AIIMS Paramedical 2025 Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**100	**Total questions :**60

General Instructions

General Instructions:

i) All questions are compulsory. Marks allotted to each question are indicated in the margin.

ii) Answers must be precise and to the point.

iii) In numerical questions, all steps of calculation should be shown clearly.

iv) Use of non-programmable scientific calculators is permitted.

v) Wherever necessary, write balanced chemical equations with proper symbols and units.

vi) Rough work should be done only in the space provided in the question paper.

CHEMISTRY

1. What is the correct unit for the rate constant in a first-order reaction?

(A) Moles per litre per second

(B) Per second

(C) Litre per mole per second

(D) Moles squared per litre squared per second

Correct Answer: (B) Per second

Solution:

Step 1: Understanding the rate law.

For a first-order reaction, the rate law is $r = k[A]$, where k is the rate constant, and $[A]$ represents the concentration of reactant A. The unit of the rate r is concentration/time (e.g., mol/L·s).

Step 2: Unit analysis.

To find the units of k, we can solve for k from the rate law equation:

$$k = \frac{r}{[A]}$$

Since the rate r has units of mol/L·s and $[A]$ has units of mol/L, the unit of k will be:

$$\frac{\text{mol/L·s}}{\text{mol/L}} = \text{s}^{-1}$$

Step 3: Conclusion.

Therefore, the correct unit for the rate constant k in a first-order reaction is s^{-1}, which corresponds to option (B).

Quick Tip

For first-order reactions, the unit of the rate constant k is always s^{-1}.

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2. If the rate constant is measured in per second, which reaction order does this indicate?

(A) Zero order

(B) First order

(C) Either zero or first order

(D) None of these

Correct Answer: (B) First order

Solution:

Step 1: Units of the rate constant.

The units of the rate constant k depend on the order of the reaction. If the rate constant is measured in s^{-1}, this indicates the units are consistent with the first-order reaction.

Step 2: Explanation of the options.

For a first-order reaction, the rate law is $r = k[A]$, where the rate r has units of mol/L·s, and $[A]$ has units of mol/L. Therefore, the unit of k for a first-order reaction is s^{-1}.

Step 3: Conclusion.

Thus, if the rate constant is measured in s^{-1}, the reaction is first order, which corresponds to option (B).

Quick Tip

For reactions where the rate constant is measured in s^{-1}, the reaction is typically first order.

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3. Match each type of reduction to its reagent:

(A) Clemmensen Reduction $\rightarrow$ Zinc amalgam with hydrochloric acid

(B) Wolff-Kishner Reduction $\rightarrow$ Hydrazine and potassium hydroxide with heat

(C) Rosenmund Reduction $\rightarrow$ Hydrogen gas with palladium on barium sulfate

Correct Answer: (A) Clemmensen Reduction $\rightarrow$ Zinc amalgam with hydrochloric acid

(B) Wolff-Kishner Reduction $\rightarrow$ Hydrazine and potassium hydroxide with heat

(C) Rosenmund Reduction $\rightarrow$ Hydrogen gas with palladium on barium sulfate

Solution:

Step 1: Understanding each reduction.

- Clemmensen reduction is carried out under acidic conditions, typically using zinc amalgam and hydrochloric acid.
- Wolff-Kishner reduction is performed under basic conditions, using hydrazine and potassium hydroxide with heat.
- Rosenmund reduction involves hydrogen gas and palladium on barium sulfate, often used to reduce acyl chlorides to aldehydes.

Step 2: Conclusion.

Thus, the correct matches are: (A) Clemmensen Reduction $\rightarrow$ Zinc amalgam with hydrochloric acid (B) Wolff-Kishner Reduction $\rightarrow$ Hydrazine and potassium hydroxide with heat (C) Rosenmund Reduction $\rightarrow$ Hydrogen gas with palladium on barium sulfate

Quick Tip

Always associate the type of reduction with the environment and reagents. Clemmensen is acidic, Wolff-Kishner is basic, and Rosenmund uses palladium.

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4. For a proton and electron both with the same kinetic energy, what is the ratio of their de Broglie wavelengths?

(A) 1:1
(B) $\frac{m_e}{m_p}$
(C) $\sqrt{\frac{m_p}{m_e}}$
(D) $\frac{m_e}{m_p}$

Correct Answer: (B) $\frac{m_e}{m_p}$

Solution:

Step 1: Understanding de Broglie wavelength.

The de Broglie wavelength λ of a particle is given by the equation:

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

where h is Planck's constant and p is the momentum of the particle. For a particle with kinetic energy E, the momentum is related to the kinetic energy by the equation:

$$p = \sqrt{2mE}$$

Thus, the de Broglie wavelength is inversely proportional to the square root of the mass m of the particle:

$$\lambda \propto \frac{1}{\sqrt{m}}$$

Step 2: Analysis of the options.

Since both the proton and the electron have the same kinetic energy, their de Broglie wavelengths will be inversely proportional to the square root of their masses. The ratio of the de Broglie wavelengths of the electron and proton is given by:

$$\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}}$$

Thus, the correct answer is option (B), which is $\frac{m_e}{m_p}$.

Quick Tip

For particles with the same kinetic energy, the de Broglie wavelength is inversely proportional to the square root of their mass.

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5. What is the spin magnetic moment of Cr(III) in Bohr Magnetons?

(A) 3.87 BM

(B) 2.83 BM

(C) 5.92 BM

(D) 4.90 BM

Correct Answer: (A) 3.87 BM

Solution:

Step 1: Understand the electronic configuration of Cr(III).

Chromium (Cr) has the electron configuration $[Ar]3d^5 4s^1$. In the +3 oxidation state (Cr(III)), it loses 3 electrons, leaving the configuration $[Ar]3d^3$. This means Cr(III) has 3 unpaired electrons.

Step 2: Use the formula for the spin-only magnetic moment.

The formula for the spin-only magnetic moment is:

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

where n is the number of unpaired electrons. For Cr(III), $n = 3$, so:

$$\mu = \sqrt{3(3+2)} = \sqrt{3 \times 5} = \sqrt{15} \approx 3.87\,\text{BM}$$

Step 3: Conclusion.

