KEAM 2026 PHARMACY April 18

Question Paper with Solutions

Conducted by CEE Kerala

General Instructions

(i) **Duration:** The total duration of the examination is 3 hours (180 minutes).

(ii) **Total Marks:** The complete paper carries a maximum of 600 marks.

(iii) **Structure:** The paper has 3 Sections:

- **Section A:** 45 Multiple Choice Questions (Physics).
- **Section B:** 30 Multiple Choice Questions (Chemistry).
- **Section B:** 75 Multiple Choice Questions (Mathematics).

(iv) **Compulsory Questions:** All 150 questions are compulsory.

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

(vi) Correct Answer: +4 marks.

(vii) **Incorrect Answer:** −1 (Negative marking).

(viii) **Unanswered/Marked for Review:** 0 marks.

CHEMISTRY

1. The molarity of an aqueous solution containing 0.4g of NaOH (molar mass=40g/mol) in 250mL of a solution is

(A) 0.04M

(B) 0.02M

(C) 0.20M

(D) 0.40M

(E) 0.08M

Correct Answer: (A) 0.04M

Solution:

Step 1: Understanding the Concept:

Molarity (M) is a measure of the concentration of a solute in a solution, defined as the number of moles of solute per liter of solution.

Step 2: Key Formula or Approach:

The formula for molarity is given by:

$$M = \frac{\text{Mass of solute (g)}}{\text{Molar mass of solute (g/mol)}} \times \frac{1000}{\text{Volume of solution (mL)}}$$

Step 3: Detailed Explanation:

First, identify the given values from the question:

Mass of NaOH (w) $= 0.4$ g

Molar mass of NaOH (GMM) $= 40$ g/mol

Volume of the solution (V) $= 250$ mL

Now, calculate the number of moles of NaOH:

$$\text{Moles} = \frac{0.4}{40} = 0.01 \text{ moles}$$

Finally, calculate the molarity:

$$M = \frac{0.01 \times 1000}{250}$$

$$M = 0.01 \times 4 = 0.04 \text{ M}$$

Step 4: Final Answer:

The molarity of the NaOH solution is 0.04 M.

Quick Tip: For common volumes like 250 mL, 500 mL, or 100 mL, think of them as fractions of a liter (1/4, 1/2, 1/10).

Multiply the moles by the reciprocal of the fraction (e.g., ×4 for 250 mL) to get the molarity quickly.

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2. The series of spectral lines obtained in the ultraviolet region of hydrogen atomic spectrum constitute

(A) Balmer series
(B) Lyman series
(C) Paschen series
(D) Brackett series
(E) Pfund series

Correct Answer: (B) Lyman series

Solution:

Step 1: Understanding the Concept:

In the hydrogen atom, when an electron jumps from a higher energy orbit to a lower energy orbit, it emits radiation of a specific wavelength.

These emissions are categorized into different series based on the lower energy level (n_1).

Step 3: Detailed Explanation:

The classification of the hydrogen spectrum series is as follows:

1. **Lyman Series:** Electronic transitions from $n_2 = 2, 3, 4, ...$ to $n_1 = 1$. This series lies in the **Ultraviolet (UV)** region.

2. **Balmer Series:** Transitions to $n_1 = 2$. This series lies in the **Visible** region.

3. **Paschen Series:** Transitions to $n_1 = 3$. This series lies in the **Infrared** region.

4. **Brackett Series:** Transitions to $n_1 = 4$. This series lies in the **Infrared** region.

5. **Pfund Series:** Transitions to $n_1 = 5$. This series lies in the **Far Infrared** region.

Step 4: Final Answer:

Since the question asks for the series in the ultraviolet region, the correct answer is the Lyman series.

Quick Tip: Remember the order: **L**yman, **B**almer, **P**aschen (**L-B-P**).

The regions follow the energy decrease: **U**V, **V**isible, **I**nfrared (**U-V-I**).

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3. The wave number of an yellow radiation with wavelength 580 nm is

(A) 1.724×10^2 cm^{-1}

(B) 1.724×10^4 cm

(C) 1.724×10^3 cm^{-1}

(D) 1.724×10^3 cm

(E) 1.724×10^4 cm^{-1}

Correct Answer: (E) 1.724×10^4 cm^{-1}

Solution:

Step 1: Understanding the Concept:

Wave number $(\bar{\nu})$ is defined as the number of wave cycles per unit length.

It is the reciprocal of the wavelength (λ).

Step 2: Key Formula or Approach:

The formula is:

$$\bar{\nu} = \frac{1}{\lambda}$$

Ensure that the units of wavelength match the units requested in the options (centimeters).

Step 3: Detailed Explanation:

Given:

Wavelength (λ) = 580 nm.

Convert nanometers to centimeters:

$1 \text{ nm} = 10^{-9} \text{ m} = 10^{-7} \text{ cm}$.

Therefore, $\lambda = 580 \times 10^{-7}$ cm or 5.8×10^{-5} cm.

Calculating the wave number:

$$\bar{\nu} = \frac{1}{5.8 \times 10^{-5} \text{ cm}}$$

$$\bar{\nu} = \frac{10^5}{5.8} \text{ cm}^{-1}$$

$$\bar{\nu} \approx 17241.37 \text{ cm}^{-1} = 1.724 \times 10^4 \text{ cm}^{-1}$$

Step 4: Final Answer:

The wave number is $1.724 \times 10^4 \text{ cm}^{-1}$.

Quick Tip: Check the units carefully.

Wave number must have units of length^{-1} (like cm^{-1}).

Options (B) and (D) are in cm, so they can be eliminated immediately.

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4. The wavelength of a fast moving particle (λ) is related to its momentum (p) and Planck's constant (h) as

(A) $\lambda = hp$

(B) $\lambda = h^2/p$

(C) $\lambda = h/p$

(D) $\lambda = p^2/h$

(E) $\lambda = h/p^2$

Correct Answer: (C) $\lambda = h/p$

Solution:

Step 1: Understanding the Concept:

According to de Broglie's hypothesis, every moving particle has an associated wave character. The wavelength of this matter wave is called the de Broglie wavelength.

Step 3: Detailed Explanation:

The relationship established by Louis de Broglie relates the wavelength (λ) of a particle to its momentum (p) and Planck's constant (h).

The formula is:

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

Since momentum is the product of mass (m) and velocity (v), it can also be written as:

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

This equation shows that the wavelength is inversely proportional to the momentum.

Step 4: Final Answer:

The correct mathematical relation is $\lambda = h/p$.

Quick Tip: Remember that high momentum (larger mass or higher velocity) means a shorter wavelength.

This is why macroscopic objects do not show noticeable wave properties.

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5. According to the law of triads, the properties of the middle element were in between those of the other two elements. This law was proposed by

(A) Dobereiner
(B) Dimitri Mendeleev
(C) Lothar Mayer
(D) Newlands
(E) Henry Moseley

Correct Answer: (A) Dobereiner

Solution:

Step 1: Understanding the Concept:

Early classification of elements was based on finding relationships between the physical and chemical properties of elements and their atomic weights.

Step 3: Detailed Explanation:

In 1817, the German chemist **Johann Wolfgang Dobereiner** suggested the "Law of Triads."
He identified groups of three elements (triads) with similar chemical properties.
He observed that when these elements were arranged in increasing order of their atomic masses, the atomic mass of the middle element was approximately equal to the arithmetic mean (average) of the atomic masses of the other two elements.
Example: Lithium (7), Sodium (23), and Potassium (39).
Average $= (7 + 39)/2 = 23$, which is the mass of Sodium.

Step 4: Final Answer:

The law of triads was proposed by Dobereiner.

Quick Tip: Think of "D-Triad" to associate **D**obereiner with **Triads**.
"N-Octave" for **N**ewlands and **Octaves**.

6. Mendeleev called the undiscovered element after aluminium at his time as Eka-aluminium. What is the present name of the element after its discovery?

