KEAM 2025 April 29 Pharmacy Question Paper With Solution

Time Allowed :90 Minutes	**Maximum Marks : 300**	**Total Questions :**75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question paper comprises 75 questions.
2. The Paper is divided into two parts- Physics and Chemistry.
3. There are 30 questions in Physics and 45 questions in Chemistry.
4. For each correct response, candidates are awarded 4 marks.
5. The total duration of the exam is 90 minutes.
6. The maximum marks for the exam are 300.

1. A solution is prepared by adding 4 g of a substance to 46 g of ethanol. What is the mass percentage of the solute?

(A) 8%

(B) 10%

(C) 4%

(D) 6%

(E) 12

Correct Answer: (1) 8%

Solution: To calculate the mass percentage of the solute, we use the formula:

$$\text{Mass percentage of solute} = \left(\frac{\text{Mass of solute}}{\text{Mass of solution}} \right) \times 100$$

Where:

- Mass of solute = 4 g
- Mass of solvent (ethanol) = 46 g
- Mass of solution = Mass of solute + Mass of solvent = 4 g + 46 g = 50 g

Now, substituting these values:

$$\text{Mass percentage of solute} = \left(\frac{4}{50} \right) \times 100 = 8\%$$

Thus, the correct answer is 8% (1).

Quick Tip

The mass percentage of a solute is calculated by dividing the mass of the solute by the total mass of the solution, then multiplying by 100.

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2. The order of energy of orbitals in the same subshell is

(A) $E_{2s}(\text{Na}) > E_{2s}(\text{Li}) > E_{2s}(\text{K})$

(B) $E_{2s}(\text{Li}) > E_{2s}(\text{Na}) > E_{2s}(\text{K})$

(C) $E_{2s}(\text{K}) > E_{2s}(\text{Na}) > E_{2s}(\text{Li})$

(D) $E_{2s}(\text{Na}) > E_{2s}(\text{K}) > E_{2s}(\text{Li})$

(E)

$$E_{2s}(\text{Na}) > E_{2s}(\text{K}) > E_{2s}(\text{Li})$$

Correct Answer: (2) $E_{2s}(\text{Li}) > E_{2s}(\text{Na}) > E_{2s}(\text{K})$

Solution: The order of energy of orbitals in the same subshell is influenced by the effective nuclear charge (Z_{eff}) and shielding effects.

- For E_{2s} orbitals, the energy depends on the atomic number (Z). As the number of protons in the nucleus increases, the effective nuclear charge increases, pulling the electrons closer to the nucleus and lowering the energy of the orbital.

- Lithium (Li) has the smallest atomic number, so its 2s orbital will be at a higher energy level than the other elements in the same subshell due to less shielding.

- Sodium (Na) has more protons, and the 2s orbital experiences more shielding than in lithium, lowering the energy further. - Potassium (K) has the largest atomic number and experiences the most shielding, so its 2s orbital has the least energy.

Thus, the correct order of energy is $E_{2s}(\text{Li}) > E_{2s}(\text{Na}) > E_{2s}(\text{K})$.

Quick Tip

The energy of orbitals in the same subshell decreases with increasing atomic number due to the increased effective nuclear charge, which pulls the electrons closer.

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3. Which of the following is correct about the stability of half-filled and completely filled subshells?

(i) Relatively small shielding

(ii) Larger coulombic repulsion energy

(iii) Smaller exchange energy

(iv) Smaller coulombic repulsion energy

(v) Larger exchange energy

(A) (i), (ii) and (iii)

(B) (i), (iii) and (v)

(C) (i), (iv) and (v)

(D) (ii), (iii) and (v)

(E) (i), (ii) and (iv)

Correct Answer: (C) (i), (iv) and (v)

Solution: - Relatively small shielding (i): This is true for half-filled and completely filled subshells. Due to the symmetric distribution of electrons, these configurations are more stable, leading to small shielding effects.
- Larger coulombic repulsion energy (ii): This is incorrect. For half-filled or completely filled subshells, the electrons are arranged symmetrically, reducing repulsion and making the system more stable.
- Smaller exchange energy (iii): This is incorrect. A half-filled or fully filled subshell has more exchange energy, which contributes to stability. This is why configurations like d^5 and p^6 are particularly stable.
- Smaller coulombic repulsion energy (iv): This is correct. Due to electron pairing and symmetric arrangement, there is less repulsion between electrons, leading to lower coulombic repulsion energy. - Larger exchange energy (v): This is correct. The exchange energy is maximized in half-filled and fully filled subshells, contributing to the stability of these configurations.
Thus, the correct answer is (C) (i), (iv), and (v). These are the characteristics of half-filled and fully filled subshells that make them particularly stable.

Quick Tip

Half-filled and completely filled subshells are highly stable due to their larger exchange energy and lower coulombic repulsion, making them energetically favorable.

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4. The correct order of ionization enthalpy is

(A) C < B < O < N

(B) B < O < C < N

(C) N < C < O < B

(D) B < C < O < N

(E) C < B < O < N

Correct Answer: (D) B < C < O < N

Solution: Ionization enthalpy is the energy required to remove an electron from an atom in the gaseous state. The trend in ionization enthalpy follows the atomic structure and the number of protons in the nucleus.
- B < C: Boron (B) has a lower ionization enthalpy than Carbon (C) because it has a single electron in the 2p orbital, which is easier to remove compared to the 2p orbital in carbon.
- C < O: Oxygen (O) has a higher ionization enthalpy than carbon due to increased effective nuclear charge and a smaller atomic radius, which makes it harder to remove an electron.
- O < N: Nitrogen (N) has a higher ionization enthalpy than oxygen due to its stable half-filled 2p orbitals (which provides extra stability).
Thus, the correct order of ionization enthalpy is (D) B < C < O < N.

Quick Tip

Ionization enthalpy generally increases across a period due to increased nuclear charge, but decreases down a group due to increased atomic size and shielding effects.

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5. The increasing order of atomic radii is

(A) C < N < O < F

(B) F < O < C < N

(C) O < F < N <C

(D) F < N < O < C

(E) F < O < N < C

Correct Answer: (E) F < O < N < C

Solution: The atomic radius generally decreases across a period due to the increase in nuclear charge, which pulls the electrons closer to the nucleus. Going down a group, the atomic radius increases due to the addition of electron shells.
- Fluorine (F) has the smallest atomic radius in this group because it has the highest nuclear charge and the smallest number of electron shells. - Oxygen (O) has a slightly larger atomic

radius than fluorine, as it has one less proton and one more electron shell. - Nitrogen (N) has a larger atomic radius compared to oxygen because of its lower nuclear charge and electron shielding. - Carbon (C) has the largest atomic radius in this sequence due to its even lower nuclear charge and electron shielding effects.
Thus, the correct increasing order of atomic radii is (E) F $<$ O $<$ N $<$ C.

Quick Tip

As we move across a period from left to right, atomic radii decrease due to increasing nuclear charge. As we move down a group, atomic radii increase due to added electron shells.

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6. Which of the following molecules has an expanded octet?

(A) BCl_3

(B) NO_2

(C) NO

(D) SF_6

(E) BeH_2

Correct Answer: (D) SF_6

Solution: An expanded octet occurs when elements from the third period and beyond can accommodate more than 8 electrons in their valence shell due to the availability of d-orbitals.
- BCl_3: Boron (B) in BCl_3 does not have an expanded octet. It follows the octet rule and has only 6 electrons in its valence shell.
- NO_2 : NO_2 does not have an expanded octet, as nitrogen follows the octet rule and has 8 electrons in its valence shell.
- NO: NO does not have an expanded octet either. Nitrogen in this molecule follows the octet rule.
- SF_6 : SF_6 (sulfur hexafluoride) is the correct answer. Sulfur can accommodate more than 8 electrons in its valence shell due to the availability of d-orbitals, and it forms an expanded octet in SF_6.

- BeH_2: BeH_2 does not have an expanded octet. Beryllium (Be) follows the duet rule and only has 4 electrons in its valence shell.

Thus, the correct answer is (D) , SF_6 as sulfur in this molecule has an expanded octet.

Quick Tip

Elements in the third period or higher, like sulfur, can have an expanded octet as they have access to d-orbitals in their valence shell.

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7. Which of the following molecules has 3 bond pairs and 2 lone pairs of electrons?

(A) NH_3

(B) SO_2

(C) ClF_3

(D) SF_4

(E) H_2O

Correct Answer: (C) ClF_3

Solution: To determine the number of bond pairs and lone pairs in a molecule, we need to look at its Lewis structure and VSEPR theory:

- NH_3(Ammonia) has 3 bond pairs and 1 lone pair on nitrogen.
- SO_2(Sulfur dioxide) has 2 bond pairs and 1 lone pair on sulfur.
- ClF_3 (Chlorine trifluoride) has 3 bond pairs and 2 lone pairs on chlorine.
- SF_4(Sulfur tetrafluoride) has 4 bond pairs and 1 lone pair on sulfur.
- H_2O (Water) has 2 bond pairs and 2 lone pairs on oxygen.

Thus, the molecule with 3 bond pairs and 2 lone pairs is ClF_3 (C).

Quick Tip

To find bond pairs and lone pairs, draw the Lewis structure and apply the VSEPR theory for electron pair geometry.

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8. Which of the following is an extensive property?

(A) Molar volume

(B) Internal energy

(C) Temperature

(D) Density

(E) Pressure

Correct Answer: (B) Internal energy

Solution: - Extensive properties depend on the amount or size of the substance, and they change as the size of the system changes. Examples include mass, volume, and internal energy.

- Molar volume is an extensive property because it depends on the amount of substance present.

- Internal energy is also an extensive property because it depends on the quantity of the system.

- Temperature is an intensive property because it does not change with the amount of substance.

- Density is an intensive property because it is independent of the amount of substance.

- Pressure is an intensive property because it does not depend on the amount of substance in the system.

Thus, the correct answer is Internal energy (B), as it is an extensive property.

Quick Tip

Extensive properties like internal energy depend on the size or amount of the substance, while intensive properties like temperature do not.

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9. Which of the following molecules has the highest standard enthalpy change of fusion ($\Delta_{fus}H^{\circ}$) (in kJ mol^{-1})?

(A) H_2O

(B) CO

(C) C_6H_6

(D) CCl_4

(E) NaCl

Correct Answer: (E) NaCl

Solution: The standard enthalpy change of fusion ($\Delta_{fus}H^\circ$) refers to the heat absorbed when one mole of a substance undergoes fusion (melts) at constant pressure.
- H_2O: Water has a relatively moderate $\Delta_{fus}H^\circ$, as its intermolecular hydrogen bonding makes it require a significant amount of heat to melt, but it is not the highest among the options listed.
- CO: Carbon monoxide has a low $\Delta_{fus}H^\circ$, as its molecular forces are relatively weak, requiring less energy to melt. - C_6H_6 : Benzene (CH) has a higher $\Delta_{fus}H^\circ$ than CO but is still lower than that of ionic compounds.
- CCl_4: Carbon tetrachloride has a moderate $\Delta_{fus}H^\circ$, though not as high as ionic compounds.
- NaCl: Sodium chloride is an ionic compound, and ionic bonds are very strong. Therefore, NaCl requires a large amount of energy to overcome the lattice energy during fusion, resulting in a higher enthalpy change of fusion compared to the other molecules listed.
Thus, the correct answer is (E) NaCl.

Quick Tip

Ionic compounds like NaCl tend to have the highest enthalpy change of fusion because their strong ionic bonds require more energy to break.

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10. At equilibrium, the concentration of $N_2 = 5 \times 10^{-3}$ M, $O_2 = 2.8 \times 10^{-3}$ M, and $NO = 1.4 \times 10^{-3}$ M in a sealed vessel at 800 K. What is the value of K_c for the reaction at the same temperature?