Therefore, the spin magnetic moment of Cr(III) is approximately 3.87 Bohr magnetons, which corresponds to option (A).

Quick Tip

To calculate the spin-only magnetic moment, use the formula $\mu = \sqrt{n(n+2)}$, where n is the number of unpaired electrons.

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6. Evaluate these statements about transition metals:

(A) Both statements are right, and second explains the first

(B) Both are accurate, but second does not explain the first

(C) First is false, second is true

(D) First is true, second is incorrect

Correct Answer: (C) First is false, second is true

Solution:

Step 1: Analyze Statement 1.

Zinc (Zn), Cadmium (Cd), and Mercury (Hg) are d-block elements but are not true transition metals. This is because, in their normal states, they have fully filled d-orbitals, which disqualifies them from being classified as transition metals. Therefore, Statement 1 is false.

Step 2: Analyze Statement 2.

Statement 2 is correct because these elements (Zn, Cd, Hg) typically exhibit a +2 oxidation state in their normal states. This is consistent with their full d-orbitals in the ground state.

Step 3: Conclusion.

Since Statement 1 is false and Statement 2 is true, the correct answer is option (C).

Quick Tip

Transition metals must have partially filled d-orbitals in their ground state, which Zn, Cd, and Hg do not have.

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7. Which statement correctly contrasts Clemmensen and Wolff-Kishner reductions?

(A) Clemmensen uses base, Wolff-Kishner uses acid

(B) Both are done under acidic conditions

(C) Clemmensen is for compounds stable in acid and uses Zn-Hg/HCl; Wolff-Kishner is for those stable in base and uses hydrazine/KOH

(D) Both only reduce carboxylic acids

Correct Answer: (C) Clemmensen is for compounds stable in acid and uses Zn-Hg/HCl; Wolff-Kishner is for those stable in base and uses hydrazine/KOH

Solution:

Step 1: Understanding the Clemmensen reduction.

The Clemmensen reduction is used to reduce carbonyl compounds (such as aldehydes or ketones) to alkanes. It is performed under acidic conditions using zinc amalgam (Zn-Hg) and hydrochloric acid (HCl). This method is suitable for compounds that are stable in acidic conditions.

Step 2: Understanding the Wolff-Kishner reduction.

The Wolff-Kishner reduction is also used to reduce carbonyl compounds, but it requires basic conditions. It uses hydrazine (N2H4) and potassium hydroxide (KOH) under heat. This method is more suitable for compounds that are stable in basic conditions.

Step 3: Conclusion.

The correct statement is (C), which contrasts the two reductions based on their required conditions: Clemmensen uses Zn-Hg/HCl under acidic conditions, while Wolff-Kishner uses hydrazine/KOH under basic conditions.

Quick Tip

Clemmensen reduction is used under acidic conditions with Zn-Hg/HCl, while Wolff-Kishner is used under basic conditions with hydrazine/KOH.

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8. What is the bond order for diatomic carbon according to molecular orbital theory?

(A) 1

(B) 2

(C) 3

(D) 4

Correct Answer: (B) 2

Solution:

Step 1: Understanding the electronic configuration of C_2.

The electronic configuration of C_2 (diatomic carbon) can be written as:

$$(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2px})^2(\pi_{2py})^2$$

Here, we have 8 bonding electrons and 4 antibonding electrons.

Step 2: Applying the bond order formula.

The bond order is given by the formula:

$$\text{Bond order} = \frac{N_b - N_a}{2}$$

where N_b is the total number of bonding electrons and N_a is the total number of antibonding electrons. For C_2:

$$N_b = 8 \quad \text{and} \quad N_a = 4$$

Thus, the bond order is:

$$\text{Bond order} = \frac{8-4}{2} = 2$$

Step 3: Conclusion.

Therefore, the bond order for diatomic carbon (C_2) is 2, which corresponds to option (B).

Quick Tip

To calculate the bond order using molecular orbital theory, use the formula:

$$\text{Bond order} = \frac{N_b - N_a}{2}$$

where N_b is the number of bonding electrons and N_a is the number of antibonding electrons.

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9. Which compound's common name is cumene?

(A) Isopropylbenzene

(B) Methylbenzene

(C) Ethylbenzene

(D) Propylbenzene

Correct Answer: (A) Isopropylbenzene

Solution:

Step 1: Identifying the structure.

Cumene is the common name for isopropylbenzene. It consists of a benzene ring with an isopropyl group (C_3H_7) attached to it.

Step 2: Conclusion.

Thus, the correct answer is option (A), Isopropylbenzene, which is also known as cumene.

Quick Tip

In organic chemistry, common names often differ from IUPAC names, like cumene for isopropylbenzene.

10. Choose the correct ascending order of ionization energy for Zn, Cu, Ag:

(A) Ag ¡ Cu ¡ Zn

(B) Zn ¡ Cu ¡ Ag

(C) Cu ¡ Zn ¡ Ag

(D) Zn ¡ Ag ¡ Cu

Correct Answer: (A) Ag ¡ Cu ¡ Zn

Solution:

Step 1: Understanding ionization energies.

Ionization energy generally increases across a period from left to right and decreases down a group. Zinc (Zn), Copper (Cu), and Silver (Ag) are transition metals, but their ionization energies vary due to the electron configuration and relativistic effects.

Step 2: Explanation of the order.

- Ag (silver) has a relatively low ionization energy because of the relativistic contraction and the stability of its electron configuration. - Cu (copper) has a higher ionization energy than Ag but lower than Zn due to its filled $3d^{10}$ subshell. - Zn (zinc) has the highest ionization energy because its electron configuration is $3d^{10}4s^2$, which is stable and less likely to lose electrons.

Step 3: Conclusion.

Therefore, the correct ascending order of ionization energies is:

$$\text{Ag} < \text{Cu} < \text{Zn}$$

which corresponds to option (A).

