reacts to form product (IV), forming a primary alcohol.

Thus, the correct matching is:

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

Answer: (1) (I)

Quick Tip

Hydration of alkenes under acidic conditions follows Markovnikov's rule, leading to the formation of alcohols. The OH group attaches to the more substituted carbon.

---

38. Which among the following is *not* an Analgesic?

1. Morphene

2. Heroin
3. Codeine
4. Ranitidine

Solution:

Ranitidine is not an analgesic. It is an H_2 receptor antagonist used to reduce stomach acid production.

Answer: (4) Ranitidine

Quick Tip

Analgesics are drugs used to relieve pain, while Ranitidine is used for treating acid-related conditions like ulcers.

---

39. The increasing order of acidity of the following compounds based on pKa values is:

- (A) $BrCH_2COOH$
- (B) $ClCH_2COOH$
- (C) FCH_2COOH
- (D) $HCOOH$

Choose the correct answer from the options given below:

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

Solution:

The acidity of carboxylic acids depends on the electron-withdrawing effects of substituents on the carbon atom adjacent to the carboxyl group. More electronegative substituents increase the acidity by stabilizing the conjugate base.

- Fluorine (F) is the most electronegative element, followed by chlorine (Cl) and bromine (Br). - Formic acid (HCOOH) lacks an additional halogen, making it the least acidic in comparison.

Thus, the increasing order of acidity based on pKa values is:

$$HCOOH < BrCH_2COOH < ClCH_2COOH < FCH_2COOH$$

Answer: (1) (D) < (A) < (B) < (C)

Quick Tip

Electron-withdrawing groups, especially halogens, increase the acidity of carboxylic acids. The stronger the electronegativity, the greater the acidity.

---

40. For SN_2 reaction, the increasing order of the reactivity of the following alkyl halides is:

(A) $CH_3CH_2CH_2CH_2Br$ (B) $CH_3CH_2CH(Br)CH_3$ (C) $(CH_3)_3CBr$ (D) $(CH_3)_2CHCH_2Br$

Choose the correct answer from the options given below:

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

Solution:

For SN_2 reactions, the reactivity order depends on the steric hindrance around the carbon attached to the leaving group (in this case, bromine). Less steric hindrance favors the SN_2 mechanism, as it allows easier backside attack by the nucleophile.

- (A) $CH_3CH_2CH_2CH_2Br$: Primary alkyl halide (least steric hindrance). - (B) $CH_3CH_2CH(Br)CH_3$: Secondary alkyl halide (moderate steric hindrance). - (C) $(CH_3)_3CBr$: Tertiary alkyl halide (most steric hindrance, least reactive in SN_2). - (D) $(CH_3)_2CHCH_2Br$: Secondary alkyl halide (moderate steric hindrance).

Thus, the correct increasing order of reactivity in SN_2 is:

$$(C) < (B) < (D) < (A)$$

Answer: (4) (C) < (B) < (D) < (A)

Quick Tip

In SN_2 reactions, reactivity increases with decreasing steric hindrance. Primary alkyl halides are most reactive, while tertiary alkyl halides are least reactive.

Read the following passage and answer the next five questions based on it.

Battery or cell converts chemical energy of the redox reaction to electrical energy. In fuel cells (a galvanic cell), the chemical energy of combustion of fuels like H_2, ethanol, etc., is directly converted to electrical energy. In a fuel cell, H_2 and O_2 react to produce electricity, where H_2 gas is oxidized at the anode and oxygen is reduced at the cathode, and the reactions involved are:

$$\text{Anode reaction: } H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$$

$$\text{Cathode reaction: } O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

67.2 L of H_2 at STP reacts in 15 minutes.

41. The number of moles of hydrogen oxidized is:

1. 0.33 moles
2. 33.3 moles
3. 3.0 moles
4. 1.33 moles

Solution:

Using the ideal gas equation, 22.4 L of any gas at STP is equivalent to 1 mole of gas. Therefore, the number of moles of H_2 in 67.2 L is:

$$\frac{67.2}{22.4} = 3.0 \,\text{moles}$$

Answer: (3) 3.0 moles

Quick Tip

At STP, 22.4 L of any gas is equivalent to 1 mole. Use this relationship to quickly calculate the number of moles for any volume at STP.

---

42. The number of moles of electrons produced in the oxidation of 67.2 L of H_2 at STP is:

1. 2 moles
2. 4 moles
3. 1 mole
4. 6 moles

Solution:

According to the anode reaction:

$$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$$

For every mole of H_2, 2 moles of electrons are produced. Since 3.0 moles of H_2 are oxidized, the number of moles of electrons produced is:

$$3.0 \times 2 = 6 \text{ moles of electrons}$$

Answer: (4) 6 moles

Quick Tip

For redox reactions, calculate the number of moles of electrons based on the stoichiometry of the half-reaction involving electrons.

---

43. The quantity of electricity produced in the oxidation of 67.2 L of H_2 at STP is:

1. 96500 C
2. 579000 C
3. 193000 C

4. 48250 C

Solution:

The total charge (Q) is calculated using the equation:

$$Q = n \times F$$

where $n = 6$ moles of electrons and $F = 96500$ C/mol is Faraday's constant. Therefore:

$$Q = 6 \times 96500 = 579000\,\text{C}$$

Answer: (2) 579000 C

Quick Tip

To calculate the total charge produced in a reaction, multiply the moles of electrons by Faraday's constant (96500 C/mol).