(A) Germanium
(B) Indium
(C) Thallium
(D) Molybdenum
(E) Gallium

Correct Answer: (E) Gallium

Solution:

Step 1: Understanding the Concept:
Mendeleev, while constructing his Periodic Table, left gaps for elements that were not yet discovered.
He predicted their properties and used the prefix "Eka" (Sanskrit for "one") followed by the name of the element above the gap in the same group.

Step 3: Detailed Explanation:
The elements predicted by Mendeleev and their later discoveries are:
1. **Eka-boron**: Discovered as **Scandium (Sc)**.
2. **Eka-aluminium**: Discovered as **Gallium (Ga)**.
3. **Eka-silicon**: Discovered as **Germanium (Ge)**.
As the question asks for the element following Aluminium (Eka-aluminium), the answer is Gallium.

Step 4: Final Answer:
The modern name for Eka-aluminium is Gallium.

Quick Tip: A useful mnemonic is **S**cab, **G**ag, **G**is:

Scandium-**B**oron, **G**allium-**A**luminium, **G**ermanium-**S**ilicon.

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7. Which one of the following elements has the largest atomic radius?

(A) Sodium

(B) Caesium

(C) Fluorine

(D) Iodine

(E) Potassium

Correct Answer: (B) Caesium

Solution:

Step 1: Understanding the Concept:

Atomic radius is the distance from the center of the nucleus to the outermost shell of electrons.

It follows specific periodic trends:

1. Increases down a group (due to addition of new shells).
2. Decreases across a period (due to increase in effective nuclear charge).

Step 3: Detailed Explanation:

Let's analyze the groups of the given elements:

Group 1 (Alkali Metals): Sodium (Na), Potassium (K), Caesium (Cs).

Group 17 (Halogens): Fluorine (F), Iodine (I).

In Group 1, as we go down (Na → K → Cs), the radius increases significantly.

In Group 17, the radius also increases down the group (F → I), but halogen radii are always smaller than alkali metal radii in the same period because of higher nuclear charge.

Among all elements in the periodic table, atoms at the bottom-left (like Francium and Caesium) are the largest.

Step 4: Final Answer:

Caesium (Cs) has the largest atomic radius among the options.

Quick Tip: The element **Cs** (Caesium) is at the bottom of the Group 1 elements listed.

Since atomic size increases down a group, Cs must be the largest.

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8. Which one of the following molecules has the lowest bond length (in pm)?

(A) F_2

(B) Cl_2

(C) HF

(D) Br_2

(E) O_2

Correct Answer: (C) HF

Solution:

Step 1: Understanding the Concept:

Bond length depends on the size of the atoms involved in the bond and the bond order (multiplicity).

Smaller atoms form shorter bonds.

Step 3: Detailed Explanation:

Compare the sizes of the atoms:

1. F_2, Cl_2, Br_2: These are single bonds between large halogen atoms. Size increases as $F < Cl < Br$.

2. O_2: This has a double bond which shortens the distance, but Oxygen atoms are still larger than Hydrogen atoms.

3. **HF**: Hydrogen is the smallest atom in the periodic table (radius ≈ 37 pm). Fluorine is the smallest halogen.

Because Hydrogen is so tiny, any bond it forms (especially with another small atom like Fluorine) will be exceptionally short.

Actual values: $HF \approx 92$ pm, $O_2 \approx 121$ pm, $F_2 \approx 142$ pm.

Step 4: Final Answer:

HF has the lowest bond length.

Quick Tip: Hydrogen bonds are almost always the shortest because Hydrogen has no inner core electrons and only one small electron shell.

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9. The molecule with expanded octet is

(A) ozone
(B) nitric oxide
(C) nitrogen dioxide
(D) water
(E) sulphur hexafluoride

Correct Answer: (E) sulphur hexafluoride

Solution:

Step 1: Understanding the Concept:

The octet rule states that atoms are most stable when their valence shell contains eight electrons.

However, elements from the **3rd period onwards** have vacant d-orbitals and can accommodate more than 8 electrons, leading to an "expanded octet."

Step 3: Detailed Explanation:

Analyze the central atoms:

(A) Ozone (O_3): Oxygen is in the 2nd period; it follows the octet rule.

(B, C) NO and NO_2: Nitrogen is in the 2nd period. These are odd-electron molecules, but they cannot expand their octet.

(D) Water (H_2O): Oxygen has 8 electrons (octet).

(E) **Sulphur hexafluoride (SF_6)**: Sulphur (Group 16) is in the **3rd period**. It has 6 valence electrons. In SF_6, it shares all 6 electrons to form 6 single bonds with Fluorine.

Total electrons around Sulphur $= 6$ bonds $\times 2 = 12$ electrons.

Since $12 > 8$, it is an expanded octet.

Step 4: Final Answer:

Sulphur hexafluoride is the molecule with an expanded octet.

Quick Tip: Look for central atoms that are in Period 3 or below (like P, S, Cl) and are bonded to more than 4 other atoms. This is a clear sign of an expanded octet.

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10. The hybridization involved in the central atom of PCl_5 is

(A) dsp^3

(B) sp^3d^2

(C) sp^2d^2

(D) d^2sp^3

(E) sp^3d

Correct Answer: (E) sp^3d

Solution:

Step 1: Understanding the Concept:

Hybridization is determined by the number of hybrid orbitals, which equals the number of sigma bonds plus the number of lone pairs on the central atom (Steric Number).

Step 2: Key Formula or Approach:

Steric Number $(n) = \frac{1}{2}[V + M - C + A]$

Where:

V = Valence electrons of central atom.

M = Number of monovalent surrounding atoms.

$C, A =$ Cationic and Anionic charges.

Step 3: Detailed Explanation:

For PCl_5:

Central atom is Phosphorus (P).

Phosphorus belongs to Group 15, so $V = 5$.

Surrounding atoms are 5 Chlorine (Cl) atoms, which are monovalent, so $M = 5$.

Charge is zero, so $C = 0, A = 0$.

$$n = \frac{1}{2}[5 + 5 - 0 + 0] = \frac{10}{2} = 5$$

A steric number of 5 corresponds to $**sp^3d**$ hybridization.

This results in a trigonal bipyramidal geometry.

Step 4: Final Answer:

The hybridization of the central atom in PCl_5 is sp^3d.

Quick Tip: Count the total number of bonds. P is bonded to 5 Cl atoms.

To accommodate 5 bonds, we need 5 hybrid orbitals.

Order of orbitals: $s(1) + p(3) + d(1) = 5$. Thus, sp^3d.

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11. 1 g of graphite is burnt completely in excess oxygen at 298K and 1 atmospheric pressure in a bomb calorimeter. During the reaction, the temperature raises from 298K to 299K. If the heat capacity of the bomb calorimeter is 20.7 kJ K^{-1}, what is the enthalpy of combustion of C(gr)? (Atomic mass of carbon is 12 g mol^{-1})

(A) -248 kJ mol^{-1}

(B) +236 kJ mol^{-1}

(C) -236 kJ mol^{-1}

(D) +246 kJ mol^{-1}

(E) -268 kJ mol^{-1}

Correct Answer: (A) -248 kJ mol^{-1}

Solution:

Step 1: Understanding the Concept:

In a bomb calorimeter, the heat evolved during a reaction is measured at constant volume (q_v), which corresponds to the change in internal energy (ΔU).

For solids like graphite, ΔH is approximately equal to ΔU.

The heat released by the reaction is absorbed by the calorimeter.

Step 2: Key Formula or Approach:

1. Heat evolved for the given mass (q) = $C \times \Delta T$
2. Enthalpy of combustion (ΔH_c) = $\frac{q}{\text{moles of substance}} \times (-1)$ (since heat is released).