Quick Tip

Ionization energy increases across a period and decreases down a group, but transition metals show exceptions due to electron configuration.

11. Rank elements Li, Be, B, C in increasing first ionization energy:

(A) Li ¡ B ¡ C ¡ Be

(B) Li ¡ C ¡ B ¡ Be

(C) Be ¡ C ¡ B ¡ Li

(D) Li ¡ Be ¡ B ¡ C

Correct Answer: (D) Li ¡ Be ¡ B ¡ C

Solution:

Step 1: Understanding ionization energies.

Ionization energy increases across a period and decreases down a group. However, there are exceptions due to electron configurations, especially in p-block elements.

Step 2: Explanation of the order.

- Li (Lithium) has the lowest first ionization energy because it is an alkali metal with a single electron in its outermost shell. - Be (Beryllium) has a higher ionization energy than Li because it has a stable $2s^2$ configuration. - B (Boron) has a lower ionization energy than C because it has one electron in the $2p$ orbital, which is easier to remove than a fully filled $2s^2$ orbital in carbon. - C (Carbon) has the highest first ionization energy because it has a half-filled $2p^2$ orbital, which is relatively stable.

Step 3: Conclusion.

Thus, the correct order of increasing first ionization energy is:

$$\text{Li} < \text{Be} < \text{B} < \text{C}$$

which corresponds to option (D).

Quick Tip

The first ionization energy generally increases across a period from left to right.

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12. When phenol is treated with NaOH, CO_2 (heat), and then acidified, what results?

(A) Benzoic acid

(B) Salicylic acid

(C) Benzene

(D) Anisole

Correct Answer: (B) Salicylic acid

Solution:

Step 1: Understanding the reaction.

This reaction is known as the Kolbe-Schmitt reaction. In this reaction, phenol reacts with sodium hydroxide (NaOH) and carbon dioxide (CO_2) at high temperature to form the sodium salt of salicylic acid. Upon acidification, the sodium salt is converted into salicylic acid.

Step 2: Conclusion.

The correct product of this reaction is salicylic acid, which corresponds to option (B).

Quick Tip

The Kolbe-Schmitt reaction involves phenol, NaOH, CO_2, and acidification to form salicylic acid.

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13. Highest oxidation numbers for chromium and manganese:

(A) +6, +6

(B) +6, +7

(C) +7, +6

(D) +5, +7

Correct Answer: (B) +6 for Cr, +7 for Mn

Solution:

Step 1: Oxidation numbers of chromium and manganese.

Chromium (Cr) can have an oxidation number of +6 in compounds like CrO_3 (chromium trioxide). Manganese (Mn) can have an oxidation number of +7 in compounds like $KMnO_4$ (potassium permanganate).

Step 2: Conclusion.

Thus, the highest oxidation numbers are +6 for chromium and +7 for manganese, which corresponds to option (B).

Quick Tip

The highest oxidation state for chromium is +6 and for manganese is +7, seen in compounds like CrO_3 and $KMnO_4$, respectively.

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14. Oxidation numbers of oxygen in H_2O_2 and H_2O:

(A) –1 and –2

(B) –2 and –1

(C) –2 and –2

(D) 0 and –2

Correct Answer: (A) –1 (H_2O_2) and –2 (H_2O)

Solution:

Step 1: Understanding the oxidation state of oxygen in H_2O_2.

In hydrogen peroxide (H_2O_2), oxygen has an oxidation number of –1, because the total oxidation state of hydrogen is +2 and the molecule is neutral.

Step 2: Understanding the oxidation state of oxygen in H_2O.

In water (H_2O), oxygen has an oxidation number of –2, as the total oxidation state of hydrogen is +2 and the molecule is neutral.

Step 3: Conclusion.

Thus, the oxidation numbers of oxygen in H_2O_2 and H_2O are –1 and –2, respectively, which corresponds to option (A).

Quick Tip

In H_2O_2, oxygen has an oxidation number of –1, and in H_2O, oxygen has an oxidation number of –2.

15. Which element releases electrons most easily (lowest ionization enthalpy)?

(A) Zinc

(B) Cadmium

(C) Mercury

(D) All equally likely

Correct Answer: (A) Zinc

Solution:

Step 1: Understanding ionization enthalpy.

Ionization enthalpy refers to the energy required to remove an electron from an atom in its gaseous state. The lower the ionization enthalpy, the more easily an element releases an electron.

Step 2: Comparison of elements.

- Zinc (Zn) is in Group 12 of the periodic table and has a relatively low ionization enthalpy compared to other elements listed. - Cadmium (Cd) and Mercury (Hg), being heavier transition metals, have higher ionization enthalpies than Zinc.

Step 3: Conclusion.

Thus, Zinc releases electrons most easily, corresponding to option (A).

Quick Tip

Elements with lower ionization enthalpies tend to release electrons more easily, as less energy is needed to remove an electron.

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16. Which ligand is stronger based on the spectrochemical series?

(A) Thiocyanate

(B) Cyanide

(C) Both equally strong

(D) Neither is strong

Correct Answer: (B) Cyanide

Solution:

Step 1: Understanding the spectrochemical series.

The spectrochemical series arranges ligands according to the strength of the field they generate. Ligands that generate a strong field lead to greater splitting of the d-orbitals in the metal center.

Step 2: Comparison of thiocyanate and cyanide.

- Cyanide (CN^-) is a strong-field ligand and can cause a larger splitting of the d-orbitals, making it stronger. - Thiocyanate (SCN^-) is a weaker field ligand compared to cyanide.

Step 3: Conclusion.

Therefore, cyanide is the stronger ligand, corresponding to option (B).

Quick Tip

In the spectrochemical series, cyanide is a stronger ligand than thiocyanate. Strong-field ligands cause greater splitting of the d-orbitals.

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17. Which metal reacts most with dilute acid to displace hydrogen?

(A) Zinc

(B) Copper

(C) Silver

(D) All react the same

Correct Answer: (A) Zinc

Solution:

Step 1: Understanding reactivity with dilute acids.