---

44. If the entire current produced is used for the electrodeposition of silver (atomic weight = 108 g/mol) from Silver (I) solution, the amount of silver deposited will be:

1. 324 g
2. 648 g
3. 108 g
4. 216 g

Solution:

Using Faraday's laws of electrolysis, the amount of silver deposited is given by:

$$\text{Amount of Ag deposited} = \frac{Q \times M}{n \times F}$$

where $Q = 579000$ C, $M = 108$ g/mol, $n = 1$, and $F = 96500$ C/mol. Therefore:

$$\text{Amount of Ag deposited} = \frac{579000 \times 108}{1 \times 96500} = 648\,\text{g}$$

Answer: (2) 648 g

Quick Tip

Faraday's laws of electrolysis allow you to calculate the amount of substance deposited by using the formula $\frac{Q \times M}{n \times F}$, where M is the molar mass, and n is the charge number.

45. The source of electrical energy on the Apollo moon flight was:

1. Lead storage battery
2. A generator set
3. Ni-Cd cells
4. H_2-O_2 fuel cell

Solution:

The Apollo moon flight used an H_2-O_2 fuel cell for electrical energy as it provided a high energy-to-weight ratio and also produced water as a by-product, which was useful for the astronauts.

Answer: (4) H_2-O_2 fuel cell

Quick Tip

Fuel cells are highly efficient for space missions as they generate electricity directly from chemical reactions and provide useful by-products like water.

Read the following passage and answer the next five questions based on it.

Transition Series Elements:

Sc Ti V Cr Mn Fe Co Ni Cu Zn

Y Zr Nb Mo Tc Ru Rh Pd Ag Cd

La Hf Ta W Re Os Ir Pt Au Hg

In any transition series, as we move from left to right the d-orbitals are progressively filled and their properties vary accordingly.

f-block Elements:

Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu

Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

The above are the two series of f-block elements in which the chemical properties won't change much. The 5f-series elements are radioactive in nature and mostly are artificially synthesized in laboratories and thus much is not known about their chemical properties.

46. Identify the *incorrect* statement:

1. Second ionization enthalpy of Ag is greater than second ionization enthalpy of Pd.
2. Zr and Hf share almost identical nuclear properties.
3. Melting point of Mn is lower than that of Cr.
4. Interstitial compounds are non-stoichiometric and neither ionic nor covalent in nature.

Solution:

The incorrect statement is (1). The second ionization enthalpy of Pd is higher than that of Ag due to the stability of the d^{10} configuration in Pd.

Answer: (1) Second ionization enthalpy of Ag is greater than second ionization enthalpy of Pd.

Quick Tip

Ionization enthalpy trends depend on electronic configurations. Pd has a stable d^{10} configuration, making it harder to remove the second electron than in Ag.

---

47. Which of the following is the correct order of second ionization enthalpy?

1. V > Cr > Mn
2. V < Cr < Mn
3. V < Cr > Mn
4. V > Cr < Mn

Solution:

The correct order of second ionization enthalpy is:

$$V < Cr > Mn$$

This is because Cr has a stable half-filled d^5 configuration, making it harder to ionize compared to V and Mn.

Answer: (3) V $<$ Cr $>$ Mn

Quick Tip

Half-filled and fully filled configurations (like Cr's d^5) offer greater stability, which increases ionization enthalpy.

---

48. Which of the following pair of compounds exhibits the same colour in aqueous solution?

1. $FeCl_2$, $CuCl_2$
2. $VOCl_2$, $FeCl_2$
3. $VOCl_2$, $CuCl_2$
4. $VOCl_2$, $MnCl_2$

Solution:

$FeCl_2$ and $VOCl_2$ both exhibit a green color in aqueous solution, as both transition metals exhibit similar d-electron configurations in solution.

Answer: (2) $VOCl_2$, $FeCl_2$

Quick Tip

Transition metal compounds' color in solution is due to d-d transitions, which depend on the metal's oxidation state and ligand effects.

---

49. Which metal has the highest oxidation state in the first row transition series?

1. Cr
2. Fe
3. Mn
4. V

Solution:

Manganese (Mn) has the highest oxidation state (+7) in the first row of transition elements, as seen in compounds like $KMnO_4$.

Answer: (3) Mn

Quick Tip

Manganese achieves its highest oxidation state of +7 in compounds like permanganates (e.g., $KMnO_4$), where all d and s electrons are involved in bonding.

---

50. Why do the actinoids exhibit a higher number of oxidation states than lanthanoids?

1. 4f orbitals are more diffused than the 5f orbitals.
2. Energy difference between 5f and 6d is less with respect to the energy difference between 4f and 5d.
3. Energy difference between 5f and 6d is more with respect to the energy difference between 4f and 5d.
4. Actinoids are more reactive in nature than the lanthanoids.

Solution:

The actinoids exhibit a higher number of oxidation states because the energy difference between the 5f and 6d orbitals is less compared to the energy difference between the 4f and 5d orbitals in lanthanoids. This smaller energy difference allows for easier involvement of both the 5f and 6d electrons in bonding, resulting in more available oxidation states for actinoids.

Answer: (2) Energy difference between 5f and 6d is less with respect to the energy difference between 4f and 5d.

Quick Tip

Actinoids show a wider range of oxidation states due to the smaller energy gap between their 5f and 6d orbitals, allowing for the participation of more electrons in bonding.