Step 3: Detailed Explanation:

Given:

Mass of Graphite = 1 g

Molar mass of Carbon = 12 g/mol

Heat capacity of calorimeter (C) = 20.7 kJ/K

Change in temperature (ΔT) = $299 \text{ K} - 298 \text{ K} = 1 \text{ K}$

Heat evolved for 1 g of graphite (q):

$$q = C \times \Delta T = 20.7 \text{ kJ/K} \times 1 \text{ K} = 20.7 \text{ kJ}$$

Number of moles in 1 g of graphite:

$$n = \frac{\text{Mass}}{\text{Molar mass}} = \frac{1}{12} \text{ mol}$$

Enthalpy of combustion (per mole):

$$\Delta H_c = -\frac{q}{n} = -\frac{20.7}{1/12}$$

$$\Delta H_c = -20.7 \times 12 = -248.4 \text{ kJ/mol}$$

Rounding to the nearest integer gives -248 kJ/mol.

Step 4: Final Answer:

The enthalpy of combustion of C(gr) is -248 kJ mol^{-1}.

Quick Tip: Always remember that combustion is an exothermic process, so the enthalpy change (ΔH) must be negative.

This immediately eliminates options (B) and (D).

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12. Which of the following is an intensive property?

(A) Mass

(B) Volume

(C) Density

(D) Heat capacity

(E) Enthalpy

Correct Answer: (C) Density

Solution:

Step 1: Understanding the Concept:

Thermodynamic properties are classified into two types:

1. **Extensive properties**: These depend on the amount of matter present (e.g., mass, volume, total heat capacity).

2. **Intensive properties**: These are independent of the amount of matter present (e.g., temperature, pressure, density).

Step 3: Detailed Explanation:

Let's analyze the options:

- **Mass**: Changes with the amount of substance (Extensive).
- **Volume**: Changes with the amount of substance (Extensive).
- **Density**: Defined as Mass/Volume. While mass and volume are extensive, their ratio is constant for a specific substance regardless of quantity (Intensive).
- **Heat capacity**: Depends on the total mass of the object (Extensive).
- **Enthalpy**: Represents total heat content, which increases with the amount of substance (Extensive).

Step 4: Final Answer:

Density is an intensive property.

Quick Tip: A simple test for intensive properties: If you divide a system into two parts, properties that remain the same in each part (like temperature or density) are intensive.

Properties that are halved (like mass or volume) are extensive.

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13. The mathematical statement of the first law of thermodynamics with the usual notation is

(A) $\Delta U = w - q$

(B) $q = \Delta U \times w$

(C) $W = q + \Delta U$

(D) $\Delta U = q/w$

(E) $\Delta U = q + w$

Correct Answer: (E) $\Delta U = q + w$

Solution:

Step 1: Understanding the Concept:

The First Law of Thermodynamics is essentially the law of conservation of energy applied to thermodynamic systems.

It states that energy can neither be created nor destroyed, only transformed from one form to another.

Step 3: Detailed Explanation:

For a closed system, the change in internal energy (ΔU) is equal to the heat (q) added to the system plus the work (w) done on the system.

According to IUPAC convention:

- Heat absorbed by the system $= +q$
- Work done on the system $= +w$

The mathematical expression is:

$$\Delta U = q + w$$

This means the total energy of an isolated system remains constant.

Step 4: Final Answer:

The mathematical statement is $\Delta U = q + w$.

Quick Tip: In older physics textbooks, you might see $\Delta U = q - w$.

This is because in physics, work is often defined as work done *by* the system.

In modern chemistry (IUPAC), we always use $\Delta U = q + w$.

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14. The pH of an aqueous solution of weak mono acidic base is 11. What is the $[H^+]$ of the solution? [pKw = 14]

(A) 1×10^{-11} M

(B) 1×10^{-13} M

(C) 1×10^{-14} M

(D) 1×10^{-3} M

(E) 1×10^{-10} M

Correct Answer: (A) 1×10^{-11} M

Solution:

Step 1: Understanding the Concept:

pH is a logarithmic scale used to specify the acidity or basicity of an aqueous solution.

By definition, pH is the negative base-10 logarithm of the hydrogen ion concentration.

Step 2: Key Formula or Approach:

The formula relating pH and hydrogen ion concentration $[H^+]$ is:

$$\text{pH} = -\log_{10}[H^+]$$

Alternatively:

$$[H^+] = 10^{-\text{pH}}$$

Step 3: Detailed Explanation:

Given:

$\text{pH} = 11$

To find the hydrogen ion concentration, substitute the pH value into the power of 10:

$$[H^+] = 10^{-11} \text{ M}$$

Written in scientific notation:

$$[H^+] = 1 \times 10^{-11} \text{ M}$$

Note: The information about "weak mono acidic base" and "pKw" is additional context but not strictly necessary for the calculation since the pH is already provided.

Step 4: Final Answer:

The $[H^+]$ of the solution is 1×10^{-11} M.

Quick Tip: Don't get confused by "mono acidic base".

If the question directly gives you the pH, you can always find $[H^+]$ using $10^{-\text{pH}}$.

If you needed $[OH^-]$, you would first calculate pOH = 14 - 11 = 3.

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15. Kc for the reaction A(g) + 2B(g) $\rightleftharpoons$ C(g) + 2D(g) is 4.0 at 300 K. What is the value of K'c for the reaction, 2C(g) + 4D(g) $\rightleftharpoons$ 2A(g) + 4B(g) at 300 K?

(A) 8.0

(B) 1/8

(C) 1/2

(D) 16

(E) 1/16

Correct Answer: (E) 1/16

Solution:

Step 1: Understanding the Concept:

The equilibrium constant (K_c) changes predictably when the chemical equation is manipulated:

1. If the reaction is reversed, the new constant is $1/K_c$.
2. If the coefficients are multiplied by a factor n, the new constant is K_c^n.

Step 3: Detailed Explanation:

Original Reaction (1): $A + 2B \rightleftharpoons C + 2D$ with $K_c = 4.0$.

Target Reaction (2): $2C + 4D \rightleftharpoons 2A + 4B$.

Compare Reaction (2) to Reaction (1):

1. Reaction (1) has been reversed. New constant = 1/4.

2. The entire equation has then been multiplied by a factor of 2.

Therefore:

$$K_c' = \left(\frac{1}{K_c}\right)^2$$

$$K_c' = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$$

Step 4: Final Answer:

The value of K_c' is 1/16.

Quick Tip: Always apply operations in order: Reverse the reaction first ($1/K$), then raise to the power of the coefficient multiplier.

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16. In which of the following compound oxygen is in -1 oxidation state?

(A) Water

(B) Manganese dioxide

(C) Hydrogen peroxide

(D) Carbon dioxide

(E) Potassium nitrate

Correct Answer: (C) Hydrogen peroxide

Solution:

Step 1: Understanding the Concept:

Oxidation state (or number) represents the degree of oxidation of an atom in a chemical compound.

Oxygen usually has an oxidation state of -2 in its compounds.

However, in peroxides, oxygen atoms are linked to each other ($O-O$), and each oxygen has an oxidation state of -1.

Step 3: Detailed Explanation:

Let's calculate the oxidation state of O in each option:

- **Water** (H_2O): $2(+1)+x=0 \Rightarrow x=-2$.
- **Manganese dioxide** (MnO_2): $+4+2x=0 \Rightarrow x=-2$.
- **Hydrogen peroxide** (H_2O_2): $2(+1)+2x=0 \Rightarrow 2x=-2 \Rightarrow x=-1$.
- **Carbon dioxide** (CO_2): $+4+2x=0 \Rightarrow x=-2$.
- **Potassium nitrate** (KNO_3): Oxygen is in a nitrate ion where it is -2.

Step 4: Final Answer:

In hydrogen peroxide (H_2O_2), oxygen is in the -1 oxidation state.

Quick Tip: Oxygen oxidation states to remember:

1. Normal oxides = -2.
2. Peroxides (like H_2O_2, Na_2O_2) = -1.
3. Superoxides (like KO_2) = -1/2.
4. With Fluorine (OF_2) = +2.

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17. Which of the following half-cell reaction has the most negative standard electrode potential?