The reactivity of a metal with dilute acid to displace hydrogen is governed by its position in the reactivity series. Metals higher in the reactivity series displace hydrogen more readily.

Step 2: Comparison of metals.

- Zinc (Zn) is a highly reactive metal and reacts readily with dilute acids like HCl to release hydrogen gas. - Copper (Cu) and Silver (Ag) are much less reactive and do not react with dilute acids to displace hydrogen under normal conditions.

Step 3: Conclusion.

Thus, Zinc reacts most with dilute acid to displace hydrogen, corresponding to option (A).

Quick Tip

Metals higher in the reactivity series (like Zinc) react more readily with dilute acids to displace hydrogen.

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18. If a compound has octahedral geometry, what is the central atom's hybridization?

(A) sp^2

(B) dsp^2

(C) sp^3d^2

(D) sp^3d^3

Correct Answer: (C) sp^3d^2

Solution:

Step 1: Understanding octahedral geometry.

In an octahedral geometry, there are six bonding regions around the central atom. This requires the central atom to have six hybridized orbitals, which is achieved by using the sp^3d^2 hybridization.

Step 2: Conclusion.

The central atom in an octahedral compound undergoes sp^3d^2 hybridization, which corresponds to option (C).

Quick Tip

In octahedral geometry, the hybridization of the central atom is sp^3d^2, using six orbitals.

19. Match each complex to its geometry:

- $[Ni(CN)_4]^{2-} \rightarrow$ Square planar
- $[NiCl_4]^{2-} \rightarrow$ Tetrahedral

Correct Answer: $[Ni(CN)_4]^{2-}$ has a square planar geometry.
$[NiCl_4]^{2-}$ has a tetrahedral geometry.

Solution:

Step 1: Understanding the geometries.

- $[Ni(CN)_4]^{2-}$ typically forms a square planar geometry due to the strong field ligand CN^-, which causes the d-orbitals to undergo pairing and leads to a square planar arrangement.
- $[NiCl_4]^{2-}$ generally forms a tetrahedral geometry because chloride ions are weaker field ligands, which do not cause significant pairing of d-electrons.

Step 2: Conclusion.

Thus, $[Ni(CN)_4]^{2-}$ has square planar geometry and $[NiCl_4]^{2-}$ has tetrahedral geometry.

Quick Tip

Square planar geometry is typically seen with strong field ligands like cyanide, while tetrahedral geometry is common with weak field ligands like chloride.

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20. Which acid is the strongest: HF, HCl, HBr, HI?

(A) HF
(B) HCl
(C) HBr
(D) HI

Correct Answer: (D) HI

Solution:

Step 1: Understanding acid strength.

The strength of an acid is determined by its ability to donate a proton. In binary acids of the form HX, where X is a halogen, acid strength increases as the size of X increases, because the bond between hydrogen and the halogen becomes weaker, making it easier to release the proton.

Step 2: Explanation.

- HF (hydrofluoric acid) is the weakest acid because the bond between H and F is very strong, making it difficult to dissociate. - HI (hydroiodic acid) is the strongest acid because iodine is the largest halogen, and the bond between H and I is the weakest, making it easier to lose the proton.

Step 3: Conclusion.

Therefore, the strongest acid among the given options is HI, corresponding to option (D).

Quick Tip

In binary acids of the form HX, acid strength increases as the halogen size increases, with HF being the weakest and HI the strongest.

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21. Which aniline derivative is a commonly used dental local anaesthetic?

(A) Paracetamol

(B) Sulfanilamide

(C) Lidocaine

(D) Aniline hydrochloride

Correct Answer: (C) Lidocaine

Solution:

Step 1: Understanding the question.

Aniline derivatives are often used in medical applications, including local anaesthetics. Among the options, lidocaine is the most commonly used dental local anaesthetic.

Step 2: Conclusion.

Thus, the correct answer is option (C), Lidocaine.

Quick Tip

Lidocaine is a commonly used local anaesthetic due to its effectiveness and low toxicity.

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22. Which of these separation technique pairs is correctly matched?

(A) Ortho and para nitrophenol: fractional distillation

(B) Crude oil/petroleum: steam distillation

(C) Cereal and amla: simple distillation

(D) Crude oil/petroleum: fractional distillation

Correct Answer: (D) Crude oil/petroleum: fractional distillation

Solution:

Step 1: Understanding the separation techniques.

- Fractional distillation is used to separate mixtures with different boiling points. Crude oil consists of a mixture of hydrocarbons, and fractional distillation is used to separate them based on their boiling points. - Steam distillation is used for separating compounds that are sensitive to heat. This technique is not ideal for separating crude oil.

Step 2: Conclusion.

Therefore, the correct matching pair is Crude oil/petroleum and fractional distillation, which corresponds to option (D).

Quick Tip

Crude oil is typically separated by fractional distillation due to the wide range of boiling points of its components.

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23. Pick the reaction that shows the Gattermann-Koch process:

(A) Benzene + methyl chloride $\rightarrow$ ethylbenzene ($AlCl_3$ catalyst)

(B) Benzene + CO + HCl $\rightarrow$ benzaldehyde ($AlCl_3$, CuCl catalysts)

(C) Benzene + bromine $\rightarrow$ bromobenzene ($FeBr_3$ catalyst)

(D) Benzene + acetyl chloride $\rightarrow$ acetophenone ($AlCl_3$ catalyst)

Correct Answer: (B) Benzene + CO + HCl $\rightarrow$ benzaldehyde ($AlCl_3$, CuCl catalysts)

Solution:

Step 1: Understanding the Gattermann-Koch process.

The Gattermann-Koch process is used for the formylation of benzene. In this process, benzene reacts with carbon monoxide (CO) and hydrochloric acid (HCl) in the presence of $AlCl_3$ and CuCl catalysts to form benzaldehyde.

Step 2: Conclusion.

Thus, the correct reaction for the Gattermann-Koch process is:

$$\text{Benzene} + \text{CO} + \text{HCl} \rightarrow \text{Benzaldehyde}$$

which corresponds to option (B).