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

(A) 0.41

(B) 0.14

(C) 0.18

(D) 0.5

(E) 0.28

Correct Answer: (B) 0.14

Solution: The equilibrium constant K_c for the reaction is calculated using the formula:

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

Substitute the given concentrations into the equation:

$$K_c = \frac{(1.4 \times 10^{-3})^2}{(5 \times 10^{-3})(2.8 \times 10^{-3})}$$

First, calculate the numerator and denominator:

- Numerator: $(1.4 \times 10^{-3})^2 = 1.96 \times 10^{-6}$ - Denominator: $(5 \times 10^{-3})(2.8 \times 10^{-3}) = 1.4 \times 10^{-5}$

Now, divide the numerator by the denominator:

$$K_c = \frac{1.96 \times 10^{-6}}{1.4 \times 10^{-5}} = 0.14$$

Thus, the correct answer is (B) 0.14.

Quick Tip

To calculate K_c, remember to use the concentrations of products and reactants raised to the power of their stoichiometric coefficients.

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11. Given the reaction:

$$\text{Cu(s)} + 2\text{Ag}^+_{(aq)} \rightleftharpoons \text{Cu}^{2+}_{(aq)} + 2\text{Ag(s)} \quad (\text{E}^\circ_{\text{cell}} = 0.295\,\text{V},\ 2.303\,\frac{RT}{F} = 0.059\,\text{V})$$

What is the value of the equilibrium constant K?

(A) 10^{20}

(B) 10^{15}

(C) 10^{10}

(D) 10^{-1}

(E) 10^{-2}

Correct Answer: (C) 10^{10}

Solution: To find the equilibrium constant K, we use the Nernst equation in its logarithmic form:

$$E^{\circ}_{\text{cell}} = \frac{0.059}{n} \log K$$

Here: - $E^{\circ}_{\text{cell}} = 0.295\,\text{V}$ - $n = 2$ (because there are 2 electrons involved in the reaction)
Substitute the given values into the equation:

$$0.295 = \frac{0.059}{2} \log K$$

Solve for $\log K$:

$$\log K = \frac{0.295 \times 2}{0.059} = 10$$

Thus, $K = 10^{10}$.
So, the correct answer is (C) 10^{10}.

Quick Tip

The equilibrium constant K can be calculated using the Nernst equation, which relates the cell potential to the equilibrium constant for a given reaction.

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12. Which of the following compounds is used to cover the surface of a metallic object to prevent corrosion?

(A) Phenol
(B) Benzene
(C) Acetone
(D) Bisphenol
(E) Nitrophenol

Correct Answer: (D) Bisphenol

Solution: Corrosion is the degradation of metals due to chemical reactions with environmental elements, often oxygen or water. To prevent corrosion, the surface of metals is typically coated with protective substances.
- Phenol: This compound is not typically used for corrosion protection. It is an aromatic alcohol used in various chemical processes.
- Benzene: Benzene is a solvent and is not used for coating metals to prevent corrosion.
- Acetone: Acetone is a solvent and has no role in protecting metals from corrosion.
- Bisphenol: Bisphenol is used in the production of protective coatings like epoxy resins, which are used to prevent corrosion of metallic surfaces. Therefore, it is the correct answer.
- Nitrophenol: This compound is not used for corrosion protection and has other industrial applications.
Thus, the correct answer is (D) Bisphenol, as it is used in the preparation of protective coatings for metals.

Quick Tip

Bisphenol is commonly used in epoxy resins, which are widely applied for corrosion-resistant coatings on metal surfaces.

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13. Which of the following gases has the lowest solubility in water at 298 K?

(A) Argon

(B) Carbon dioxide

(C) Formaldehyde

(D) Methane

(E) Vinyl chloride

Correct Answer: (A) Argon

Solution: The solubility of gases in water can be understood in terms of Henry's Law, which states that the solubility of a gas in a liquid is directly proportional to its partial pressure. Some gases have very low solubility due to their chemical properties.

- Argon (A): Argon is a noble gas, and noble gases have the lowest solubility in water due to their non-polar nature. This makes Argon the correct answer as it has the lowest solubility among the listed gases. - Carbon dioxide (B): Carbon dioxide dissolves readily in water due to its ability to react with water to form carbonic acid, which increases its solubility.
- Formaldehyde (C): Formaldehyde is polar and can easily dissolve in water due to its ability to form hydrogen bonds with water molecules. - Methane (D): While methane is non-polar, it still has a higher solubility than argon due to its smaller size and higher tendency to interact with water to a slight extent.
- Vinyl chloride (E): Vinyl chloride, although non-polar, is more soluble in water than argon. Thus, the correct answer is (A) Argon, as it is a noble gas with the lowest solubility in water among the options listed.

Quick Tip

Noble gases like argon have the lowest solubility in water because of their non-polar nature and the lack of significant interactions with water molecules.

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14. In a reaction, $3A \rightarrow$ Products, the concentration of A decreases from 0.6 mol L^{-1} to 0.3 mol L^{-1} in 20 minutes. What is the rate of the reaction during this interval?

(A) 0.05 mol L^{-1} min^{-1}

(B) 0.005 mol L^{-1} min^{-1}

(C) 0.03 mol L^{-1} min^{-1}

(D) 0.6 mol L^{-1} min^{-1}

(E) 0.003 mol L^{-1} min^{-1}

Correct Answer: (B) 0.005 mol L^{-1} min^{-1}

Solution: The rate of the reaction can be calculated by the change in concentration of the reactant over time. The formula for the rate of reaction is:

$$\text{Rate} = \frac{\Delta[\text{A}]}{\Delta t}$$

Where: - $\Delta[\text{A}]$ is the change in concentration of A, - Δt is the time interval.

Given: - Initial concentration of $A = 0.6\,\text{mol L}^{-1}$, - Final concentration of $A = 0.3\,\text{mol L}^{-1}$, - Time interval $\Delta t = 20\,\text{minutes}$.

The change in concentration $\Delta[\text{A}]$ is:

$$\Delta[\text{A}] = 0.6 - 0.3 = 0.3\,\text{mol L}^{-1}$$

Now, calculate the rate:

$$\text{Rate} = \frac{0.3}{20} = 0.015\,\text{mol L}^{-1}\,\text{min}^{-1}$$

Since the stoichiometry of the reaction is 3:1 (3 moles of A react to form products), the rate of disappearance of A is:

$$\text{Rate of reaction} = \frac{0.015}{3} = 0.005\,\text{mol L}^{-1}\,\text{min}^{-1}$$

Thus, the correct answer is (B) 0.005 mol L^{-1} min^{-1}.

Quick Tip

To find the rate of a reaction, remember to divide the change in concentration by the time, and consider the stoichiometric coefficients of the reaction when the reactant and product coefficients differ.

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15. The following data were obtained for the reaction:

$$2NO(g) + O_2(g) \rightarrow 2N_2O(g)$$

at different concentrations:

Experiment	[NO] (mol L^{-1})	[O_2] (mol L^{-1})	Initial Rate (mol L^{-1} min^{-1})
1	0.30	0.30	0.096
2	0.60	0.30	0.384
3	0.30	0.60	0.192
4	0.60	0.60	0.768

The rate law of this reaction is:

(A) Rate = k[NO][O_2]²

(B) Rate = k[NO][O_2]

(C) Rate = k[NO]²[O_2]²

(D) Rate = k[NO]²[O_2]

(E) Rate = k[NO]²[O_2]³

Correct Answer: (D) Rate = k[NO]²[O_2]

Solution: To determine the rate law, we use the data from the experiments to analyze how the rate depends on the concentrations of NO and O_2.

1. Experiment 1 and Experiment 2:

The concentration of O_2 remains constant, while the concentration of NO doubles (from 0.30 to 0.60 mol L^{-1}), and the rate increases by a factor of 4 (from 0.096 to 0.384 mol L^{-1} min^{-1}).

This suggests that the rate is proportional to $[NO]^2$, i.e., the order with respect to NO is 2.

2. Experiment 1 and Experiment 3:

The concentration of NO remains constant, while the concentration of O_2 doubles (from 0.30 to 0.60 mol L^{-1}), and the rate increases by a factor of 2 (from 0.096 to 0.192 mol L^{-1} min^{-1}).

This suggests that the rate is proportional to $[O_2]$, i.e., the order with respect to O_2 is 1.

Thus, the rate law is Rate =

$$k[NO]^2[O_2]$$

, corresponding to option (D).

Quick Tip

The order of reaction with respect to each reactant is determined by comparing experiments where the concentration of one reactant is changed while the others are held constant. The rate is proportional to the concentration raised to the power of the order.

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16. Which of the following transition elements has both bcc and ccp structures at normal temperature?

(A) Titanium

(B) Vanadium

(C) Silver

(D) Chromium

(E) Manganese

Correct Answer: (E) Manganese

Solution: The structure of transition metals at normal temperature can vary based on temperature. The crystal structure of an element refers to the arrangement of atoms within the solid.

- Titanium (A): Titanium has a hcp (hexagonal close-packed) structure at room temperature.
- Vanadium (B): Vanadium has a bcc (body-centered cubic) structure at room temperature.
- Silver (C): Silver has a ccp (cubic close-packed) structure.
- Chromium (D): Chromium has a bcc structure at room temperature.
- Manganese (E): Manganese is unique in that it exhibits both bcc and ccp structures at different temperatures. At lower temperatures, it adopts a bcc structure, and at higher temperatures, it adopts a ccp structure.

Thus, the correct answer is (E) Manganese, which has both bcc and ccp structures at normal temperature.

Quick Tip

Some transition metals exhibit allotropic forms at different temperatures, meaning their crystal structure can change with temperature, as seen with manganese.

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17. The most common oxidation states of chromium are

(A) +2 and +7

(B) +2 and +3

(C) +1 and +6

(D) +3 and +6

(E) +2 and +4

Correct Answer: (D) +3 and +6

Solution: Chromium (Cr) is a transition metal and exhibits several oxidation states. The most common oxidation states of chromium are:
- +2: Chromium in the +2 oxidation state is common, but less stable compared to +3 and +6.
- +3: This is one of the most stable and common oxidation states of chromium, often seen in chromium compounds.
- +6: This is another common oxidation state of chromium, found in compounds like chromates and dichromates.
Thus, the most common oxidation states of chromium are +3 and +6. Therefore, the correct answer is (D) +3 and +6.

Quick Tip

Chromium commonly exists in oxidation states +2, +3, and +6, with the most stable and frequent ones being +3 and +6.

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18. What is the magnetic moment of a divalent ion with three unpaired electrons?

(A) 2.84 BM

(B) 5.92 BM

(C) 3.87 BM

(D) 4.90 BM

(E) 1.73 BM

Correct Answer: (C) 3.87 BM

Solution: The magnetic moment of a transition metal ion can be calculated using the formula:

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

Where: - n is the number of unpaired electrons.
Given that the ion has 3 unpaired electrons, we substitute $n = 3$ into the formula:

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

Thus, the magnetic moment of the divalent ion with three unpaired electrons is 3.87 BM.

Therefore, the correct answer is (C) 3.87 BM.

Quick Tip

The magnetic moment can be calculated for transition metal ions using the formula $\mu = \sqrt{n(n+2)}$, where n is the number of unpaired electrons.

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19. The bond angle of Cr-O-Cr bond in dichromate ion is

(A) 90°

(B) 126°

(C) 109°

(D) 60°

(E) 120°

Correct Answer: (B) 126°

Solution: In the dichromate ion ($Cr_2O_7^{2-}$), the central chromium atoms are bonded to oxygen atoms in a bent structure. The bond angle between the Cr-O-Cr bond is determined by the geometry of the ion, which is based on the hybridization of the chromium atoms.

- The dichromate ion ($Cr_2O_7^{2-}$) adopts a angular or bent structure with a bond angle of 126°.
- This bond angle is a result of the repulsion between the electron pairs around the chromium atoms and is consistent with the sp^2 hybridization of the chromium atoms.

Thus, the correct answer is (B) 126°.