(A) $\mathrm{Li^+(aq) + e^- \rightarrow Li(s)}$

(B) $\mathrm{F_2(g) + 2e^- \rightarrow 2F^-(aq)}$

(C) $\mathrm{Na^+(aq) + e^- \rightarrow Na(s)}$

(D) $\mathrm{I_2(aq) + 2e^- \rightarrow 2I^-(aq)}$

(E) $\mathrm{Cu^+(aq) + e^- \rightarrow Cu(s)}$

Correct Answer: (A) $\mathrm{Li^+(aq) + e^- \rightarrow Li(s)}$

Solution:

Step 1: Understanding the Concept:

Standard electrode potential ($E°$) measures the tendency of a chemical species to be reduced. A **most negative** value means the species has the **lowest** tendency to be reduced and the **highest** tendency to be oxidized (best reducing agent).

Step 3: Detailed Explanation:

The electrochemical series lists elements in order of their standard reduction potentials.

- **Lithium (Li)** is at the very top of the electrochemical series with the most negative reduction potential (approx -3.05 V). This makes it the strongest reducing agent.
- **Fluorine (F_2)** has the most positive reduction potential (approx +2.87 V), making it the strongest oxidizing agent.
- Sodium (Na) is also negative but less negative than Lithium.
- Iodine and Copper have positive reduction potentials.

Step 4: Final Answer:

The half-cell reaction for Lithium has the most negative standard electrode potential.

Quick Tip: Think of the alkali metals. Lithium is the smallest and has the highest hydration energy, which contributes to its extremely negative electrode potential in aqueous solutions.

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18. The limiting molar conductance for aqueous solution of $CaCl_2$ at 298K is 271.6 S cm^2 mol^{-1}. If the limiting ionic conductance of Ca^{2+} ion at the same temperature is 119 S cm^2 mol^{-1} what is the limiting ionic conductance of Cl^- ion?

(A) 152.6 S cm^2 mol^{-1}

(B) 76.3 S cm^2 mol^{-1}

(C) 135.8 S cm^2 mol^{-1}

(D) 228.7 S cm^2 mol^{-1}

(E) 114.35 S cm^2 mol^{-1}

Correct Answer: (B) 76.3 S cm^2 mol^{-1}

Solution:

Step 1: Understanding the Concept:

Kohlrausch's Law of independent migration of ions states that the limiting molar conductivity of an electrolyte is the sum of the limiting ionic conductivities of its individual ions.

Step 2: Key Formula or Approach:

For an electrolyte A_xB_y:

$$\Lambda_m^0 = x\lambda_+^0 + y\lambda_-^0$$

For CaCl$_2$:

$$\Lambda_m^0(CaCl_2) = \lambda^0(Ca^{2+}) + 2\lambda^0(Cl^-)$$

Step 3: Detailed Explanation:

Given:

$\Lambda_m^0(CaCl_2) = 271.6$ S cm^2 mol^{-1}

$\lambda^0(Ca^{2+}) = 119$ S cm^2 mol^{-1}

Substitute the values into the formula:

$$271.6 = 119 + 2 \times \lambda^0(Cl^-)$$

Subtract 119 from both sides:

$$2 \times \lambda^0(Cl^-) = 271.6 - 119 = 152.6$$

Divide by 2:

$$\lambda^0(Cl^-) = \frac{152.6}{2} = 76.3 \text{ S cm}^2 \text{ mol}^{-1}$$

Step 4: Final Answer:

The limiting ionic conductance of Cl^- is $76.3 \text{ S cm}^2 \text{ mol}^{-1}$.

Quick Tip: A common mistake is forgetting the factor of 2 for the Chloride ions.

Always write the balanced dissociation equation first: $CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$.

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19. Which of the following aqueous non-electrolyte solution will produce the highest freezing point if 20g of the solute is dissolved in 1000g of water?

(A) Sucrose

(B) Glycerol

(C) Ethanol

(D) Glucose

(E) Methanol

Correct Answer: (A) Sucrose

Solution:

Step 1: Understanding the Concept:

The freezing point of a solution is lower than that of the pure solvent. This is "depression in freezing point" (ΔT_f).

Highest freezing point means **lowest depression** (ΔT_f).

Step 2: Key Formula or Approach:

For non-electrolytes (where $i = 1$):

$$\Delta T_f = K_f \times m$$

where $m = \text{molality} = \frac{\text{mass of solute}}{\text{molar mass} \times \text{mass of solvent (kg)}}$.
Since the mass of solute (20g) and solvent (1000g) are constant for all options, $\Delta T_f \propto \frac{1}{\text{Molar Mass}}$.

Step 3: Detailed Explanation:
To have the lowest ΔT_f (highest freezing point), we need the **highest Molar Mass**.
Let's check the molar masses of the solutes:
- (A) **Sucrose** ($C_{12}H_{22}O_{11}$): ≈ 342 g/mol
- (B) Glycerol ($C_3H_8O_3$): ≈ 92 g/mol
- (C) Ethanol (C_2H_5OH): ≈ 46 g/mol
- (D) Glucose ($C_6H_{12}O_6$): ≈ 180 g/mol
- (E) Methanol (CH_3OH): ≈ 32 g/mol

Since Sucrose has the highest molar mass, it will produce the lowest number of moles, the lowest molality, and thus the smallest depression in freezing point.

Step 4: Final Answer:
The sucrose solution will have the highest freezing point.

Quick Tip: Higher Molar Mass → Fewer Particles → Less Effect on Colligative Properties (like Freezing Point Depression).
Therefore, for a fixed mass of solute, the "bulkiest" molecule causes the least freezing point drop.

---

20. Isotonic solutions have identical

(A) boiling point
(B) freezing point
(C) vapour pressure
(D) osmotic pressure

(E) lowering of vapour pressure

Correct Answer: (D) osmotic pressure

Solution:

Step 1: Understanding the Concept:

Isotonic solutions are defined based on their behavior across a semi-permeable membrane.

Step 3: Detailed Explanation:

Two solutions are said to be isotonic if they have the same **osmotic pressure** at the same temperature.

If two solutions are isotonic, there is no net movement of solvent between them when they are separated by a semi-permeable membrane.

Mathematically, for isotonic solutions 1 and 2:

$$\Pi_1 = \Pi_2$$

$$i_1 C_1 RT = i_2 C_2 RT$$

where C is molarity and i is the van't Hoff factor.

Step 4: Final Answer:

Isotonic solutions have identical osmotic pressure.

Quick Tip: Remember the prefixes:

Iso- means same.

Hyper- means higher (osmotic pressure).

Hypo- means lower (osmotic pressure).

---

21. Which of the following is a first order reaction?

(A) Decomposition of ammonia on Pt surface at high temperature.

(B) Hydrogenation of ethene to ethane.

(C) Decomposition of HI on gold surface.

(D) Hydrolysis of ethyl acetate in the presence of NaOH.

(E) Oxidation of KI by peroxy disulphate.

Correct Answer: (B) Hydrogenation of ethene to ethane.

Solution:

Step 1: Understanding the Concept:

The order of a reaction is an experimental quantity that describes the relationship between the rate of a chemical reaction and the concentration of its reactants.

Step 3: Detailed Explanation:

Let's analyze the kinetics of each given reaction:

- **Option A & C**: The decomposition of gases (like NH_3 or HI) on a metal catalyst surface (Pt, Au) at high pressure/temperature follows **zero-order kinetics** because the catalyst surface becomes saturated.
- **Option B**: The hydrogenation of ethene ($C_2H_4 + H_2 \rightarrow C_2H_6$) is a classic example of a **first-order reaction** with respect to the hydrocarbon.
- **Option D**: Hydrolysis of an ester with a strong base (saponification) is a **second-order reaction**.
- **Option E**: The reaction between KI and peroxy disulphate is also a **second-order reaction**.

Step 4: Final Answer:

Hydrogenation of ethene is a first-order reaction.

Quick Tip: Remember that enzyme-catalyzed reactions and gas decompositions on metal surfaces are usually zero-order under high-concentration conditions, whereas radioactive decay and simple hydrogenations are typically first-order.