Quick Tip

The Gattermann-Koch process is a method for synthesizing benzaldehyde from benzene using CO and HCl in the presence of $AlCl_3$ and CuCl catalysts.

PHYSICS

Q24. What are the dimensional formula units for voltage?

Answer:

$$[V] = M^1L^2T^{-3}A^{-1}$$

Solution:

Step 1: Understanding voltage dimensions.

Voltage (or electric potential) is defined as energy per unit charge. The dimensional formula for energy is ML^2T^{-2}, and for charge, it is AT. Dividing energy by charge gives the dimensional formula for voltage:

$$[V] = \frac{ML^2T^{-2}}{AT} = ML^2T^{-3}A^{-1}$$

Quick Tip

Voltage has the dimensional formula $M^1L^2T^{-3}A^{-1}$, which is derived from the relationship between energy and charge.

Q25. What is the ratio of the de Broglie wavelengths for an electron and a proton if both have equal kinetic energy?

Answer:

$$\frac{\lambda_{\text{proton}}}{\lambda_{\text{electron}}} = \sqrt{\frac{m_{\text{proton}}}{m_{\text{electron}}}}$$

Solution:

Step 1: Understanding the de Broglie wavelength.

The de Broglie wavelength λ of a particle is given by the equation:

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

where h is Planck's constant and p is the momentum of the particle. The momentum p is related to the kinetic energy E by the equation:

$$p = \sqrt{2mE}$$

Thus, the de Broglie wavelength is inversely proportional to the square root of the mass m of the particle.

Step 2: Comparing the wavelengths of the proton and electron.

Since both the electron and proton have the same kinetic energy, their momentum is proportional to the square root of their masses. Therefore, the ratio of their de Broglie wavelengths is:

$$\frac{\lambda_{\text{proton}}}{\lambda_{\text{electron}}} = \sqrt{\frac{m_{\text{proton}}}{m_{\text{electron}}}}$$

Quick Tip

For two particles with the same kinetic energy, the ratio of their de Broglie wavelengths is inversely proportional to the square root of their masses.

Q26. If current drops from 4 A to 0 A in 0.5 s, and voltage is 120 V, find the self-inductance.

Answer:

$$L = \frac{V\Delta t}{\Delta I} = \frac{120 \times 0.5}{4} = 15\,\text{H}$$

Solution:

Step 1: Understanding the formula.

The self-inductance L can be calculated using the formula:

$$L = \frac{V\Delta t}{\Delta I}$$

where: - V is the voltage (120 V), - Δt is the time duration (0.5 s), - ΔI is the change in current (from 4 A to 0 A, so $\Delta I = 4\,\text{A}$).

Step 2: Substituting the values.

Substituting the known values into the formula:

$$L = \frac{120 \times 0.5}{4} = \frac{60}{4} = 15\,\text{H}$$

Step 3: Conclusion.

Thus, the self-inductance is $15\,\text{H}$.

Quick Tip

The formula for self-inductance is derived from the relationship between voltage, current, and time in an inductor.

Q27. Apply the mirror formula if focal length $f = l$ m and object distance $u = 15$ m.

Answer:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \Rightarrow \quad v = \frac{uf}{u - f}$$

Solution:

Step 1: Understanding the mirror formula.

The mirror formula relates the object distance (u), image distance (v), and focal length (f) of a mirror. It is given by:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

Rearranging the formula to solve for v:

$$v = \frac{uf}{u - f}$$

Step 2: Conclusion.

Thus, the image distance v can be calculated using the formula $v = \frac{uf}{u-f}$. If $f = l$ m and $u = 15$ m, we can substitute these values to find v.

Quick Tip

The mirror formula is essential for determining the image distance when the object distance and focal length are known.

Q28. What is the Bohr radius of a hydrogen atom?

Answer:

$$a_0 \approx 0.53\,\text{Å}$$

Solution:

Step 1: Understanding the Bohr radius.

The Bohr radius a_0 is the radius of the smallest orbit around the nucleus in a hydrogen atom. It is given by the formula:

$$a_0 = \frac{4\pi\epsilon_0 h^2}{m_e e^2}$$

where: - ϵ_0 is the permittivity of free space, - h is Planck's constant, - m_e is the electron mass, - e is the electron charge.

Step 2: Numerical value.

The numerical value for the Bohr radius is approximately 0.53 Å.

Step 3: Conclusion.

Thus, the Bohr radius of a hydrogen atom is $a_0 \approx 0.53\,\text{Å}$.

Quick Tip

The Bohr radius is a fundamental constant and represents the distance between the electron and the nucleus in the hydrogen atom's ground state.

Q29. How can energy losses in a transformer be minimised?

Answer:

$$\text{Use thick wires to reduce resistance, i.e., R} \downarrow \quad \Rightarrow \quad P_{\text{loss}} = I^2 R \downarrow$$

Solution:

Step 1: Understanding the energy loss in a transformer.

The energy losses in a transformer are mainly due to resistance in the wires. The power loss due to resistance is given by the formula:

$$P_{\text{loss}} = I^2 R$$

where I is the current and R is the resistance.

Step 2: Minimising energy losses.

To minimise energy losses, we need to reduce the resistance R. This can be achieved by using thicker wires, as thicker wires have lower resistance. Thus, by decreasing R, the power loss P_{loss} also decreases.

Step 3: Conclusion.

Therefore, energy losses can be minimised by using thick wires to reduce the resistance.

Quick Tip

In a transformer, reducing the resistance of the wires minimizes energy losses, as power loss is proportional to the square of the current and the resistance.

Q30. Given $E(t) = 108t - 22$, how is velocity derived from the electric field?

Answer:

$$v(t) = \frac{q}{m} \int E(t)\, dt = \frac{q}{m} \int (108t - 22)\, dt$$

Solution:

Step 1: Understanding the relationship between electric field and velocity.

The velocity $v(t)$ of a charged particle in an electric field can be derived from the electric field $E(t)$ by integrating it over time. The relationship is given by:

$$v(t) = \frac{q}{m} \int E(t)\, dt$$

where q is the charge of the particle, m is the mass, and $E(t)$ is the electric field as a function of time.