Quick Tip

In polyatomic ions like the dichromate ion, the bond angles are influenced by the geometry of the central atom, which is often determined by the number of bonding pairs and lone pairs around it.

20. Which of the following transition metal oxide is used in dry battery cells?

(A) ZnO

(B) TiO

(C) V_2O_5

(D) NiO

(E) MnO_2

Correct Answer: (E) MnO_2

Solution: In dry cell batteries, various metal oxides are used as cathode materials. Among the given options:

- ZnO (A): Zinc oxide is used in some battery chemistries but not typically in dry cells.

- TiO (B): Titanium oxide is not commonly used in dry cell batteries. - V_2O_5 (C): Vanadium pentoxide is used in some special battery chemistries but is not the primary component in dry batteries.

- NiO (D): Nickel oxide is used in certain types of rechargeable batteries (like Ni-Cd batteries), but not in dry cell batteries. - MnO_2 (E): Manganese dioxide (MnO_2) is widely used as the cathode material in alkaline batteries, which are a type of dry cell battery.

Thus, the correct answer is (E) MnO_2, as it is commonly used in dry cell batteries.

Quick Tip

Manganese dioxide (MnO) is a key component in alkaline batteries, which are one of the most common types of dry cell batteries.

21. The first and second ionization enthalpies of lanthanoids are comparable with the element

(A) Chromium

(B) Calcium

(C) Germanium

(D) Cesium

(E) Cadmium

Correct Answer: (B) Calcium

Solution: The first and second ionization enthalpies of lanthanoids (elements from the lanthanide series) are quite high due to the strong effective nuclear charge experienced by the electrons as the atomic size decreases across the series. The trend of ionization enthalpy in lanthanoids is somewhat comparable to calcium because:]

- Calcium (B): Calcium belongs to the alkaline earth metals group and has relatively higher ionization enthalpies, similar to the trend seen in lanthanoids. Both show a similar increase in ionization energy across their respective series due to the increasing nuclear charge.

Thus, the correct answer is (B) Calcium because its ionization enthalpies are comparable to that of the lanthanoids.

Quick Tip

Lanthanoids and alkaline earth metals (like calcium) exhibit similar trends in ionization enthalpy, especially as you move across the period.

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22. The percentage of Cr(III) in Ruby is

(A) 0.5 to 1 %

(B) 1 to 2 %

(C) 0.1 to 0.4 %

(D) 2 to 3 %

(E) 0.1 to 0.3 %

Correct Answer: (A) 0.5 to 1 %

Solution: Ruby is a gemstone composed of corundum (AlO), where small amounts of chromium (Cr) are incorporated into the crystal lattice, giving the gemstone its characteristic red color.

- The percentage of chromium in ruby is typically between 0.5% and 1% by weight. The chromium atoms are responsible for the red color due to the absorption of certain wavelengths of light.
Thus, the correct answer is (A) 0.5 to 1 %.

Quick Tip

Chromium (Cr) is the element responsible for the red color in ruby, with its content typically ranging from 0.5

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23. Which of the following is an outer orbital complex?

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

(B) $[Mn(CN)_6]^{3-}$

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

(D) $[MnCl_6]^{3-}$

(E) $[Fe(CN)_6]^{3-}$

Correct Answer: (D) $[MnCl_6]^{3-}$

Solution: Outer orbital complexes involve transition metal ions that have d-orbitals available in their outermost electron shell. These complexes are typically formed by transition metals that can utilize d-orbitals beyond the $3d$ shell (e.g., $4d$ or $5d$ orbitals) to bond with ligands.
- Option (A): $[Co(NH_3)_6]^{3+}$ is a low-spin inner orbital complex, where the $3d$ orbitals are involved, so it is not an outer orbital complex.
- Option (B): $[Mn(CN)_6]^{3-}$ involves inner orbital bonding as well, where the $3d$ orbitals are involved.
- Option (C): $[Co(C_2O_4)_3]^{3-}$ is also an inner orbital complex.
- Option (D): $[MnCl_6]^{3-}$ is an outer orbital complex because Mn(III) uses its $4d$ orbitals to form bonds with the chloride ligands.
- Option (E): $[Fe(CN)_6]^{3-}$ is another inner orbital complex, as Fe(III) uses its $3d$ orbitals for bonding.
Thus, the correct answer is (D) $[MnCl_6]^{3-}$, which is an outer orbital complex.

Quick Tip

Outer orbital complexes typically involve transition metals in higher oxidation states that utilize $4d$ or $5d$ orbitals in bonding with ligands.

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24. What is the colour of the complex $[Ni(en)_3]^{2+}$ in water?

(A) Pale blue

(B) Purple

(C) Violet

(D) Green

(E) Orange

Correct Answer: (C) Violet

Solution: The color of coordination complexes depends on the nature of the metal-ligand interactions and the ligand field. The Ni(II) ion in the complex $[Ni(en)_3]^{2+}$ (where en is ethylenediamine, a bidentate ligand) results in a violet color due to the d-d transitions in the metal's d-orbitals.

- Option (A): Pale blue is often associated with Cu(II) complexes, but not with $[Ni(en)_3]^{2+}$.
- Option (B): Purple is also not typically the color of $[Ni(en)_3]^{2+}$.
- Option (C): Violet is the correct color for $[Ni(en)_3]^{2+}$, as the complex exhibits d-d transitions that absorb light in the visible spectrum.
- Option (D): Green is more commonly observed in some Ni(II) complexes, but not for $[Ni(en)_3]^{2+}$.
- Option (E): Orange is not typical for Ni(II) complexes, which are more often violet or green.

Thus, the correct answer is (C) Violet, as $[Ni(en)_3]^{2+}$ appears violet in water.

Quick Tip

The color of a coordination complex is related to the d-d transitions in the metal's d-orbitals, and the nature of the ligand field significantly influences the absorption of light.

25. Hardness of water is estimated by titration with

(A) DMG

(B) Cupron

(C) α-nitroso-β-naphthol

(D) Na_2] EDTA

(E) Ethylenediamine

Correct Answer:(D) Na_2] EDTA

Solution: The hardness of water refers to the concentration of calcium (Ca^2) and magnesium (Mg^2) ions in the water. One of the most common methods for determining the hardness of water is by using EDTA (Ethylene Diamine Tetra Acetic Acid), which forms complexes with the metal ions, thus enabling titration.

- Option (A): DMG (Dimethylglyoxime) is used for determining nickel, not for water hardness.

- Option (B): Cupron is a reagent used for copper analysis, not hardness estimation.

- Option (C): α-nitroso-β-naphthol is used for copper determination, not for hardness testing.

- Option (D): NaEDTA (sodium ethylenediaminetetraacetate) is a well-known reagent used in complexometric titrations to determine the hardness of water by forming complexes with calcium and magnesium ions. - Option (E): Ethylenediamine is used in coordination chemistry but is not typically used for estimating water hardness.

Thus, the correct answer is (D) NaEDTA, as it is used for the titration to estimate the hardness of water.

Quick Tip

EDTA is a powerful reagent for titrations and is commonly used for determining water hardness by forming stable complexes with calcium and magnesium ions.

26. The formula of Ammonium phosphomolybdate is

(A) $(NH_4)_3PO_4.12MoO_3$

(B) $(NH_4)_2.12MoO_4$

(C) $(NH_4)_2PO_4.12MoO_3$

(D) $(NH_4)_3PO_3.12MoO_3$

(E) $(NH_4)_3PO_4.2MoO_3$

Correct Answer: (A) $(NH_4)_3PO_4.12MoO_3$

Solution: Ammonium phosphomolybdate is a compound that contains ammonium ions (NH_4^+), phosphate (PO_4^{3-}), and molybdenum oxide. It is often used in analytical chemistry for phosphate determination.

- Option (A): The correct formula for Ammonium phosphomolybdate is $(NH_4)_3PO_4.12MoO_3$, where there are 12 moles of MoO (molybdenum trioxide) for every 1 mole of phosphate.

- Option (B): This is not correct, as it doesn't match the formula of ammonium phosphomolybdate.

- Option (C): This is incorrect because it doesn't account for the correct stoichiometry of the molybdenum and phosphate components. - Option (D): This is incorrect, as the formula of phosphomolybdate contains 12 MoO units, not 3.

- Option (E): This is incorrect as the molybdenum oxide count is also wrong.

Thus, the correct answer is (A) $(NH_4)_3PO_4.12MoO_3$, which correctly represents the formula of Ammonium phosphomolybdate.

Quick Tip

Ammonium phosphomolybdate is commonly used in phosphate determination and is a useful reagent in quantitative chemical analysis.

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27. On complete combustion of 0.96 g of an organic compound, 0.88 g of carbon dioxide and 0.1 g of water are produced. What is the percentage composition of carbon in the compound?

(A) 22%

(B) 18%

(C) 16%

(D) 20%

(E) 25%

Correct Answer: (E) 25%

Solution: To find the percentage composition of carbon, we need to first calculate the amount of carbon in the compound.

1. Moles of carbon in CO: The molar mass of CO is 44 g/mol, and it contains 1 mole of carbon per mole of CO.

Moles of CO produced = $\frac{0.88\,\text{g}}{44\,\text{g/mol}} = 0.02\,\text{mol}$

Since each mole of CO contains 1 mole of carbon, moles of carbon in CO = 0.02 mol.

2. Mass of carbon in CO:

The mass of carbon in CO = $0.02\,\text{mol} \times 12\,\text{g/mol} = 0.24\,\text{g}$.

3. Mass of hydrogen in HO:

The molar mass of HO is 18 g/mol, and it contains 2 moles of hydrogen per mole of water.

Moles of HO produced = $\frac{0.1\,\text{g}}{18\,\text{g/mol}} = 0.0056\,\text{mol}$

The mass of hydrogen in HO = $0.0056\,\text{mol} \times 2 \times 1\,\text{g/mol} = 0.0112\,\text{g}$.

4. Mass of carbon in the compound: The total mass of the organic compound is 0.96 g. The mass of carbon is found from the CO product, which is 0.24 g.

5. Percentage composition of carbon:

$$\text{Percentage of carbon} = \frac{0.24\,\text{g}}{0.96\,\text{g}} \times 100 = 25\%$$

Thus, the correct answer is (E) 25%.

Quick Tip

To calculate the percentage composition of an element in a compound after combustion, first find the mass of the element from the products (CO and HO) and then divide by the total mass of the compound.

28. Which of the following sodium salts of carboxylic acid is used for the preparation of n-hexane by Kolbe's electrolytic method?

(A) $CHCH_2]$ COONa

(B) $CH_3]$ COONa

(C) HCOONa

(D) $CH_3]$ $CH_2]$ $CH_2]$ COONa

(E) $CH_3]$ $CH_2]$ $CH_2]$ COONa

Correct Answer:(E) $CH_3]$ $CH_2]$ $CH_2]$ COONa

Solution: The Kolbe's electrolytic method is a method used to prepare alkanes by the electrolysis of sodium salts of carboxylic acids. In this process, the carboxylate ions from the salt undergo decarboxylation to form alkyl radicals, which combine to form the alkane.

- Option (A): $CHCH_2]$ COONa (sodium propionate) would not give n-hexane.
- Option (B): $CH_3]$ COONa (sodium acetate) is not used to prepare n-hexane.
- Option (C): HCOONa (sodium formate) is not used to prepare n-hexane.
- Option (D): $CH_3]$ $CH_2]$ $CH_2]$ COONa (sodium butyrate) would lead to n-pentane, not n-hexane.
- Option (E): $CH_3]$ $CH_2]$ $CH_2]$ COONa (sodium butyrate) is used to prepare n-hexane in Kolbe's electrolytic method by the decarboxylation of the butyrate salt.

Thus, the correct answer is (E) $CH_3]$ $CH_2]$ $CH_2]$ COONa

Quick Tip

In Kolbe's method, the sodium salt of a carboxylic acid undergoes electrolysis to form alkyl radicals that combine to give alkanes. For n-hexane, butyrate ion is used.