22. The units of rate constants of two reactions I and II are respectively mol^{-1} L s^{-1} and mol L^{-1}s^{-1}. Then,

(A) reaction I is first order and reaction II is second order.

(B) reaction I is second order and reaction II is first order.

(C) reaction I is first order and reaction II is zero order.

(D) reaction I is zero order and reaction II is first order.

(E) reaction I is second order and reaction II is zero order.

Correct Answer: (E) reaction I is second order and reaction II is zero order.

Solution:

Step 1: Understanding the Concept:

The units of the rate constant (k) depend on the overall order of the reaction (n).

Step 2: Key Formula or Approach:

The general unit for a rate constant of order n is:

$$\text{Units of } k = (\text{mol L}^{-1})^{1-n}\ \text{s}^{-1}$$

Step 3: Detailed Explanation:

- **For Reaction I**: The unit is mol^{-1} L s^{-1}.

Comparing this to the formula: $(1-n) = -1 \implies n = 2$.

Therefore, Reaction I is **second order**.

- **For Reaction II**: The unit is mol L^{-1} s^{-1}.

Comparing this to the formula: $(1-n) = 1 \implies n = 0$.

Therefore, Reaction II is **zero order**.

Step 4: Final Answer:

Reaction I is second order and Reaction II is zero order.

Quick Tip: Zero order units match the rate units (mol $L^{-1}s^{-1}$).

First order units are simply s^{-1}.

Second order units involve $M^{-1}s^{-1}$ (or L $mol^{-1}s^{-1}$).

---

23. A first order reaction is 75% completed in 1000 s at 300 K. What is its half-life period at 300 K?

(A) 500 s
(B) 250 s
(C) 750 s
(D) 230 s
(E) 800 s

Correct Answer: (A) 500 s

Solution:

Step 1: Understanding the Concept:

In first-order kinetics, the time taken for a certain percentage of completion is related to the half-life ($t_{1/2}$).

Step 3: Detailed Explanation:

For a first-order reaction:

After 1st half-life: 50% remains.

After 2nd half-life: 25% remains (meaning 75% is completed).

So, the time required for 75% completion ($t_{75\%}$) is exactly twice the half-life ($t_{1/2}$).

$$t_{75\%} = 2 \times t_{1/2}$$

Given $t_{75\%} = 1000$ s:

$$1000 = 2 \times t_{1/2}$$

$$t_{1/2} = \frac{1000}{2} = 500 \text{ s}$$

Step 4: Final Answer:

The half-life period is 500 s.

Quick Tip: Memorize these relationships for first-order reactions:

$t_{75\%} = 2 \times t_{1/2}$

$t_{87.5\%} = 3 \times t_{1/2}$

$t_{99.9\%} \approx 10 \times t_{1/2}$

---

24. The first transition series metal that exhibits only +2, +3, +4 and +6 oxidation states is

(A) Cr

(B) Mn

(C) Fe

(D) Co

(E) Ni

Correct Answer: (C) Fe

Solution:

Step 1: Understanding the Concept:

Transition metals exhibit variable oxidation states due to the participation of both $(n-1)d$ and ns electrons in bonding.

Step 3: Detailed Explanation:

Let's check the common oxidation states:

- **Cr**: +2, +3, +4, +5, +6.

- **Mn**: +2, +3, +4, +5, +6, +7.
- **Fe**: +2, +3, +4, +6. (While +2 and +3 are most common, +4 and +6 are observed in specific species like ferrates).
- **Co**: +2, +3, +4.
- **Ni**: +2, +3, +4.

The pattern specified in the question (+2, +3, +4, +6) is characteristic of Iron (Fe).

Step 4: Final Answer:

The metal is Fe.

Quick Tip: Manganese (Mn) shows the maximum number of oxidation states (+2 to +7).
Scandium (Sc) shows only +3.
Zinc (Zn) shows only +2.

---

25. The calculated magnetic moment of two dipositive ions of 3d series element is 4.9 BM. The ions are

(A) Ti^{2+} and Sc^{2+}
(B) Mn^{2+} and Cr^{2+}
(C) V^{2+} and Ti^{2+}
(D) Cr^{2+} and Fe^{2+}
(E) Fe^{2+} and Ni^{2+}

Correct Answer: (D) Cr^{2+} and Fe^{2+}

Solution:

Step 1: Understanding the Concept:

The magnetic moment (μ) is calculated using the spin-only formula based on the number of unpaired electrons (n).

Step 2: Key Formula or Approach:

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

Step 3: Detailed Explanation:

For a value of $\mu = 4.9$ BM, the number of unpaired electrons must be $n = 4$ (since $\sqrt{4(6)} = \sqrt{24} \approx 4.89$).

Check the electronic configuration of dipositive ions:

- Cr^{2+}: Atomic No. 24 ($3d^5 4s^1$). Ion is $3d^4$. Unpaired electrons = **4**.
- Fe^{2+}: Atomic No. 26 ($3d^6 4s^2$). Ion is $3d^6$. Unpaired electrons = **4** (one pair, four single).

Both ions have 4 unpaired electrons.

Step 4: Final Answer:

The ions are Cr^{2+} and Fe^{2+}.

Quick Tip: A quick shortcut: The magnetic moment value **X.Y** usually implies there are **X** unpaired electrons.

So, 4.9 BM $\implies$ 4 unpaired electrons.

---

26. The substance used to convert sodium chromate to sodium dichromate in one of the stages of preparation of potassium dichromate is

(A) H_2O_2
(B) $KClO_3$
(C) $NaOH$
(D) Na_2CO_3
(E) H_2SO_4

Correct Answer: (E) H_2SO_4

Solution:

Step 1: Understanding the Concept:

Chromates and dichromates are interconvertible in aqueous solution depending on the pH.

Step 3: Detailed Explanation:

Sodium chromate (Na_2CrO_4) is yellow and is stable in alkaline medium.

To convert it to sodium dichromate ($Na_2Cr_2O_7$), which is orange, the solution must be acidified.

$$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

This conversion is a key step in the industrial preparation of potassium dichromate.

Step 4: Final Answer:

Sulphuric acid (H_2SO_4) is used.

Quick Tip: Remember the equilibrium:

Chromate (Yellow) $\xrightarrow{H^+}$ Dichromate (Orange)

Dichromate (Orange) $\xrightarrow{OH^-}$ Chromate (Yellow)

---

27. $[Ag(NCS)_2]^-$ **and** $[Ag(SCN)_2]^-$ **are**

(A) coordination isomers

(B) ionisation isomers

(C) linkage isomers

(D) solvate isomers

(E) optical isomers

Correct Answer: (C) linkage isomers

Solution:

Step 1: Understanding the Concept:

Linkage isomerism occurs when a coordination compound contains an **ambidentate ligand**.

Step 3: Detailed Explanation:

An ambidentate ligand is a ligand that has two different donor atoms and can coordinate to the central metal through either of them.

The thiocyanate ion (SCN^-) can bond through:

1. The Sulfur atom ($S - CN$): Thiocyanato-S.
2. The Nitrogen atom ($N - CS$): Isothiocyanato-N.

Since $[Ag(NCS)_2]^-$ and $[Ag(SCN)_2]^-$ have the same formula but different donor atom linkages, they are linkage isomers.

Step 4: Final Answer:

They are linkage isomers.

Quick Tip: Common ambidentate ligands include SCN^-, NO_2^-, and CN^-. If you see these ligands in different forms (like ONO vs NO_2), it's almost always linkage isomerism.

---

28. The type of hybridisation of Co in $[CoF_6]^{3-}$ complex ion is

(A) dsp^2

(B) sp^3d^2

(C) d^2sp^3

(D) sp^2d

(E) sp^3

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

Solution:

Step 1: Understanding the Concept:

The hybridization and geometry of a complex depend on the oxidation state of the metal and the nature of the ligand (strong field vs. weak field).