Step 2: Substituting the given electric field.

We are given $E(t) = 108t - 22$, so we substitute this into the equation:

$$v(t) = \frac{q}{m} \int (108t - 22)\, dt$$

Step 3: Performing the integration.

Integrating $108t - 22$ with respect to time:

$$\int (108t - 22)\, dt = \frac{108t^2}{2} - 22t + C$$

Step 4: Final expression for velocity.

Thus, the velocity as a function of time is:

$$v(t) = \frac{q}{m} \left(\frac{108t^2}{2} - 22t + C \right)$$

Step 5: Conclusion.

This is the expression for the velocity of the particle derived from the electric field.

Quick Tip

To find the velocity from the electric field, integrate the electric field with respect to time, considering the charge and mass of the particle.

Q31. For a microscope with objective $f_o = 1\,$cm, eyepiece $f_e = 10\,$cm, and image distance $v = 25\,$cm, find total magnification.

Answer:

$$M = M_{\text{objective}} \cdot M_{\text{eyepiece}}, \quad \text{where} \quad M_{\text{objective}} = \frac{v}{u}, \quad M_{\text{eyepiece}} = 1 + \frac{D}{f_e}$$

Solution:

Step 1: Understanding the magnification formula.

The total magnification of a microscope is the product of the magnifications produced by the objective lens and the eyepiece. The magnification produced by the objective lens is given by:

$$M_{\text{objective}} = \frac{v}{u}$$

where v is the image distance and u is the object distance for the objective lens. The magnification produced by the eyepiece is given by:

$$M_{\text{eyepiece}} = 1 + \frac{D}{f_e}$$

where D is the least distance of distinct vision (usually taken as 25 cm), and f_e is the focal length of the eyepiece.

Step 2: Substituting the given values.

We are given $f_o = 1\,$cm, $f_e = 10\,$cm, and $v = 25\,$cm. First, calculate the magnification by the eyepiece:

$$M_{\text{eyepiece}} = 1 + \frac{25}{10} = 3.5$$

Step 3: Finding the object distance u using the lens formula.

We can use the lens formula for the objective lens:

$$\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$$

where v_o is the image distance for the objective and u_o is the object distance for the objective. Using this, we can find u. For simplicity, let's assume an appropriate value for u and calculate $M_{\text{objective}}$.

Step 4: Conclusion.

Thus, the total magnification M is the product of $M_{\text{objective}}$ and M_{eyepiece}.

Quick Tip

The total magnification of a microscope is the product of the magnifications of the objective and the eyepiece.

Q32. If light intensity is known, how is non-reflecting momentum calculated?

Answer:

$$p = \frac{U}{c}$$

where U is the energy flux and c is the speed of light.

Solution:

Step 1: Understanding the formula.

The momentum p of light can be calculated using the energy flux U and the speed of light c. The energy flux U is the energy transferred per unit area per unit time, and the speed of light is the constant $c = 3 \times 10^8$ m/s.

Step 2: Formula derivation.

The relationship between momentum and energy flux is given by:

$$p = \frac{U}{c}$$

This formula is used to find the momentum of non-reflecting light, where the energy flux U is divided by the speed of light c.

Step 3: Conclusion.

Thus, the momentum p can be calculated using the above formula.

Quick Tip

The momentum of non-reflecting light can be calculated using the energy flux divided by the speed of light.

Q33. What is the magnetic field at the centre of a current-carrying loop?

Answer:

$$B = \frac{\mu_0 I}{2R}$$

Solution:

Step 1: Understanding the formula.

The magnetic field at the center of a current-carrying loop can be derived from Ampère's law. For a circular loop of radius R, carrying a current I, the magnetic field at the center is given by:

$$B = \frac{\mu_0 I}{2R}$$

where μ_0 is the permeability of free space.

Step 2: Formula derivation.

This formula shows that the magnetic field B at the center of a loop is directly proportional to the current I and inversely proportional to the radius R. The permeability of free space μ_0 is a constant, $\mu_0 = 4\pi \times 10^{-7}$ T m/A.

Step 3: Conclusion.

Thus, the magnetic field at the center of a current-carrying loop is given by $B = \frac{\mu_0 I}{2R}$.

Quick Tip

The magnetic field at the center of a current-carrying loop is proportional to the current and inversely proportional to the radius of the loop.

Q34. Given n turns, current I, permeability, and diameter, find magnetisation.

Answer:

$$M = nI$$

Solution:

Step 1: Understanding magnetisation.

Magnetisation M is defined as the magnetic moment per unit volume of a material. For a coil with n turns carrying a current I, the magnetisation is given by the product of the number of

turns per unit length and the current:

$$M = nI$$

Step 2: Explanation.

In this formula, n is the number of turns per unit length (i.e., the number of loops per unit length of the coil), and I is the current passing through the coil. The product nI gives the magnetisation of the material. This formula is valid for a solenoid or a coil where the turns are uniformly distributed.

Step 3: Conclusion.

Thus, the magnetisation is given by $M = nI$, where n is the number of turns per unit length, and I is the current.

Quick Tip

Magnetisation is calculated as the number of turns per unit length times the current in the coil.

Q35. What is C_v for a monoatomic gas?

Answer:

$$C_v = \frac{3}{2}R$$

Solution:

Step 1: Understanding the heat capacities.

For a monoatomic ideal gas, the heat capacity at constant volume C_v is related to the ideal gas constant R. In the case of a monoatomic gas, the degrees of freedom are three translational degrees of freedom, and the heat capacity is derived using the equipartition theorem.

Step 2: Formula for C_v.

For a monoatomic ideal gas, the formula for C_v is:

$$C_v = \frac{3}{2}R$$

where R is the universal gas constant.

Step 3: Conclusion.

Thus, the heat capacity at constant volume for a monoatomic gas is $\frac{3}{2}R$.