---

29. Which of the following oxidizing agent is used for the iodination of methane?

(A) HI

(B) $KMnO_4$

(C) $K_2Cr_2O_7$

(D) HIO_3

(E) K_2CrO_4

Correct Answer: (D) HIO_3

Solution: In the iodination of methane, iodine atoms are substituted in place of hydrogen atoms of methane molecules. The reaction requires an oxidizing agent to facilitate the process.
- Option (A): HI (Hydroiodic acid) is not an oxidizing agent but is instead used as a reagent to provide the iodine source in halogenation reactions. It does not act as an oxidizer for iodination. - Option (B): $KMnO_4$ (Potassium permanganate) is a strong oxidizing agent but is typically used for oxidation reactions involving organic compounds, not specifically for iodination.
- Option (C): $K_2Cr_2O_7$(Potassium dichromate) is a powerful oxidizing agent, but it does not typically participate in iodination reactions. - Option (D): (D) HIO_3(Iodic acid) is used in the oxidation and iodination of methane. It is a suitable oxidizing agent in the iodination reaction because it facilitates the substitution of iodine into methane. - Option (E): K_2CrO_4(Potassium chromate) is also an oxidizing agent but not used for iodination of methane.
Thus, the correct answer is (D) HIO_3, which is used in the iodination of methane.

Quick Tip

For the iodination of methane, HIO_3 (Iodic acid) is the suitable oxidizing agent as it facilitates the substitution of iodine.

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30. The product obtained on ozonolysis of 3-Ethylpent-2-ene are

(A) Methanal and 3-Hexanone

(B) Pentalan and Propanone

(C) Ethanal and Pentan-3-one

(D) Ethanal and 3-Hexanone

(E) Ethanal and Butanone

Correct Answer: (C) Ethanal and Pentan-3-one

Solution: Ozonolysis is a reaction in which ozone (O_3) breaks a carbon-carbon double bond to form ozonides, which then decompose to form carbonyl compounds.
In the case of 3-Ethylpent-2-ene, the double bond between the second and third carbon atoms undergoes ozonolysis. This results in the cleavage of the double bond and the formation of two aldehyde or ketone groups.
- Option (A): Methanal and 3-Hexanone are not the products of ozonolysis of this compound. - Option (B): Pentalan and Propanone are incorrect and not products of ozonolysis. - Option (C): The correct products of ozonolysis of 3-Ethylpent-2-ene are Ethanal (acetaldehyde) and Pentan-3-one. The cleavage of the double bond results in the formation of these two compounds. - Option (D): Ethanal and 3-Hexanone are not correct, as 3-Hexanone is not the product of ozonolysis in this case. - Option (E): Ethanal and Butanone are incorrect products of this reaction.
Thus, the correct answer is (C) Ethanal and Pentan-3-one, which are the products of ozonolysis of 3-Ethylpent-2-ene.

Quick Tip

During ozonolysis, alkenes are split, and the products are typically carbonyl compounds (aldehydes or ketones) depending on the structure of the original alkene.

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31. The temperature and pressure required for reforming benzene from n-hexane is

(A) 473 K, 10-20 atm

(B) 773 K, 10-20 atm

(C) 523 K, 100 atm

(D) 973 K, 1-2 atm

(E) 573 K, 10-20 atm

Correct Answer: (C) 523 K, 100 atm

Solution: The process of reforming benzene from n-hexane involves catalytic reforming, which is a chemical process that uses heat and pressure to convert straight-chain alkanes, such as n-hexane, into aromatic hydrocarbons like benzene. The key conditions for this

reaction include specific temperatures and pressures.
- Option (A): 473 K, 10-20 atm are not ideal conditions for this process. These conditions are generally used for other types of catalytic reactions but not for the reforming of benzene.
- Option (B): 773 K, 10-20 atm is too high a temperature for the process, and it may lead to the degradation of the desired product. - Option (C): 523 K, 100 atm is the correct answer. Reforming of n-hexane to benzene typically occurs at a temperature of 523 K (high temperature) and a pressure of 100 atm. These conditions are optimal for producing the aromatic hydrocarbons. - Option (D): 973 K, 1-2 atm is too high a temperature and too low a pressure for the reforming process, leading to inefficient conversion. - Option (E): 573 K, 10-20 atm are conditions that are not typically used for benzene reforming.
Thus, the correct answer is (C) 523 K, 100 atm.

Quick Tip

For catalytic reforming of n-hexane to produce benzene, 523 K and 100 atm is the optimal temperature and pressure range for efficient conversion.

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32. Methyl fluoride is prepared by heating methyl bromide in the presence of AgF. This reaction is known as

(A) Swarts reaction

(B) Finkelstein reaction

(C) Sandmeyer's reaction

(D) Wurtz reaction

(E) Kolbe's reaction

Correct Answer: (B) Finkelstein reaction

Solution: The Finkelstein reaction is a nucleophilic substitution reaction in which an alkyl halide reacts with a sodium halide in a polar solvent (usually acetone). In this specific case, methyl bromide (CHBr) reacts with silver fluoride (AgF) to produce methyl fluoride (CHF).
- Option (A): The Swarts reaction is used to prepare alkyl fluorides from alkyl chlorides or bromides, but it requires the use of metal fluorides like AgF under high temperatures.

Although related, this is not the correct answer for the given reaction. - Option (B): The Finkelstein reaction is the correct answer. In this reaction, methyl bromide (CHBr) is treated with silver fluoride (AgF) to form methyl fluoride (CHF). It is a classic nucleophilic substitution process. - Option (C): The Sandmeyer's reaction is a method for the synthesis of aryl halides from aryl amines using copper(I) halides, and it is not applicable to the preparation of methyl fluoride. - Option (D): The Wurtz reaction is used to couple alkyl halides in the presence of sodium metal to form alkanes, but it is not used for the preparation of fluorides. - Option (E): Kolbe's reaction is used for the formation of carboxylic acids and is unrelated to the preparation of methyl fluoride.
Thus, the correct answer is (B) Finkelstein reaction, as it describes the process of preparing methyl fluoride from methyl bromide in the presence of AgF.

Quick Tip

The Finkelstein reaction is commonly used to substitute one halogen for another, especially for preparing alkyl fluorides like methyl fluoride.

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33. Benzene diazonium chloride on treatment with reagent 'X' gives iodobenzene. The reagent 'X' is

(A) Cu_2I_2

(B) AgI

(C) I_2

(D) HI

(E) KI

Correct Answer: (E) KI

Solution: In the Sandmeyer reaction, benzene diazonium chloride reacts with reagents like copper(I) halides to form halogenated benzene compounds. The specific halogen that is introduced into the benzene ring depends on the reagent used.
- Option (A): Cu_2I_2 is used in the Sandmeyer reaction to introduce an iodine atom into the benzene ring. This is a correct reagent, but the molecular structure of the halide is more

specific to KI. - Option (B): AgI is not typically used to introduce iodine into the benzene ring in the Sandmeyer reaction.
- Option (C): I_2 is not typically used in the Sandmeyer reaction directly. Iodine alone does not react as efficiently with benzene diazonium chloride.
- Option (D): HI (Hydroiodic acid) can react with diazonium salts to give iodobenzene, but KI is generally used in this reaction to specifically produce iodine as a halogen.
- Option (E): KI (Potassium iodide) is the correct reagent. Potassium iodide (KI) reacts with benzene diazonium chloride to form iodobenzene. This is a well-known Sandmeyer reaction that produces iodobenzene efficiently.
Thus, the correct answer is (E) KI, which reacts with benzene diazonium chloride to produce iodobenzene.

Quick Tip

In the Sandmeyer reaction, KI is used to form iodobenzene by replacing the diazonium group with an iodine atom.

---

34. Which of the following is not a chiral molecule?

(A) 2-Chlorobutane

(B) 2,3-Dihydroxy propanal

(C) 2-Bromo propionic acid

(D) Butan-2-ol

(E) 2-Bromo-2-methoxypropane

Correct Answer: (E) 2-Bromo-2-methoxypropane

Solution: A molecule is considered chiral if it has a non-superimposable mirror image, which generally requires the presence of a chiral center. A chiral center is typically a carbon atom bonded to four different groups. If a molecule has a plane of symmetry or superimposable mirror images, it is achiral.
- Option (A): 2-Chlorobutane is a chiral molecule. The second carbon is bonded to four different groups, making it a chiral center. - Option (B): 2,3-Dihydroxy propanal is a chiral

molecule because both the second and third carbon atoms are each attached to four different groups, which makes the molecule chiral. - Option (C): 2-Bromo propionic acid is also chiral because the central carbon (C-2) has four different substituents, making it a chiral center. - Option (D): Butan-2-ol is a chiral molecule. The second carbon is attached to four different groups, so it is a chiral center. - Option (E): 2-Bromo-2-methoxypropane is not chiral. The central carbon (C-2) is attached to two identical groups (a bromine and a methoxy group), making it a symmetrical center. As a result, this molecule has a plane of symmetry and is achiral.

Thus, the correct answer is (E) 2-Bromo-2-methoxypropane, which is not chiral.

Quick Tip

A molecule must have a chiral center with four different substituents to be considered chiral. If the central carbon has two identical groups, the molecule is achiral.

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35. The product obtained on the reaction of propanone with CH_3MgBr followed by hydrolysis is

(A) 2-Methylpropan-2-ol

(B) Butan-1-ol

(C) Butan-2-ol

(D) 2-Methylpropan-1-ol

(E) 2-Methylpropane

Correct Answer: (D) 2-Methylpropan-1-ol

Solution: The reaction involves propanone (CHCOCH) reacting with methylmagnesium bromide (CHMgBr), which is a Grignard reagent. When a Grignard reagent reacts with a ketone, it adds to the carbonyl group and the subsequent hydrolysis yields an alcohol.

- Propanone is a ketone (CHCOCH). When it reacts with CHMgBr, the nucleophilic methyl group (from CHMgBr) adds to the carbonyl carbon of propanone, producing an intermediate that, after hydrolysis, gives 2-Methylpropan-1-ol. This is a secondary alcohol (since the carbon attached to the -OH group is bonded to two other carbons).

- Option (A): 2-Methylpropan-2-ol is incorrect, as the reaction with CHMgBr does not lead to the formation of this alcohol. - Option (B): Butan-1-ol is incorrect because this would be the product if the reaction were with ethanol or acetaldehyde, not propanone. - Option (C): Butan-2-ol is also incorrect because this is the product if the reaction were with butanone, not propanone. - Option (D): 2-Methylpropan-1-ol is the correct product of the reaction as described above. - Option (E): 2-Methylpropane is a hydrocarbon and would not be the product of this reaction.
Thus, the correct answer is (D) 2-Methylpropan-1-ol.

Quick Tip

In Grignard reactions with ketones, the addition of the Grignard reagent forms a secondary alcohol after hydrolysis, and the structure of the final alcohol depends on the ketone and the reagent used.

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36. The reagent used for the conversion of carboxylic acids to primary alcohols is

(A) PCC

(B) $LiAlH_4$ / H_2O

(C) $NaNO_2$ / HCl

(D) Pd / H_2

(E) Pt / H_2

Correct Answer: (B) $LiAlH_4$ / H_2O

Solution: To reduce carboxylic acids to primary alcohols, a strong reducing agent is required.
- Option (A): PCC (Pyridinium chlorochromate) is a selective oxidizing agent, but it is used for the oxidation of alcohols to aldehydes or ketones. It is not a reducing agent and cannot reduce carboxylic acids to alcohols. - Option (B): $LiAlH_4$ (Lithium aluminum hydride) is a strong reducing agent that can reduce carboxylic acids to primary alcohols. The addition of water (HO) helps in the hydrolysis process to convert the intermediate into the alcohol. - Option (C): $NaNO_2$ (Sodium nitrite) and HCl are involved in the diazotization reaction for

aromatic compounds and do not reduce carboxylic acids to alcohols. - Option (D): Pd / H_2 (Palladium on hydrogen) is used for hydrogenation reactions but is typically used for the reduction of alkenes to alkanes, not for reducing carboxylic acids.
Thus, the correct answer is (B) $LiAlH_4$ / H_2O, as it is the correct reagent for reducing carboxylic acids to primary alcohols.