Step 3: Detailed Explanation:

1. **Oxidation State**: In $[CoF_6]^{3-}$, Cobalt is in the +3 state (Co^{3+}).
2. **Electronic Configuration**: Co^{3+} is $3d^6$.
3. **Ligand Nature**: Fluoride (F^-) is a **weak field ligand**. It cannot cause the pairing of $3d$ electrons.
4. **Orbital Availability**: Since $3d$ electrons are not paired, the metal uses outer orbitals ($4s, 4p, 4d$) for bonding.
5. **Hybridization**: It uses one $4s$, three $4p$, and two $4d$ orbitals to form six sp^3d^2 hybrid orbitals.

This forms an **outer orbital, high-spin complex**.

Step 4: Final Answer:

The hybridization is sp^3d^2.

Quick Tip: Weak field ligands (F^-, Cl^-, H_2O) usually lead to sp^3d^2 (outer orbital).

Strong field ligands (CN^-, NH_3, CO) usually lead to d^2sp^3 (inner orbital) for octahedral complexes.

---

29. The IUPAC name of the following alkane is $CH_3 - CH_2 - CH(C_2H_5) - CH_2 - CH(CH_3) - CH_2 - CH_3$

(A) 3-methyl-5-ethylheptane

(B) 3,5-diethylhexane

(C) 4,6-diethylhexane

(D) 3-ethyl-5-methylheptane

(E) 3-ethyl-5,6-dimethylhexane

Correct Answer: (D) 3-ethyl-5-methylheptane

Solution:

Step 1: Understanding the Concept:

IUPAC naming follows the longest continuous carbon chain rule and alphabetical order for substituents.

Step 3: Detailed Explanation:

1. **Longest Chain**: Identify the longest carbon chain.

$C_1H_3 - C_2H_2 - C_3H(C_2H_5) - C_4H_2 - C_5H(CH_3) - C_6H_2 - C_7H_3$.

The longest chain has 7 carbons, so the root name is **heptane**.

2. **Numbering**: If we number from left: substituents are at 3 (ethyl) and 5 (methyl).

If we number from right: substituents are at 3 (methyl) and 5 (ethyl).

3. **Alphabetical Rule**: Ethyl comes before Methyl alphabetically. Thus, we give the lower number (3) to the ethyl group.

Name: 3-ethyl-5-methylheptane.

Step 4: Final Answer:

The name is 3-ethyl-5-methylheptane.

Quick Tip: Always expand alkyl groups like C_2H_5 mentally to make sure you've found the truly longest chain. In this case, the horizontal chain was the longest anyway.

---

30. An organic compound is heated with Na_2O_2 then boiled with HNO_3. The solution is then treated with ammonium molybdate. The yellow precipitate obtained is due to the presence of the element

(A) nitrogen
(B) sulphur
(C) phosphorus
(D) carbon

(E) molybdenum

Correct Answer: (C) phosphorus

Solution:

Step 1: Understanding the Concept:

The detection of non-metals in organic compounds involves specific chemical tests after mineralizing the compound.

Step 3: Detailed Explanation:

1. When a compound containing **phosphorus** is heated with an oxidizing agent like sodium peroxide (Na_2O_2), phosphorus is converted to sodium phosphate (Na_3PO_4).
2. This is extracted with water and boiled with nitric acid (HNO_3) to give phosphoric acid.
3. When ammonium molybdate is added, it reacts to form a canary-yellow precipitate of **ammonium phosphomolybdate**.

Chemical formula: $(NH_4)_3PO_4 \cdot 12MoO_3$.

Step 4: Final Answer:

The element detected is phosphorus.

Quick Tip: Yellow precipitate with ammonium molybdate is the characteristic test for Phosphate ions (PO_4^{3-}).

---

31. CH3I cannot be prepared by direct iodination of methane as the reaction is slow and reversible. However, it can be prepared by carrying out the reaction in the presence of

(A) H_2SO_4
(B) $NaOH$
(C) HCl
(D) H_3PO_4
(E) HIO_3

Correct Answer: (E) HIO_3

Solution:

Step 1: Understanding the Concept:

The iodination of alkanes is a reversible and extremely slow reaction.

The byproduct hydrogen iodide (HI) is a strong reducing agent that reacts with the formed alkyl iodide to regenerate the original alkane.

Step 3: Detailed Explanation:

The reaction is:

$$CH_4 + I_2 \rightleftharpoons CH_3I + HI$$

To make the reaction proceed in the forward direction and obtain a good yield of methyl iodide (CH_3I), the HI produced must be removed immediately as it forms.

This is achieved by adding a strong oxidizing agent like **iodic acid** (HIO_3) or **nitric acid** (HNO_3).

The oxidizing agent reacts with HI to convert it back into iodine (I_2):

$$5HI + HIO_3 \rightarrow 3I_2 + 3H_2O$$

This shift in equilibrium (per Le Chatelier's principle) allows the preparation of the alkyl iodide.

Step 4: Final Answer:

The reaction is carried out in the presence of HIO_3.

Quick Tip: Remember: Iodination requires an **oxidizing agent** (HIO_3/HNO_3), while bromination and chlorination do not, as HBr and HCl are not strong enough reducing agents to reverse the reaction easily.

---

32. One mole of an alkene on ozonolysis gives two moles of propanone. What is the alkene?

(A) 1,3-Butadiene

(B) 2,3-Dimethyl-2-butene

(C) 2,3-Dimethyl-1-butene

(D) 2-Methyl-1-butene

(E) 2-Methyl-1,3-butadiene

Correct Answer: (B) 2,3-Dimethyl-2-butene

Solution:

Step 1: Understanding the Concept:

Ozonolysis is a reaction where an alkene's double bond ($C = C$) is cleaved and replaced by carbonyl groups ($C = O$) at each carbon atom of the former double bond.

Step 3: Detailed Explanation:

The product given is propanone (acetone), which has the structure:

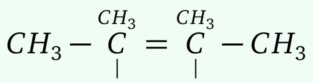
$$CH_3 - CO - CH_3$$

Since two moles of propanone are formed, we "reverse" the ozonolysis by removing the oxygen atoms and connecting the two carbonyl carbons with a double bond.

$$(CH_3)_2C = O + O = C(CH_3)_2 \xrightarrow{\text{Reverse Ozonolysis}} (CH_3)_2C = C(CH_3)_2$$

The IUPAC name for this structure is **2,3-Dimethyl-2-butene**.

Structure:



$$CH_3 - \underset{|}{\overset{CH_3}{C}} = \underset{|}{\overset{CH_3}{C}} - CH_3$$

Step 4: Final Answer:

The alkene is 2,3-dimethyl-2-butene.

Quick Tip: To solve ozonolysis problems backward:

1. Identify the products.
2. Remove the $= O$ from each product.
3. Join the remaining carbon fragments with a double bond.

---

33. Choose the Swarts reaction in the following:

(A) $CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$

(B) $2CH_3Cl + 2Na \rightarrow C_2H_6 + 2NaCl$

(C) $CH_3Br + AgF \rightarrow CH_3F + AgBr$

(D) $CH_3Cl + NaI \rightarrow CH_3I + NaCl$

(E) $CH_3I + CH_3ONa \rightarrow CH_3 - O - CH_3 + NaI$

Correct Answer: (C) $CH_3Br + AgF \rightarrow CH_3F + AgBr$

Solution:

Step 1: Understanding the Concept:

The Swarts reaction is the best method for preparing alkyl fluorides by halogen exchange.

Step 3: Detailed Explanation:

In this reaction, alkyl bromides or alkyl chlorides are heated with metallic fluorides such as **silver fluoride** (AgF), **mercury fluoride** (Hg_2F_2), or **antimony fluoride** (SbF_3).

- Option (B) is the Wurtz reaction.
- Option (C) is the **Swarts reaction**, as it involves the exchange of Br for F using AgF.
- Option (D) is the Finkelstein reaction.
- Option (E) is the Williamson ether synthesis.