Quick Tip

For a monoatomic ideal gas, $C_v = \frac{3}{2}R$, which is derived from the translational degrees of freedom.

Q36. For $V = 120\,\text{V}$, find the resonant current I_0.

Answer:

$$I_0 = \frac{V}{R} \quad \text{at resonance}$$

Solution:

Step 1: Understanding the formula for resonant current.

At resonance, the impedance of the circuit is purely resistive, and the current is determined by Ohm's law:

$$I = \frac{V}{R}$$

where V is the voltage and R is the resistance. At resonance, this equation gives the resonant current I_0.

Step 2: Formula.

Substituting $V = 120\,\text{V}$ into the formula:

$$I_0 = \frac{120}{R}$$

Thus, the resonant current is $\frac{120}{R}$, where R is the resistance of the circuit.

Step 3: Conclusion.

The resonant current is $\frac{V}{R}$, which is determined by the applied voltage and the resistance.

Quick Tip

At resonance in an AC circuit, the resonant current I_0 is given by $I_0 = \frac{V}{R}$, where V is the voltage and R is the resistance.

Q37. At $T = 27°C$, $V_i = 0.4\,\text{L}$, $V_f = 0.8\,\text{L}$, find isothermal work.

Answer:

$$W = nRT \ln \frac{V_f}{V_i}$$

Solution:

Step 1: Understanding the formula for isothermal work.

For an isothermal process, the work done by the gas is given by the formula:

$$W = nRT \ln \frac{V_f}{V_i}$$

where: - n is the number of moles of the gas,

- R is the universal gas constant,

- T is the temperature in Kelvin,

- V_f is the final volume, and

- V_i is the initial volume.

Step 2: Substituting the given values.

We are given: - $T = 27°C = 27 + 273 = 300\,\text{K}$, - $V_i = 0.4\,\text{L}$, - $V_f = 0.8\,\text{L}$.

Substitute these into the equation for work:

$$W = nR(300) \ln \frac{0.8}{0.4} = nR(300) \ln 2$$

Step 3: Conclusion.

Thus, the isothermal work done is $W = nR(300) \ln 2$. To calculate the exact value, we need the number of moles n and the value of the gas constant R.

Quick Tip

The isothermal work is calculated using the formula $W = nRT \ln \frac{V_f}{V_i}$, where n is the number of moles and T is the temperature in Kelvin.

Q38. For mass 20 kg, torque $\tau = 5\,\text{Nm}$, find angular acceleration α.

Answer:

$$\alpha = \frac{\tau}{I}, \quad \text{where} \quad I = mr^2 \quad \text{(for point mass or use appropriate shape formula)}$$

Solution:

Step 1: Understanding the relationship between torque and angular acceleration.

Torque τ is related to angular acceleration α by the equation:

$$\alpha = \frac{\tau}{I}$$

where I is the moment of inertia. For a point mass, the moment of inertia is given by $I = mr^2$, where m is the mass and r is the radius or distance from the axis of rotation.

Step 2: Substituting the known values.

Given $\tau = 5\,\text{Nm}$ and mass $m = 20\,\text{kg}$, we need the radius r to calculate I. If the radius is provided, we can calculate I and then use the equation for α.

Step 3: Conclusion.

Thus, the angular acceleration α can be calculated using $\alpha = \frac{\tau}{I}$, with $I = mr^2$ for a point mass or the appropriate moment of inertia formula for other shapes.

Quick Tip

Angular acceleration is found using $\alpha = \frac{\tau}{I}$, where I is the moment of inertia. For a point mass, $I = mr^2$.

BIOLOGY

Q39. Which technique did Mendel use while experimenting on pea plants?

(a) Natural pollination

(b) Hybridisation

(c) Grafting

(d) Emasculation

Correct Answer: (d) Emasculation

Solution:

Step 1: Understanding Mendel's method.

Mendel controlled pollination in his experiments by using the technique of emasculation, where he removed the male parts (anthers) of the flowers to prevent self-pollination. He then cross-pollinated the flowers by transferring pollen from another plant. This method ensured that Mendel could control the genetic cross-breeding of pea plants.

Step 2: Conclusion.

Thus, Mendel used emasculation to control pollination, corresponding to option (d).

Quick Tip

Mendel used emasculation to prevent self-pollination and control cross-breeding in his experiments with pea plants.

Q40. What is the term for the beginning of the menstrual cycle?

Answer:

The onset of menstruation is called menarche.

Solution:

Step 1: Definition of menarche.

Menarche is the term used to describe the first occurrence of menstruation in a female. It marks the beginning of the menstrual cycle and usually occurs between the ages of 12 and 14, although it can vary.

Step 2: Conclusion.

Therefore, the onset of the menstrual cycle is called menarche.

Quick Tip

Menarche is the first menstrual period and signifies the beginning of the menstrual cycle.

Q41. Who first classified the plant kingdom?

(a) Carlous Linnaeus

(b) R.H. Whittaker

(c) Bentham Hooker

Correct Answer: (a) Carlous Linnaeus

Solution:

Step 1: Linnaeus's classification system.

Carlous Linnaeus, a Swedish botanist, is credited with being the first to develop a modern classification system for plants and animals. His system of binomial nomenclature and hierarchical classification laid the foundation for how organisms are grouped.

Step 2: Other contributions.

Later, Bentham Hooker proposed a broader classification scheme, and R.H. Whittaker proposed a 5-kingdom classification system that included Monera, Protista, Fungi, Plantae, and Animalia. However, Linnaeus was the first to develop a classification system for plants.

Step 3: Conclusion.

Thus, Carlous Linnaeus was the first to classify the plant kingdom, corresponding to option (a).

Quick Tip

Linnaeus is known for his development of binomial nomenclature and for being the first to classify the plant kingdom.

Q42. Platelets are formed at which site?

Answer: Platelets (thrombocytes) originate in the bone marrow.

Solution:

Step 1: Understanding platelet formation.

Platelets, also known as thrombocytes, are small, cell-like structures that are formed in the bone marrow. They play a crucial role in blood clotting. Platelets are derived from large cells

in the bone marrow called megakaryocytes, which release fragments of their cytoplasm into the bloodstream.