Quick Tip

LiAlH is a very powerful reducing agent that can reduce carboxylic acids, esters, aldehydes, and ketones to alcohols.

---

37. The order of acidity of the following compounds is (i) o-Nitrophenol (ii) Phenol (iii) o-Cresol (iv) Ethanol

(A) (i) < (iii) < (ii) < (iv)

(B) (iii) < (i) < (ii) < (iv)

(C) (i) < (ii) < (iii) < (iv)

(D) (iv) < (iii) < (ii) < (i)

(E) (iii) < (ii) < (i) < (iv)

Correct Answer: (C) (i) < (ii) < (iii) < (iv)

Solution: The acidity of a compound depends on the electronic effects of substituents attached to the aromatic ring (for phenols and derivatives) and the stability of the conjugate base formed after losing a proton.

- o-Nitrophenol (i): The nitro group is an electron-withdrawing group (via both inductive and resonance effects), which increases the acidity of phenol. The ortho position further stabilizes the conjugate base, making it the most acidic among these compounds.
- Phenol (ii): Phenol itself is less acidic than o-nitrophenol, as there are no additional electron-withdrawing groups. The hydroxyl group can donate electrons via resonance, making the conjugate base less stable compared to o-nitrophenol.
- o-Cresol (iii): The methyl group is an electron-donating group via inductive effects, which

makes the conjugate base less stable and reduces the acidity of o-cresol.

- Ethanol (iv): Ethanol has a hydroxyl group, but it is not attached to an aromatic ring, and the lack of any additional electron-withdrawing groups makes it the least acidic.

Thus, the correct order of acidity is (i) $<$ (ii) $<$ (iii) $<$ (iv).

Quick Tip

When comparing the acidity of aromatic compounds, the presence of electron-withdrawing groups (like NO) generally increases acidity, while electron-donating groups (like CH) decrease acidity.

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38. When benzene is treated with carbon monoxide and hydrogen chloride in the presence of anhydrous aluminium chloride, benzaldehyde is formed. The reaction is known as

(A) Etard reaction

(B) Stephen reaction

(C) Hell-Volhard-Zelinsky reaction

(D) Gatterman-Koch reaction

(E) Aldol reaction

Correct Answer: (D) Gatterman-Koch reaction

Solution: The reaction involves the use of carbon monoxide (CO) and hydrogen chloride (HCl) in the presence of anhydrous aluminum chloride

$AlCl_3$, which leads to the formation of benzaldehyde.

- Gatterman-Koch reaction (D): This is the correct name for the reaction where benzene reacts with carbon monoxide (CO) and hydrogen chloride (HCl) in the presence of $AlCl_3$ to form benzaldehyde. It is a formylation reaction and is a type of electrophilic aromatic substitution. - Etard reaction (A): The Etard reaction involves the oxidation of toluene to benzaldehyde, not the reaction of benzene with CO and HCl. - Stephen reaction (B): The Stephen reaction is used to convert benzene into benzylamine using cyanogen chloride (CNCl) and a reducing agent. It is not related to the formation of benzaldehyde. - Hell-Volhard-

Zelinsky reaction (C): This is a halogenation reaction, where a carboxylic acid reacts with a halogen (like Br_2) in the presence of phosphorus to form an alpha-halo acid. It is not relevant here. - Aldol reaction (E): The Aldol reaction involves the condensation of aldehydes or ketones with activated carbonyl compounds to form -hydroxy aldehydes or ketones, and it is unrelated to the formation of benzaldehyde from benzene.

Thus, the correct answer is (D) Gatterman-Koch reaction, as it describes the formylation of benzene to form benzaldehyde.

Quick Tip

The Gatterman-Koch reaction is one of the key methods for formylating benzene to benzaldehyde, a widely used aromatic aldehyde.

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39. When CHCHO reacts with the mixture of HNO_3 and H_2SO_4 at 273-283K, it gives

(A) o-Nitrobenzaldehyde

(B) m-Nitrobenzaldehyde

(C) p-Nitrobenzaldehyde

(D) Toluene

(E) Nitrobenzene

Correct Answer: (A) o-Nitrobenzaldehyde

Solution: This reaction is known as nitration of benzaldehyde. When benzaldehyde $C_6H_5CHO istreatedu$ and sulfuric acid (H_2SO_4), a nitration reaction takes place. In this reaction, the nitronium ion (NO) is generated, which then attacks the aromatic ring of benzaldehyde.

- o-Nitrobenzaldehyde (A): This is the correct product. In nitration reactions, the nitronium ion typically adds to the ortho position (relative to the formyl group) because the formyl group (-CHO) is an electron-withdrawing group that deactivates the ring, making the ortho position more reactive. - m-Nitrobenzaldehyde (B): This is incorrect. The meta position is less reactive for nitration when an electron-withdrawing group like the formyl group is present. -

p-Nitrobenzaldehyde (C): This is also incorrect because the para position is generally less reactive than the ortho position in such cases. - Toluene (D): Toluene is the methylated form of benzene and will not form in this reaction because no methyl group is involved. - Nitrobenzene (E): Nitrobenzene would only form if the nitronium ion attacked the benzene ring directly without the presence of a formyl group.

Thus, the correct product is o-Nitrobenzaldehyde.

Quick Tip

The formyl group (-CHO) in benzaldehyde directs electrophilic substitution to the ortho position due to its electron-withdrawing nature.

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40. Match the following:

Compound	use
(a) Benzaldehyde	(i) food preservative
(b) Methanoic acid	(ii) nylon 6,6
(c) Sodium benzoate	(iii) perfumary
(d) Hexanedioic acid	(iv) Electroplating industry

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

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

(C) a-(iii), b-(iii), c-(ii), d-(iv)

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

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

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

Solution: Let's match each compound to its corresponding use based on its properties and common applications:

- Benzaldehyde (a): This compound is widely used in the perfume industry due to its pleasant almond-like fragrance. Thus, a-(iii).

- Methanoic acid (b): Methanoic acid, also known as formic acid, is used as a preservative and an antibacterial agent. It is sometimes used in the leather and textile industries but is more associated with electroplating. Thus, b-(iv).
- Sodium benzoate (c): Sodium benzoate is primarily used as a food preservative, as it prevents the growth of harmful bacteria. Thus, c-(i). - Hexanedioic acid (d): Also known as adipic acid, this compound is essential in the production of nylon 6,6, a synthetic polymer used in fibers and plastics. Thus, d-(ii).

Thus, the correct answer is (E) a-(iii), b-(iv), c-(i), d-(ii).

Quick Tip

Sodium benzoate is a widely used food preservative, while adipic acid is key to the production of nylon 6,6, a commonly used polymer.

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41. The number of moles of alkyl halides required to convert primary amine into quaternary ammonium salt is

(A) 1

(B) 2

(C) 3

(D) 4

(E) 5

Correct Answer: (C) 3

Solution: To convert a primary amine into a quaternary ammonium salt, three moles of alkyl halide are typically required. The reaction follows these steps:

1. First alkylation: A primary amine reacts with one mole of alkyl halide to form a secondary amine. 2. Second alkylation: The secondary amine reacts with another mole of alkyl

halide to form a tertiary amine. 3. Third alkylation: The tertiary amine then reacts with a third mole of alkyl halide to form a quaternary ammonium salt.

Therefore, 3 moles of alkyl halides are needed to completely convert the primary amine to a quaternary ammonium salt.

Thus, the correct answer is (C) 3.

Quick Tip

The conversion of primary amine to a quaternary ammonium salt requires three moles of alkyl halides in a stepwise alkylation process.

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42. The order of boiling point of the following amines is (i) Butan-1-amine

(ii) N-Ethylethanamine

(iii) N,N-Dimethylethanamine

(A) (i) ¿ (iii) ¿ (ii)

(B) (i) ¿ (ii) ¿ (iii)

(C) (iii) ¿ (ii) ¿ (i)

(D) (iii) ¿ (i) ¿ (ii)

(E) (ii) ¿ (i) ¿ (iii)

Correct Answer: (B) (i) ¿ (ii) ¿ (iii)

Solution: The boiling point of amines is influenced by the type of intermolecular forces present, specifically hydrogen bonding and the size of the molecule.

- Butan-1-amine (i): This is a primary amine, which can form hydrogen bonds with other molecules, leading to a higher boiling point compared to secondary and tertiary amines. - N-Ethylethanamine (ii): This is a secondary amine, which can also form hydrogen bonds but less effectively than primary amines because there is one alkyl group replacing a hydrogen on nitrogen. Therefore, its boiling point is lower than that of butan-1-amine. - N,N-Dimethylethanamine (iii): This is a tertiary amine, which has no hydrogen atoms attached to

the nitrogen, so it cannot form hydrogen bonds, leading to the lowest boiling point among the three.

Thus, the correct order of boiling points is (i) ¿ (ii) ¿ (iii).

Thus, the correct answer is (B) (i) ¿ (ii) ¿ (iii).

Quick Tip

The boiling point of amines decreases as the number of alkyl groups on nitrogen increases because the ability to form hydrogen bonds decreases.

---

43. An aromatic compound (X) of molecular formula, C7H7Cl, on ammonolysis gives Y (Molecular formula, C7H9N). The compound Y reacts with two moles of CH3Cl gives N, N-Dimethylphenylmethanamine. The compounds 'X' and 'Y' are

(A) Benzylchloride and Aniline

(B) Chlorobenzene and Aniline

(C) Benzylchloride and Benzylamine

(D) Chlorobenzene and Benzylamine

(E) Benzylchloride and Benzylamine

Correct Answer: (C) Benzylchloride and Benzylamine

Solution: We are given the following information: - Compound X (C7H7Cl) reacts with ammonia to give Compound Y (C7H9N). - Compound Y reacts with two moles of CH3Cl to give N,N-Dimethylphenylmethanamine.

The key reaction is the ammonolysis of benzylchloride (C6H5CH2Cl), which reacts with ammonia to form benzylamine (C6H5CH2NH2). The benzylamine further reacts with CH3Cl to give N,N-Dimethylphenylmethanamine.

Thus, X is benzylchloride and Y is benzylamine, and the correct answer is (C) Benzylchloride and Benzylamine.

Quick Tip

The reaction of benzylchloride with ammonia forms benzylamine, and further reaction with methyl chloride gives N,N-dimethylphenylmethanamine.

---

44. Oxidation of gluconic acid with nitric acid gives

(A) n-hexane

(B) fructose

(C) glucose

(D) glyceraldehyde

(E) saccharic acid

Correct Answer: (E) saccharic acid

Solution: When gluconic acid (a sugar alcohol) is oxidized with nitric acid, the oxidation occurs at the aldehyde group of the molecule, converting gluconic acid to saccharic acid (also known as glucaric acid).

- Gluconic acid has a structure where an aldehyde group is oxidized to a carboxyl group upon reaction with nitric acid, leading to the formation of saccharic acid (C6H10O8). - Other options such as glucose or fructose are sugars, and oxidation with nitric acid would not lead to saccharic acid, but rather to other oxidation products.

Thus, the correct answer is (E) saccharic acid.

Quick Tip

Oxidation of gluconic acid with nitric acid results in the formation of saccharic acid (glucaric acid), an important compound used in the synthesis of various industrial chemicals.

---

45. The carbohydrates are stored in animal body as

(A) cellulose

(B) starch

(C) glycogen

(D) amylopectin

(E) amylase

Correct Answer: (C) glycogen

Solution: - Cellulose: Cellulose is a polysaccharide found in plants, not in animals. It is the structural component of plant cell walls. - Starch: Starch is a polysaccharide found in plants, primarily used by plants to store energy. - Glycogen: This is the correct answer. Glycogen is the primary storage form of carbohydrates in animals, primarily stored in the liver and muscles. It can be broken down into glucose when needed by the body for energy. - Amylopectin: This is a component of starch, not a storage form of carbohydrates in animals. - Amylase: Amylase is an enzyme that breaks down carbohydrates, not a carbohydrate storage molecule.