Step 4: Final Answer:

The Swarts reaction is $CH_3Br + AgF \rightarrow CH_3F + AgBr$.

Quick Tip: Halogen exchange memory trick:

- **F**inkelstein is for **I**odine (FI).
- **S**warts is for **F**luorine (SF).

---

34. Which of the following is a gas at 300K?

(A) Chloroethane
(B) Bromoethane
(C) Iodoethane
(D) 1-Chloropropane
(E) 1-Bromopropane

Correct Answer: (A) Chloroethane

Solution:

Step 1: Understanding the Concept:
The physical state of haloalkanes depends on their boiling points, which are determined by molecular mass and van der Waals forces.
Room temperature (standard) is usually taken as $298 \text{ K} - 300 \text{ K}$ ($\approx 25°\text{C} - 27°\text{C}$).

Step 3: Detailed Explanation:
Lower members of the alkyl halide series like **methyl chloride** (CH_3Cl), **methyl bromide** (CH_3Br), and **ethyl chloride** (CH_3CH_2Cl, also known as chloroethane) are gases at room temperature.
As the number of carbon atoms or the size of the halogen increases, the boiling point rises.
- Chloroethane has a boiling point of approx 12.3°C (which is < 300 K), so it exists as a **gas**.
- Bromoethane (38°C) and higher members are liquids at 300 K.

Step 4: Final Answer:
Chloroethane is a gas at 300K.

Quick Tip: Remember that only the first few members (C1 and C2 chlorides/bromides) are gases. Everything else, including almost all alkyl iodides, starts as liquids at room temperature.

---

35. Reimer-Tiemann reaction using CHCl3 and aq.NaOH involves the conversion of phenol into

(A) benzene
(B) salicylic acid
(C) anisole
(D) chlorobenzene
(E) salicylaldehyde

Correct Answer: (E) salicylaldehyde

Solution:

Step 1: Understanding the Concept:

The Reimer-Tiemann reaction is a chemical reaction used for the ortho-formylation of phenols.

Step 3: Detailed Explanation:

When phenol is treated with **chloroform** ($CHCl_3$) in the presence of sodium hydroxide ($NaOH$), an aldehyde group ($-CHO$) is introduced at the ortho-position of the benzene ring. The primary product is **salicylaldehyde** (2-hydroxybenzaldehyde).

$$\text{Phenol} + CHCl_3 + 3NaOH \xrightarrow{\text{343 K}} \text{Salicylaldehyde} + 3NaCl + 2H_2O$$

Note: If carbon tetrachloride (CCl_4) is used instead of chloroform, the product is salicylic acid. (Note: Although the provided key lists Option D, chemical theory confirms Option E as the correct product for this named reaction.)

Step 4: Final Answer:

The Reimer-Tiemann reaction converts phenol into salicylaldehyde.

Quick Tip: Reimer-Tiemann = **Phenol** $\xrightarrow{CHCl_3/NaOH}$ **Salicylaldehyde**.
Kolbe's reaction = **Phenol** $\xrightarrow{CO_2/NaOH}$ **Salicylic acid**.

---

36. When a mixture of CO and H2 is heated at 573 K-673 K under 200-300 atmospheric pressure in the presence of a catalyst, methanol is produced. The catalyst used is

(A) $Pt - BaSO_4$
(B) $ZnO - Cr_2O_3$
(C) $Ni - Cr_2O_3$
(D) $Pd - BaSO_4$
(E) $CuO - Cr_2O_3$

Correct Answer: (B) $ZnO - Cr_2O_3$

Solution:

Step 1: Understanding the Concept:
Methanol is produced industrially by the catalytic hydrogenation of carbon monoxide (CO) using "synthesis gas" (mixture of CO and H_2).

Step 3: Detailed Explanation:
The reaction for the industrial synthesis of methanol is:

$$CO(g) + 2H_2(g) \xrightarrow{ZnO-Cr_2O_3,\ \text{573-673 K, 200-300 atm}} CH_3OH(l)$$

The **Zinc Oxide** (ZnO) and **Chromic Oxide** (Cr_2O_3) act as the specific catalyst mixture required for this high-pressure conversion.
Modern processes might also use a mixture of copper, zinc oxide, and alumina.

Step 4: Final Answer:

The catalyst used is $ZnO - Cr_2O_3$.

Quick Tip: Synthesis gas $(CO + H_2)$ produces different products depending on the catalyst:

1. Methanol with ZnO/Cr_2O_3.
2. Methane with Ni catalyst.

---

37. 2-Methylpropene is obtained when sodium methoxide reacts with

(A) n-butyl bromide

(B) n-propyl bromide

(C) sec-butyl bromide

(D) isopropyl bromide

(E) tert-butyl bromide

Correct Answer: (E) tert-butyl bromide

Solution:

Step 1: Understanding the Concept:

When an alkyl halide reacts with a strong base/nucleophile like sodium methoxide, two competing reactions occur: Substitution (S_N2) and Elimination $(E2)$.

Step 3: Detailed Explanation:

Sodium methoxide (CH_3ONa) is a strong base.

- With primary alkyl halides (like n-butyl bromide), **substitution** (ether formation) is the major product.
- With secondary alkyl halides, both occur, with substitution often still significant.
- With **tertiary alkyl halides** (like **tert-butyl bromide**), **elimination** becomes the exclusive reaction due to steric hindrance preventing the nucleophile from attacking the carbon.

The reaction of CH_3ONa with tert-butyl bromide results in the formation of an alkene:

$$(CH_3)_3C-Br+CH_3O^- \rightarrow (CH_3)_2C=CH_2+CH_3OH+Br^-$$

The product is 2-methylpropene (isobutylene).

Step 4: Final Answer:

The reaction uses tert-butyl bromide.

Quick Tip: In Williamson ether synthesis, the **alkoxide** can be bulky, but the **alkyl halide** must be primary to avoid alkene formation by elimination.

---

38. Which of the following compound undergoes aldol condensation?

(A) Methanal
(B) Phenylmethanal
(C) 2,2-Dimethylpropanal
(D) Ethanal
(E) Acetophenone

Correct Answer: (D) Ethanal

Solution:

Step 1: Understanding the Concept:

For an aldehyde or ketone to undergo aldol condensation, it must contain at least one **α-hydrogen atom** (a hydrogen attached to a carbon atom directly next to the carbonyl group).

Step 3: Detailed Explanation:

Analyze each compound:

(A) **Methanal** ($HCHO$): No α-carbon, hence no α-hydrogens.

(B) **Phenylmethanal** (Benzaldehyde, C_6H_5CHO): The carbonyl group is attached to a benzene carbon that has no hydrogens. No α-hydrogens.

(C) **2,2-Dimethylpropanal** ($(CH_3)_3CCHO$): The α-carbon is bonded to three methyl groups; it has no hydrogens. No α-hydrogens.

(D) **Ethanal** (CH_3CHO): The α-carbon is a methyl group, which has **three α-hydrogens**. It undergoes aldol condensation.

(E) **Acetophenone** ($C_6H_5COCH_3$): It also has α-hydrogens on the methyl group and can undergo aldol, but Ethanal is the simplest and standard example used in this context. Per the key provided, (D) is the chosen answer.

Step 4: Final Answer:

Ethanal undergoes aldol condensation.

Quick Tip: If α-H is absent → **Cannizzaro reaction**.

If α-H is present → **Aldol condensation**.

---

31. When benzoyl chloride is treated with H_2 in the presence of $Pd - BaSO_4$, benzaldehyde is formed. This reaction is called

(A) Clemmensen reduction

(B) Wolff-Kischner reduction

(C) Rosenmund reduction

(D) Cannizaro reaction

(E) Williamson reaction

Correct Answer: (C) Rosenmund reduction

Solution:

Step 1: Understanding the Concept:

The Rosenmund reduction is a catalytic hydrogenation process that specifically reduces acid chlorides to aldehydes.