Step 2: Conclusion.

Therefore, platelets are formed in the bone marrow.

Quick Tip

Platelets are produced in the bone marrow from large cells called megakaryocytes.

Q43. Adaptive radiation is an example of which type of evolution?

Answer:

Adaptive radiation refers to divergent evolution, where species diversify from a common ancestor.

Solution:

Step 1: Understanding adaptive radiation.

Adaptive radiation is a form of divergent evolution in which a single ancestral species rapidly evolves into a wide variety of species, each adapted to a different ecological niche. This process typically occurs when organisms colonize new habitats with diverse environmental conditions.

Step 2: Conclusion.

Adaptive radiation is a classic example of divergent evolution, where species diversify from a common ancestor.

Quick Tip

Adaptive radiation is a form of divergent evolution, where a species rapidly evolves into new forms to exploit different ecological niches.

Q44. Select the incorrect statement:

(a) In geitonogamy, pollination occurs in different flowers.

(b) In Vallisneria, pollination takes place with the help of water.

(c) Autogamy involves pollination within the same flower.

Correct Answer: (a) In geitonogamy, pollination occurs in different flowers.

Solution:

Step 1: Understanding geitonogamy.

Geitonogamy refers to a type of pollination in which pollen from one flower is transferred to the stigma of another flower on the same plant. This involves pollination between different flowers but within the same plant. Thus, statement (a) is incorrect because it says that geitonogamy involves different flowers on different plants.

Step 2: Understanding the pollination in Vallisneria.

Vallisneria is an aquatic plant that relies on water for pollination. Its flowers are submerged underwater, and pollination occurs via water currents, making statement (b) correct.

Step 3: Understanding autogamy.

Autogamy is the process of self-pollination, where pollen from a flower pollinates the stigma of the same flower. Thus, statement (c) is correct.

Step 4: Conclusion.

The incorrect statement is (a), as geitonogamy involves pollination between different flowers on the same plant, not different plants.

Quick Tip

Geitonogamy is pollination between flowers of the same plant, while autogamy involves self-pollination within the same flower.

Q45. Match the following pairs:

- Trichoderma – Citric Acid
- Polysporum – Statins
- Yeast – Cyclosporin A
- Monascus Purpureus – Ethanol

- Aspergillus Niger – Citric Acid

Explanation: These pairs involve microorganisms and their biotechnological products. For example, Aspergillus niger produces citric acid, and Monascus purpureus is used for statin production.

Solution:

Step 1: Understanding the products of microorganisms.

- Trichoderma is known to be used in the production of enzymes, but is not directly linked to citric acid production. - Polysporum is involved in the production of statins. - Yeast (e.g., Saccharomyces cerevisiae) is used in the production of cyclosporin A, a drug used for immunosuppression. - Monascus purpureus is used to produce ethanol. - Aspergillus niger is widely used in the production of citric acid, especially in industrial fermentation processes.

Step 2: Conclusion.

The correct matching pairs are: - Trichoderma – (produces enzymes, not citric acid directly) - Polysporum – Statins - Yeast – Cyclosporin A - Monascus Purpureus – Ethanol - Aspergillus Niger – Citric Acid

Quick Tip

Certain microorganisms are used to produce specific products, such as Aspergillus niger for citric acid and Monascus purpureus for statins.

Q46. Filariasis is caused by?

Answer: Filariasis is caused by parasitic worms (filarial nematodes).

Solution:

Step 1: Understanding filariasis.

Filariasis is a disease caused by filarial worms, which are parasitic nematodes. These worms are transmitted to humans through the bite of infected mosquitoes. Common filarial worms include *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*.

Step 2: Conclusion.

Thus, filariasis is caused by parasitic filarial nematodes.

Quick Tip

Filariasis is a tropical disease caused by parasitic nematodes, and it is transmitted by mosquitoes.

Q47. Name the repressor of the lac operon.

Answer: The repressor of the lac operon is the protein encoded by the lacI gene.

Solution:

Step 1: Understanding the lac operon.

The lac operon is a set of genes involved in the metabolism of lactose in bacteria. In the absence of lactose, the lac operon is repressed by a protein called the lac repressor, which is encoded by the lacI gene. The lac repressor binds to the operator region of the lac operon, preventing transcription of the downstream genes. When lactose is present, it binds to the repressor and inactivates it, allowing transcription to proceed.

Step 2: Conclusion.

Therefore, the repressor of the lac operon is the protein encoded by the lacI gene.

Quick Tip

The lacI gene codes for the repressor protein, which regulates the lac operon in response to the presence or absence of lactose.

Q48. When xylem is present at the same radius in a stem or root, what is this arrangement called?

(a) Radial

(b) Conjoint

(c) Open

(d) Close

Correct Answer: (b) Conjoint

Solution:

Step 1: Understanding vascular arrangement.

In plants, the vascular bundles consist of xylem and phloem tissues that transport water, nutrients, and sugars. The arrangement of xylem and phloem varies between roots and stems. In roots, the xylem and phloem are arranged in a radial pattern, where they are positioned at different radii, typically with xylem in the center and phloem on the outside. In contrast, in stems, xylem and phloem are arranged in conjoint bundles, where both tissues share the same radius.

Step 2: Explanation of options.

- Radial: Refers to xylem and phloem arranged in separate radii, a typical feature in roots. - Conjoint: Refers to xylem and phloem arranged together at the same radius, typically seen in stems. This is the correct arrangement for the question. - Open: This term is not related to the arrangement of xylem and phloem but may refer to open vascular bundles in certain contexts. - Close: Similar to ”open,” this term is not typically used to describe the vascular bundle arrangement.

Step 3: Conclusion.

Thus, the arrangement where xylem and phloem are present at the same radius in a stem or root is called conjoint, corresponding to option (b).

Quick Tip

In stems, xylem and phloem are conjoint, meaning they share the same radius, while in roots, they are arranged radially, in separate radii.