Thus, the correct answer is (C) glycogen.

Quick Tip

Animals store carbohydrates as glycogen, which is primarily stored in the liver and muscles and can be converted into glucose when required.

---

46. The dimensions of $\frac{B}{E}$ are (B: Magnetic induction, E: Electric field intensity)

(A) $M^0L^{-2}T^1$

(B) $M^0L^{-1}T^2$

(C) $M^0L^1T^1$

(D) $M^0L^{-1}T^{-1}$

(E) $M^0L^1T^{-1}$

Correct Answer: (D) $M^0L^{-1}T^{-1}$

Solution: - Magnetic induction (B) is measured in Tesla (T), and its dimensions are $M^1L^0T^{-2}A^{-1}$.
- Electric field intensity (E) is measured in Volts per meter (V/m), and its dimensions are $M^1L^1T^{-3}A^{-1}$.

Now, calculating the dimensions of $\frac{B}{E}$:

$$\frac{B}{E} = \frac{M^1L^0T^{-2}A^{-1}}{M^1L^1T^{-3}A^{-1}} = M^0L^{-1}T^1$$

Thus, the correct answer is (D) $M^0L^{-1}T^{-1}$.

Quick Tip

The ratio $\frac{B}{E}$ (magnetic induction to electric field intensity) has the dimensions $M^0L^{-1}T^{-1}$, which reflects the relationship between these physical quantities in electromagnetism.

---

47. A hockey player hits a ball with an impulse of 15 Ns. If time of hit is 0.2 s, the average force exerted by the player on the ball is

(A) 75 N

(B) 50 N

(C) 15 N

(D) 20 N

(E) 25 N

Correct Answer: (A) 75 N

Solution: Impulse is given by the equation:

$$\text{Impulse} = F_{\text{avg}} \times \Delta t$$

Where: - F_{avg} is the average force exerted - Δt is the time of impact

Given: - Impulse = 15 Ns - $\Delta t = 0.2\,\text{s}$

We can rearrange the equation to solve for the average force:

$$F_{\text{avg}} = \frac{\text{Impulse}}{\Delta t}$$

$$F_{\text{avg}} = \frac{15}{0.2} = 75\,\text{N}$$

Thus, the correct answer is (A) 75 N.

Quick Tip

Impulse is the product of force and time. To find the average force, divide the impulse by the time duration.

---

48. If the position of the particle as a function of time t is $\vec{r} = 8t\hat{i} + 3t^2\hat{j} + 3\hat{k}$ m, then the acceleration of the particle is (in m/s^2)

(A) 6

(B) 3

(C) 8

(D) 4

(E) 5

Correct Answer: (A) 6

Solution: The position of the particle is given by:

$$\vec{r}(t) = 8t\hat{i} + 3t^2\hat{j} + 3\hat{k}$$

To find the acceleration, we first need to find the velocity and then differentiate it to get the acceleration.

1. The velocity $\vec{v}(t)$ is the first derivative of the position with respect to time:

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = \frac{d}{dt}(8t\hat{i} + 3t^2\hat{j} + 3\hat{k})$$

$$\vec{v}(t) = 8\hat{i} + 6t\hat{j} + 0\hat{k}$$

2. The acceleration $\vec{a}(t)$ is the first derivative of velocity with respect to time:

$$\vec{a}(t) = \frac{d\vec{v}}{dt} = \frac{d}{dt}(8\hat{i} + 6t\hat{j} + 0\hat{k})$$

$$\vec{a}(t) = 0\hat{i} + 6\hat{j} + 0\hat{k}$$

Thus, the acceleration is:

$$\vec{a}(t) = 6\hat{j}\ \text{m/s}^2$$

The magnitude of the acceleration is $6\,\text{m/s}^2$.

Thus, the correct answer is (A) 6.

Quick Tip

To find acceleration from position, first differentiate position to get velocity, then differentiate velocity to get acceleration.

---

49. The force acting on the particle of 0.2 kg mass whose displacement is described by the equation $x = 3t + 7t^2$ m

(A) 1.0 N

(B) 3.2 N

(C) 6.4 N

(D) 8.6 N

(E) 2.8 N

Correct Answer: (E) 2.8 N

Solution: To find the force acting on the particle, we need to use Newton's second law of motion, $F = ma$, where a is the acceleration of the particle.

1. First, we differentiate the displacement equation to get the velocity:

$$x(t) = 3t + 7t^2$$

$$v(t) = \frac{dx}{dt} = 3 + 14t$$

2. Then, we differentiate the velocity equation to get the acceleration:

$$a(t) = \frac{dv}{dt} = 14$$

The acceleration is constant, $a(t) = 14\,\text{m/s}^2$.

3. Using Newton's second law:

$$F = ma = 0.2\,\text{kg} \times 14\,\text{m/s}^2 = 2.8\,\text{N}$$

Thus, the correct answer is (E) 2.8 N.

Quick Tip

For constant acceleration, calculate the force by multiplying mass with constant acceleration.

---

50. A bullet of 10 g mass is fired at a speed of 50 m/s by a gun of 2 kg mass. The recoil speed of the gun (in m/s) is

(A) 0.3

(B) 0.25

(C) 0.5

(D) 0.75

(E) 1.25

Correct Answer: (B) 0.25

Solution: We will use the principle of conservation of momentum. The total momentum before firing is zero, and the total momentum after firing must also be zero (since no external force is acting on the system).

Let: - $m_1 = 10\,\text{g} = 0.01\,\text{kg}$ (mass of the bullet) - $v_1 = 50\,\text{m/s}$ (speed of the bullet) - $m_2 = 2\,\text{kg}$ (mass of the gun) - v_2 (recoil velocity of the gun)

Using conservation of momentum:

$$m_1 v_1 + m_2 v_2 = 0$$

$$0.01 \times 50 + 2 \times v_2 = 0$$

$$0.5 + 2v_2 = 0$$

$$2v_2 = -0.5$$

$$v_2 = \frac{-0.5}{2} = -0.25\,\text{m/s}$$

Thus, the recoil speed of the gun is 0.25 m/s in the opposite direction.

Thus, the correct answer is (B) 0.25.

Quick Tip

Use the conservation of momentum to find recoil velocities in cases of firing projectiles or when forces cause movement in opposite directions.

---

51. The work done to lift a 60 kg mass to a height of 5 m from the ground is (g = 10 m/s^2)

(A) 3000 J

(B) 750 J

(C) 1250 J

(D) 6000 J

(E) 4500 J

Correct Answer: (A) 3000 J

Solution: The work done to lift an object against gravity is given by the formula:

$$W = mgh$$

Where: - $m = 60\,\text{kg}$ (mass) - $g = 10\,\text{m/s}^2$ (acceleration due to gravity) - $h = 5\,\text{m}$ (height)

Substituting the values:

$$W = 60 \times 10 \times 5 = 3000\,\text{J}$$

Thus, the correct answer is (A) 3000 J.

Quick Tip

To calculate the work done against gravity, use the formula $W = mgh$, where m is the mass, g is the gravitational constant, and h is the height.

---

52. Energy equivalent of mass 0.5 kg is

(A) 9×10^{16} J

(B) 3×10^{16} J

(C) 2.5×10^{16} J

(D) 6×10^{16} J

(E) 4.5×10^{16} J

Correct Answer: (E) 4.5×10^{16} J

Solution: The energy equivalent of mass can be calculated using Einstein's famous equation:

$$E = mc^2$$

Where: - $m = 0.5$ kg (mass) - $c = 3 \times 10^8$ m/s (speed of light)

Substituting the values:

$$E = 0.5 \times (3 \times 10^8)^2$$

$$E = 0.5 \times 9 \times 10^{16} = 4.5 \times 10^{16} \text{ J}$$

Thus, the correct answer is (E) 4.5×10^{16} J.

Quick Tip

To find the energy equivalent of mass, use the equation $E = mc^2$, where c is the speed of light, 3×10^8 m/s.

---

53. Three particles of equal mass lie at distances of 1 cm, 2 cm, and 3 cm from the origin. The distance of their center of mass from the origin is

(A) 2 cm

(B) 1 cm

(C) 2.5 cm

(D) 3 cm

(E) 6 cm

Correct Answer: (A) 2 cm

Solution: The center of mass (COM) of three particles of equal mass can be calculated using the formula:

$$x_{\text{COM}} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$

Since all particles have equal mass, the formula simplifies to:

$$x_{\text{COM}} = \frac{x_1 + x_2 + x_3}{3}$$

Where: - $x_1 = 1\,\text{cm}$ - $x_2 = 2\,\text{cm}$ - $x_3 = 3\,\text{cm}$

Substituting the values:

$$x_{\text{COM}} = \frac{1 + 2 + 3}{3} = \frac{6}{3} = 2\,\text{cm}$$

Thus, the correct answer is (A) 2 cm.

Quick Tip

For particles with equal mass, the center of mass is simply the average of their positions.

---

54. Angular momentum of a particle will not be zero, if the

(A) angle between position vector and linear momentum is 0°

(B) particle is at the origin

(C) angle between position vector and linear momentum is 90°

(D) linear momentum vanishes

(E) angle between position vector and linear momentum is 180°

Correct Answer: (C) angle between position vector and linear momentum is 90°

Solution: The angular momentum L of a particle is given by:

$$L = r \times p$$

Where: - r is the position vector - p is the linear momentum vector

Angular momentum will be zero when the position vector and the linear momentum vector are parallel or antiparallel (i.e., when the angle between them is either 0° or 180°), because the cross product of parallel or antiparallel vectors is zero.

However, angular momentum will be non-zero when the angle between the position vector and linear momentum vector is 90° because the cross product will give a maximum value.

Thus, the correct answer is (C) angle between position vector and linear momentum is 90°.

Quick Tip

The angular momentum of a particle is zero when the position and momentum vectors are either parallel or antiparallel (0° or 180°), and non-zero when the angle is 90°.

---

55. An astronaut experiences weightlessness in space satellite because

(A) the gravitational force is small at that location

(B) both the astronaut and the satellite are in free fall towards Earth

(C) of the small gravity in the horizontal direction

(D) of the small gravity in the vertical direction

(E) of the gravitational pull of the moon

Correct Answer: (B) both the astronaut and the satellite are in free fall towards Earth

Solution: An astronaut in space experiences weightlessness because both the astronaut and the satellite are in free fall towards Earth. In orbit, both the astronaut and the satellite are moving together, and they are both accelerating at the same rate due to Earth's gravity. Because of this, the astronaut does not experience any force acting on their body, and they feel weightless.

This phenomenon occurs even though the gravitational force is still acting on them, but the feeling of weightlessness arises because there is no normal force exerted by a surface. Both the astronaut and satellite are in free fall, experiencing microgravity.

Thus, the correct answer is (B) both the astronaut and the satellite are in free fall towards Earth.

Quick Tip

An astronaut feels weightless in space because they and the spacecraft are both in free fall, experiencing the same gravitational acceleration.

---

56. For smaller deformations, stress is directly proportional to the strain for any material. Then the constant of proportionality is called as its

(A) modulus of elasticity

(B) Poisson's ratio

(C) compressibility

(D) coefficient of deformation

(E) mechanical strength

Correct Answer: (A) modulus of elasticity

Solution: The modulus of elasticity, also known as Young's modulus, is the constant of proportionality in Hooke's law that relates stress and strain for materials under elastic deforma-

tion. This law states that for small deformations (in the elastic range), the stress applied to a material is directly proportional to the strain produced.

The modulus of elasticity (E) represents the stiffness of a material. It can be defined as the ratio of stress to strain:

$$E = \frac{\text{stress}}{\text{strain}}$$

- Poisson's ratio (B): Poisson's ratio is the ratio of lateral strain to longitudinal strain when a material is subjected to stress. It is not the constant of proportionality between stress and strain.
- Compressibility (C): Compressibility refers to the measure of a material's ability to decrease in volume under pressure, not related to stress-strain proportionality.
- Coefficient of deformation (D): This term is not typically used in relation to stress-strain relationships.
- Mechanical strength (E): Mechanical strength is the ability of a material to withstand an applied force without breaking or deforming. It is not directly related to the proportionality of stress and strain.

Thus, the correct answer is (A) modulus of elasticity.

Quick Tip

For materials under small deformations, the modulus of elasticity is the proportional constant between stress and strain.

---

57. Which one of the following principles helps to explain the flow of blood in an artery?

(A) Magnus effect

(B) Boyle's law

(C) Pascal's law

(D) Bernoulli's principle

(E) Archimedes' principle

Correct Answer: (D) Bernoulli's principle

Solution: Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. This principle is fundamental in explaining the flow of blood in arteries because it accounts for how changes in the speed of blood flow can create changes in blood pressure.

- Magnus effect (A): This effect is observed when a rotating body moves through a fluid, causing a change in the fluid's velocity. It is related to spinning objects but not directly relevant to blood flow in arteries. - Boyle's law (B): Boyle's law describes the inverse relationship between pressure and volume for a fixed amount of gas. It does not explain blood flow.
- Pascal's law (C): Pascal's law deals with the pressure exerted by a fluid in a confined space and is not as relevant to blood flow through open arteries.
- Archimedes' principle (E): Archimedes' principle is related to the buoyant force on an object submerged in a fluid and does not explain the flow of blood.

Thus, the correct answer is (D) Bernoulli's principle as it helps explain how changes in blood velocity influence pressure within the arteries.

Quick Tip

Bernoulli's principle is key in understanding the relationship between blood velocity and pressure in arteries.

---

58. An ideal Carnot engine has an efficiency of 40%. The ratio of the temperature of the sink to that of the source is

(A) 0.4

(B) 0.6

(C) 0.5

(D) 0.2

(E) 0.3

Correct Answer: (B) 0.6

Solution: The efficiency of a Carnot engine is given by the formula:

$$\eta = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

Where: - η is the efficiency, - T_{sink} is the temperature of the sink (cold reservoir), - T_{source} is the temperature of the source (hot reservoir).

We are given that the efficiency $\eta = 0.40$, so:

$$0.40 = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

Solving for the ratio $\frac{T_{\text{sink}}}{T_{\text{source}}}$:

$$\frac{T_{\text{sink}}}{T_{\text{source}}} = 1 - 0.40 = 0.60$$

Thus, the correct answer is (B) 0.6.

Quick Tip

For a Carnot engine, the efficiency depends on the ratio of the temperatures of the sink and the source. A higher ratio means a less efficient engine.

---

59. If Q1 and Q2 are respectively the heat supplied and expelled by a system at a constant temperature, then the work done by the system is

(A) $Q_1 - Q_2$

(B) $Q_1 + Q_2$

(C) $\frac{Q_1 - Q_2}{2}$

(D) $\frac{Q_2 - Q_1}{2}$

(E) $\frac{Q_1+Q_2}{2}$

Correct Answer: (A) $Q_1 - Q_2$

Solution: In thermodynamics, when a system undergoes a process at constant temperature, the heat supplied to the system, Q_1, and the heat expelled from the system, Q_2, are related to the work done by the system. According to the first law of thermodynamics, for a process at constant temperature (isothermal process), the change in internal energy $\Delta U = 0$. Therefore, the work done by the system is the difference between the heat absorbed and the heat expelled:

$$W = Q_1 - Q_2$$

Thus, the correct answer is (A).

Quick Tip

In an isothermal process, the work done is the difference between the heat supplied and the heat expelled by the system.

---

60. For the oscillations of a spring with spring constant k, the false statement is

(A) Stiff springs have high value of k

(B) Soft springs have small value of k

(C) The spring constant is independent of the elastic properties of the spring

(D) For smaller oscillations, the spring executes simple harmonic motion

(E) The period of oscillations of the spring depends upon the value of k

Correct Answer: (C) The spring constant is independent of the elastic properties of the spring

Solution: - Option A: Stiff springs have a high value of spring constant k, which represents the stiffness of the spring. This statement is correct. - Option B: Soft springs have a low value

of spring constant k, which indicates a less stiff spring. This statement is correct.

- Option C: The spring constant k is actually dependent on the material's elasticity and the dimensions of the spring. A spring with a different material or structure will have a different spring constant, so this statement is false.

- Option D: For small oscillations, the spring follows simple harmonic motion (SHM) where the restoring force is directly proportional to the displacement. This statement is correct.

- Option E: The period of oscillations of a spring is given by $T = 2\pi\sqrt{\frac{m}{k}}$, so the period depends on the value of k. This statement is correct.

Thus, the false statement is (C), as the spring constant is indeed dependent on the elastic properties of the spring.

Quick Tip

The spring constant k depends on the material, structure, and dimensions of the spring. It is not independent of these factors.

---

61. If the amplitude of the wave $y = 3\sin(3x - 5t) + A\cos(3x - 5t)$ m is 5 m, the value of A is

(A) 3 m

(B) 2 m

(C) 1 m

(D) 5 m

(E) 4 m

Correct Answer: (E) 4 m

Solution: The given wave equation is:

$$y = 3\sin(3x - 5t) + A\cos(3x - 5t)$$

This is a combination of a sine and cosine wave, where the total amplitude A_{total} can be found using the following formula for the resultant amplitude when combining sinusoidal functions of the same frequency:

$$A_{\text{total}} = \sqrt{(3)^2 + (A)^2}$$

We are given that the total amplitude is 5 m:

$$5 = \sqrt{9 + A^2}$$

Squaring both sides:

$$25 = 9 + A^2$$

$$A^2 = 16$$

$$A = 4 \text{ m}$$

Thus, the value of A is 4 m.

Quick Tip

When combining sinusoidal waves, the total amplitude can be found using the Pythagorean theorem $A_{\text{total}} = \sqrt{A_1^2 + A_2^2}$, where A_1 and A_2 are the individual amplitudes.

---

62. In dielectrics, polarization is the dipole moment per unit

(A) area

(B) electric field

(C) volume

(D) length

(E) charge

Correct Answer: (C) volume

Solution: In dielectrics, polarization refers to the alignment of dipoles within a material under the influence of an external electric field. It is defined as the dipole moment per unit volume of the material. The dipole moment is a measure of the separation of positive and negative charges in a molecule or material.

Thus, polarization P is given by:

$$P = \frac{\text{Dipole moment}}{\text{Volume}}$$

Therefore, the correct answer is (C), as polarization is the dipole moment per unit volume.

Quick Tip

Remember that polarization is always related to volume in the context of dielectrics, as it measures the alignment of dipoles throughout the entire material.

---

63. The energy density of the electric field $2\,\text{V/m}$ in a capacitor C is ε_0 is the permittivity of free space

(A) $3\varepsilon_0$

(B) $\frac{\varepsilon_0}{2}$

(C) $4\varepsilon_0$

(D) $\frac{\varepsilon_0}{4}$

(E) $2\varepsilon_0$

Correct Answer: (E) $2\varepsilon_0$

Solution: The energy density of an electric field is given by the formula:

$$u = \frac{1}{2}\varepsilon_0 E^2$$

where: - u is the energy density - ε_0 is the permittivity of free space - E is the electric field

Given: - The electric field $E = 2\,\text{V/m}$

Now substituting the value of E into the formula:

$$u = \frac{1}{2}\varepsilon_0(2)^2$$

$$u = \frac{1}{2}\varepsilon_0 \times 4 = 2\varepsilon_0$$

Thus, the energy density is $2\varepsilon_0$.

Hence, the correct answer is (E) $2\varepsilon_0$.

Quick Tip

To calculate the energy density, use the formula $u = \frac{1}{2}\varepsilon_0 E^2$. It tells you how much energy is stored in a given electric field.

---

64. A carbon resistor has a tolerance of 20%. As per the colour codes of resistors, the last band in that resistor is

(A) silver

(B) absent

(C) red

(D) gold

(E) blue

Correct Answer: (B) absent

Solution: In the colour code for carbon resistors, the first three bands represent the digits of the resistor value, and the fourth band represents the tolerance. For carbon resistors:

- A tolerance of 20% corresponds to no colour band (or absent).
- A gold band indicates a tolerance of 5%.
- A silver band indicates a tolerance of 10%.

Thus, for a resistor with a tolerance of 20%, the last band would be absent.

Hence, the correct answer is (B) absent.

Quick Tip

When you see no colour band on a resistor, the tolerance is 20%. For other common tolerance values, gold corresponds to 5% and silver to 10%.

---

65. When a current of 2 A flows through a wire for 2.5 s, the amount of heat liberated is 20 J. The resistance of the wire is

(A) 4 Ω

(B) 3 Ω

(C) 1 Ω

(D) 2 Ω

(E) 5 Ω

Correct Answer: (D) 2 Ω

Solution: The heat H liberated by a current I flowing through a resistor R over a time t is given by Joule's Law:

$$H = I^2 R t$$

Where: - $H = 20\,\text{J}$ (the heat liberated) - $I = 2\,\text{A}$ (current) - $t = 2.5\,\text{s}$ (time)

Substituting the given values into the equation:

$$20 = (2)^2 R \times 2.5$$

$$20 = 4R \times 2.5$$

$$20 = 10R$$

$$R = \frac{20}{10} = 2\,\Omega$$

Thus, the resistance of the wire is $2\,\Omega$.

Hence, the correct answer is (D) 2 Ω.

Quick Tip

To find the resistance using the heat liberated, use the formula $H = I^2Rt$, where I is the current, R is the resistance, and t is the time.

---

66. The magnetic moment of an electron revolving in an orbit of 0.5 m radius with a velocity of 8×10^7 m/s is (in Am^2)

(A) 3.2×10^{-12} Am^2

(B) 0.4×10^{-12} Am^2

(C) 6.4×10^{-12} Am^2

(D) 1.6×10^{-1} Am^2

(E) 0.8×10^{-12} Am^2

Correct Answer: (A) 3.2×10^{-12} Am^2

Solution: The magnetic moment μ of an electron moving in a circular orbit is given by the formula:

$$\mu = I \times A$$

Where: - $I = \frac{ev}{2\pi r}$ is the current due to the electron's motion, with e being the charge of the electron, v the velocity of the electron, and r the radius of the orbit. - $A = \pi r^2$ is the area of the orbit.

Substitute the known values: - $e = 1.6 \times 10^{-19}$ C - $v = 8 \times 10^7$ m/s - $r = 0.5$ m

The current I is:

$$I = \frac{1.6 \times 10^{-19} \times 8 \times 10^7}{2\pi \times 0.5}$$

$$I = \frac{1.28 \times 10^{-11}}{3.1416 \times 0.5}$$

$$I = 8.16 \times 10^{-12} \text{ A}$$

Now, the magnetic moment is:

$$\mu = I \times A = 8.16 \times 10^{-12} \times \pi \times (0.5)^2$$

$$\mu = 8.16 \times 10^{-12} \times 0.7854$$

$$\mu = 3.2 \times 10^{-12}\,\text{Am}^2$$

Thus, the magnetic moment is $3.2 \times 10^{-12}\,\text{Am}^2$.

Hence, the correct answer is (A) $3.2 \times 10^{-12}\,\text{Am}^2$.

Quick Tip

For calculating the magnetic moment of an electron, remember to use $\mu = I \times A$, and for current I, use $I = \frac{ev}{2\pi r}$.

---

67. If an electron moves with a velocity v in a magnetic field B, the magnetic force on the electron is maximum when the angle between v and B is

(A) 30°

(B) 180°

(C) 60°

(D) 90°

(E) 0°

Correct Answer: (D) 90°

Solution: The magnetic force F on a charged particle moving in a magnetic field is given by the equation:

$$F = qvB\sin\theta$$

Where: - q is the charge of the particle - v is the velocity of the particle - B is the magnetic field - θ is the angle between the velocity vector and the magnetic field vector.

For the magnetic force to be maximum, $\sin\theta$ must be maximum. The maximum value of $\sin\theta$ is 1, which occurs when $\theta = 90°$.

Thus, the magnetic force is maximum when the angle between v and B is 90°.

Hence, the correct answer is (D) 90°.

Quick Tip

For maximum magnetic force on a moving particle, the angle between the velocity vector and the magnetic field should be 90°.

---

68. The flux linked with a coil at any instant is given by $\Phi = 5t^2 - 25t - 150$ (in SI units). The emf induced in the coil at $t = 2$ s is

(A) +5 V

(B) +3 V

(C) -1 V

(D) -5 V

(E) -3 V

Correct Answer: (A) +5 V

Solution: The emf induced in the coil is given by Faraday's Law of Induction:

$$\text{emf} = -\frac{d\Phi}{dt}$$

Where: - $\Phi = 5t^2 - 25t - 150$ is the magnetic flux as a function of time.

To find the emf at $t = 2$ s, we first differentiate Φ with respect to time t:

$$\frac{d\Phi}{dt} = \frac{d}{dt}(5t^2 - 25t - 150)$$

$$\frac{d\Phi}{dt} = 10t - 25$$

Now, substitute $t = 2$ s into the equation:

$$\frac{d\Phi}{dt} = 10(2) - 25 = 20 - 25 = -5$$

The emf is:

$$\text{emf} = -(-5) = +5\,\text{V}$$

Thus, the emf induced in the coil at $t = 2$ s is +5 V.

Hence, the correct answer is (A) +5 V.

Quick Tip

The induced emf can be calculated by differentiating the flux Φ with respect to time and applying Faraday's Law of Induction.

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69. If the frequency of an electromagnetic wave is 2 MHz, then the time period of oscillation of the accelerated charge is

(A) 2.5×10^{-7} s

(B) 1×10^{-7} s

(C) 5×10^{-7} s

(D) 6×10^{-7} s

(E) 2×10^{-7} s

Correct Answer: (C) 5×10^{-7} s

Solution: The time period T of an oscillating charge (or an electromagnetic wave) is related to the frequency f by the formula:

$$T = \frac{1}{f}$$

Where: - T is the time period - f is the frequency

We are given the frequency $f = 2\,\text{MHz} = 2 \times 10^6\,\text{Hz}$.

Now, calculate the time period T:

$$T = \frac{1}{f} = \frac{1}{2 \times 10^6} = 5 \times 10^{-7}\,\text{s}$$

Thus, the time period of oscillation is 5×10^{-7} seconds.

Hence, the correct answer is (C) 5×10^{-7} s.

Quick Tip

The time period T is the inverse of the frequency. For high frequencies, the time period is very small.

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70. The eye defect astigmatism can be corrected by using a

(A) convex lens

(B) spherical lens

(C) plano-convex lens

(D) concave lens

(E) cylindrical lens

Correct Answer: (E) cylindrical lens

Solution: Astigmatism is an eye condition where the cornea or lens has an irregular shape, causing blurred or distorted vision. This defect arises due to an uneven curvature of the eye's lens or cornea, which does not focus light onto a single point of the retina.

The best way to correct astigmatism is by using a cylindrical lens, which has different curvatures in different directions. A cylindrical lens helps to focus light properly and corrects the uneven focus caused by the irregular shape of the cornea or lens.

- Convex lens (A): A convex lens is used to correct farsightedness (hyperopia), not astigmatism.
- Spherical lens (B): A spherical lens is used to correct myopia or hyperopia but is not ideal for astigmatism.
- Plano-convex lens (C): This lens has one flat surface and one convex surface, but it is not specifically designed for correcting astigmatism.
- Concave lens (D): A concave lens is used for myopia (nearsightedness), not for astigmatism.

Thus, the correct answer is (E) cylindrical lens.

Quick Tip

Cylindrical lenses are specifically designed to correct astigmatism by compensating for the uneven curvature of the eye's lens or cornea.

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71. The intensity of a polarized light can be controlled by a second polarizer from

(A) 100% to 0%

(B) 50% to 0%

(C) 25% to 0%

(D) 10% to 0%

(E) 75% to 0%

Correct Answer: (B) 50% to 0%

Solution: The intensity of polarized light passing through a second polarizer is governed by **Malus's Law**, which states:

$$I = I_0 \cos^2 \theta$$

where: - I is the intensity of light after passing through the second polarizer,
- I_0 is the initial intensity of the polarized light,
- θ is the angle between the polarization direction of the first polarizer and the transmission axis of the second polarizer.

When unpolarized light passes through the first polarizer, its intensity is reduced to 50% because only one plane of polarization is allowed to pass.

After that, using a second polarizer (also called an analyzer), the intensity can be further varied depending on the angle θ. The maximum intensity occurs when $\theta = 0^\circ$ ($\cos^2 0^\circ = 1$),

so output is 50% of original.

The minimum intensity occurs when $\theta = 90^\circ$ ($\cos^2 90^\circ = 0$), so output is 0%.

Therefore, the intensity of polarized light can be controlled from 50% to 0% by rotating the second polarizer.

Hence, the correct answer is (B) 50% to 0%.

Quick Tip

Unpolarized light becomes partially polarized after the first polarizer, reducing its intensity by half. A second polarizer can then control this intensity from 50% to 0%, based on their relative orientation.

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72. If a particle is moving with a momentum of $(2 \times 10^{10})h\, kgms^{-1}$, then the de Broglie wavelength associated with it (in angstrom) is (where h is Planck's constant)

(A) 1.5

(B) 2.5

(C) 1.0

(D) 0.5

(E) 0.75

Correct Answer: (D) 0.5

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

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

where: - h is Planck's constant ($h = 6.626 \times 10^{-34}$ J s), - p is the momentum of the particle.

We are given that the momentum $p = (2 \times 10^{10})h$. Substituting this into the de Broglie wavelength formula:

$$\lambda = \frac{h}{(2 \times 10^{10})h}$$

Simplify the expression:

$$\lambda = \frac{1}{2 \times 10^{10}}$$

Now, calculate the value:

$$\lambda = 5 \times 10^{-11}\,\text{m}$$

Since the question asks for the wavelength in angstroms ($1\,\text{Å} = 10^{-10}\,\text{m}$), convert the wavelength from meters to angstroms:

$$\lambda = 5 \times 10^{-11}\,\text{m} \times \frac{1\,\text{Å}}{10^{-10}\,\text{m}} = 0.5\,\text{Å}$$

Thus, the de Broglie wavelength associated with the particle is $0.5\,\text{Å}$.

Hence, the correct answer is (D) 0.5.

Quick Tip

The de Broglie wavelength is inversely proportional to the momentum of the particle. When the momentum is expressed as a multiple of Planck's constant, the calculation simplifies significantly.

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73. The angular momentum of the electron revolving in 2^{nd} orbit is

(A) $\frac{h}{\pi}$

(B) $\frac{h}{2\pi}$

(C) $\frac{2h}{\pi}$

(D) $\frac{3h}{2\pi}$

(E) $\frac{h}{3\pi}$

Correct Answer: (A) $\frac{h}{\pi}$

Solution: The angular momentum of an electron in an atomic orbital is quantized and given by the formula:

$$L = n \cdot \frac{h}{2\pi}$$

where: - L is the angular momentum,

- n is the principal quantum number (which corresponds to the energy level or shell),

- h is Planck's constant ($h = 6.626 \times 10^{-34}$ J s).

For the 2^{nd} orbit, the principal quantum number $n = 2$. Substituting $n = 2$ into the formula:

$$L = 2 \cdot \frac{h}{2\pi}$$

Simplify the expression:

$$L = \frac{2h}{2\pi} = \frac{h}{\pi}$$

Thus, the angular momentum of the electron in the 2^{nd} orbit is $\frac{h}{\pi}$.

Hence, the correct answer is (A) $\frac{h}{\pi}$.

Quick Tip

The angular momentum of an electron in the n^{th} orbit is directly proportional to the principal quantum number n. For the 2^{nd} orbit, $n = 2$, which simplifies the calculation.

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74. In the nuclear process, $^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + e^{+} + X$, then X is

(A) neutrino

(B) anti-neutrino

(C) electron

(D) positron

(E) neutron

Correct Answer: (A) neutrino

Solution: The given nuclear process is:

$$^{22}_{11}Na \rightarrow ^{22}_{10}Ne + e^{+} + X$$

This represents a beta-plus decay (or positron emission), where a proton in the nucleus is converted into a neutron, releasing a positron (e^{+}) and another particle (X).

Step 1: Conservation of Mass Number
The mass number must be conserved in the reaction. The mass number of the reactant ($^{22}_{11}Na$) is 22. The mass number of the products must also sum to 22:

$$\text{Mass number of } ^{22}_{10}Ne = 22, \quad \text{Mass number of } e^{+} = 0, \quad \text{Mass number of } X = 0$$

Thus, the mass number is conserved:

$$22 = 22 + 0 + 0$$

Step 2: Conservation of Atomic Number The atomic number (or charge) must also be conserved. The atomic number of the reactant ($^{22}_{11}Na$) is 11. The atomic numbers of the products must sum to 11:

$$\text{Atomic number of } ^{22}_{10}Ne = 10, \quad \text{Atomic number of } e^{+} = +1, \quad \text{Atomic number of } X = 0$$

Thus, the atomic number is conserved:

$$11 = 10 + 1 + 0$$

Step 3: Identification of X In beta-plus decay, a proton in the nucleus is converted into a neutron, a positron (e^{+}), and a neutrino (ν). The neutrino is emitted to conserve energy, momentum, and other quantum numbers. Therefore, X must be a neutrino.

Final Answer The particle X is a neutrino.

Hence, the correct answer is (A) neutrino.

Quick Tip

In beta-plus decay, a proton decays into a neutron, emitting a positron and a neutrino. The neutrino ensures conservation of energy and momentum.

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75. In a semiconductor crystal, the total number of electrons in the outer shell is $4N$. At absolute zero, the number of energy states of valence and conduction band are respectively

(A) 0 and $4N$

(B) $4N$ and $4N$

(C) $4N$ and 0

(D) $8N$ and 0

(E) 0 and 8N

Correct Answer: (B) $4N$ and $4N$

Solution: In a semiconductor crystal, the behavior of electrons at absolute zero temperature ($T = 0\,\text{K}$) is governed by the properties of the valence band and the conduction band. Let us analyze the situation step by step:

Step 1: Understanding the Valence Band

- The valence band is the energy band where electrons are normally present at absolute zero.
- At absolute zero, all available energy states in the valence band are fully occupied by electrons.
- Given that the total number of electrons in the outer shell is $4N$, all these electrons will occupy the valence band.
- Therefore, the number of energy states in the valence band that are occupied is $4N$.

Step 2: Understanding the Conduction Band

- The conduction band is the energy band above the valence band, where electrons can move

freely to conduct electricity.
- At absolute zero, no electrons have enough energy to jump from the valence band to the conduction band because there is no thermal energy available.
- However, the number of energy states in the conduction band is equal to the number of electrons in the valence band, as each electron in the valence band corresponds to an empty state in the conduction band. - Therefore, the number of energy states in the conduction band is also $4N$, but these states are unoccupied at absolute zero.

Step 3: Conclusion - At absolute zero, the number of energy states in the valence band that are occupied is $4N$.
- The number of energy states in the conduction band is $4N$, but they are unoccupied.

Thus, the number of energy states of the valence and conduction bands at absolute zero are $4N$ and $4N$, respectively.

Hence, the correct answer is (B) $4N$ and $4N$.

Quick Tip

At absolute zero, all energy states in the valence band are occupied, while the conduction band has the same number of states but remains unoccupied due to the lack of thermal energy.