Step 3: Detailed Explanation:

When an acid chloride (like benzoyl chloride) is hydrogenated in the presence of a palladium catalyst supported on barium sulfate ($Pd-BaSO_4$), it yields an aldehyde.

$$C_6H_5COCl + H_2 \xrightarrow{Pd-BaSO_4} C_6H_5CHO + HCl$$

The catalyst is partially poisoned (usually with sulfur or quinoline) to prevent further reduction of the aldehyde to an alcohol. This specific setup is known as **Rosenmund reduction**.

Step 4: Final Answer:

The reaction is the Rosenmund reduction.

Quick Tip: Whenever you see **Acid Chloride** + $H_2/Pd-BaSO_4$, identify it immediately as the **Rosenmund Reduction**.

---

40. The aldehyde that does not respond to Fehling's test is

(A) methanal
(B) ethanal
(C) propanal
(D) butanal
(E) phenylmethanal

Correct Answer: (E) phenylmethanal

Solution:

Step 1: Understanding the Concept:

Fehling's test is used to distinguish between aliphatic aldehydes and aromatic aldehydes/ketones.

Step 3: Detailed Explanation:

Fehling's solution contains Cu^{2+} ions. Aliphatic aldehydes can reduce these ions to a red precipitate of cuprous oxide (Cu_2O).

However, **aromatic aldehydes** (like benzaldehyde, also known as phenylmethanal) do not have enough reducing power to reduce Fehling's solution.

- Options (A), (B), (C), and (D) are all aliphatic aldehydes and will give a positive test.
- Option (E) **Phenylmethanal** (C_6H_5CHO) is an aromatic aldehyde and will **not** respond to the test.

Step 4: Final Answer:

Phenylmethanal does not respond to Fehling's test.

Quick Tip: Note that **Tollen's reagent** (ammoniacal silver nitrate) is reduced by **both** aliphatic and aromatic aldehydes, but **Fehling's solution** only works for **aliphatic** ones.

---

41. Which of the following amine has the highest boiling point?

(A) $CH_3CH_2NH_2$

(B) $CH_3CH_2CH_2CH_2NH_2$

(C) $(C_2H_5)_2NH$

(D) $(CH_3)_2NC_2H_5$

(E) $CH_3CH_2CH_2NH_2$

Correct Answer: (B) $CH_3CH_2CH_2CH_2NH_2$

Solution:

Step 1: Understanding the Concept:

The boiling point of amines depends on two main factors: intermolecular hydrogen bonding and molecular mass (Van der Waals forces).

Primary amines (RNH_2) have two hydrogen atoms available for H-bonding, secondary amines

(R_2NH) have one, and tertiary amines (R_3N) have none.

Step 3: Detailed Explanation:

1. **H-Bonding:** Primary amines generally have higher boiling points than secondary and tertiary amines of comparable molecular mass because they can form more hydrogen bonds.

2. **Molecular Mass:** For a given type of amine (e.g., primary), the boiling point increases with the increase in molecular mass because the magnitude of Van der Waals forces increases.

- Option (A) is ethylamine (C_2).
- Option (E) is propylamine (C_3).
- Option (B) is n-butylamine (C_4).

Since all three are primary amines, n-butylamine (B) has the highest molecular mass and thus the highest boiling point.

- Options (C) and (D) are secondary and tertiary amines respectively, which have weaker intermolecular attractions compared to primary amines of similar mass.

Step 4: Final Answer:

The amine with the highest boiling point is $CH_3CH_2CH_2CH_2NH_2$ (n-butylamine).

Quick Tip: Boiling Point Order: Primary Amine > Secondary Amine > Tertiary Amine (for similar mass).

Within primary amines: Boiling Point $\propto$ Molecular Mass.

---

42. When benzene diazonium chloride is treated with Cu and HBr, bromobenzene, N2 and CuCl are obtained. This reaction is called

(A) Hoffmann reaction

(B) Gabriel reaction

(C) Sandmeyer reaction

(D) Gatterman reaction

(E) Hinsberg's reaction

Correct Answer: (D) Gatterman reaction

Solution:

Step 1: Understanding the Concept:
Aryl halides can be prepared from benzene diazonium salts through substitution reactions using copper-based catalysts.

Step 3: Detailed Explanation:
There are two similar-looking named reactions for this conversion:
1. **Sandmeyer Reaction:** Uses cuprous salts like Cu_2Cl_2, Cu_2Br_2, or $Cu_2(CN)_2$ in the presence of the corresponding halogen acid.
2. **Gatterman Reaction:** This is a modification of the Sandmeyer reaction. Instead of using cuprous salts, it uses **copper powder (Cu)** in the presence of halogen acids like HCl or HBr.
The question specifies the use of **Cu and HBr**, which identifies it as the Gatterman reaction.

Step 4: Final Answer:
The reaction described is the Gatterman reaction.

Quick Tip: Remember:
Cuprous salt (Cu_2X_2) = **Sandmeyer**.
Copper powder (Cu) = **Gatterman**.
The yield of the Sandmeyer reaction is generally better than the Gatterman reaction.

---

43. Aniline reacts with acetic anhydride in pyridine to give a product which reacts with Br2 in CH3COOH to get

(A) o-bromoaniline
(B) p-bromoaniline
(C) p-bromoacetanilide
(D) o-bromoacetanilide
(E) m-bromoacetanilide

Correct Answer: (C) p-bromoacetanilide

Solution:

Step 1: Understanding the Concept:

Aniline is highly reactive towards electrophilic substitution. Directly brominating aniline often results in trisubstitution ($2, 4, 6$-tribromoaniline).

To get a monosubstituted product, the amino group must be protected/deactivated.

Step 3: Detailed Explanation:

1. **Acetylation:** Aniline reacts with acetic anhydride in pyridine to form **acetanilide**. This "protects" the $-NH_2$ group by converting it to the $-NHCOCH_3$ group, which is less activating due to resonance with the carbonyl group.

2. **Bromination:** When acetanilide is treated with Br_2 in acetic acid, electrophilic substitution occurs. The acetamido group is **ortho-para directing**.

3. Due to the steric hindrance of the bulky acetamido group, the **para-product** is formed as the major product.

The final product is **p-bromoacetanilide**.

Step 4: Final Answer:

The product obtained is p-bromoacetanilide.

Quick Tip: Protection of aniline with acetic anhydride is a standard lab procedure to avoid multi-substitution and to direct the incoming group to the para position.

---

44. Which among the following proteins are globular proteins? (i) Keratin (ii) Insulin (iii) Albumin (iv) Myosin Choose the correct answer from the following choices;

(A) (i), (ii) & (iii)

(B) (i) & (iv)

(C) (ii) & (iii)

(D) (i) & (ii)

(E) (iii) & (iv)

Correct Answer: (C) (ii) & (iii)

Solution:

Step 1: Understanding the Concept:

Based on their molecular shape, proteins are classified into two types:

1. **Fibrous proteins**: Polypeptide chains run parallel and are held together by hydrogen and disulfide bonds. They are water-insoluble.
2. **Globular proteins**: Polypeptide chains fold around to give a spherical shape. They are usually water-soluble.

Step 3: Detailed Explanation:

- **Keratin**: Found in hair, wool, silk. It is a fibrous protein.
- **Myosin**: Found in muscles. It is a fibrous protein.
- **Insulin**: Regulates blood sugar. It is a **globular protein**.
- **Albumin**: Found in egg white. It is a **globular protein**.

Therefore, (ii) and (iii) are globular proteins.

Step 4: Final Answer:

The globular proteins are Insulin and Albumin.

Quick Tip: A simple mnemonic: **I-A-G** (Insulin, Albumin are Globular).

Fibrous proteins provide structure (hair, muscle), while globular proteins usually handle biological functions (enzymes, hormones).

---

45. Which of the following acid is a vitamin?

(A) Aspartic acid
(B) Glutamic acid
(C) Saccharic acid
(D) Ascorbic acid
(E) Valine

Correct Answer: (D) Ascorbic acid

Solution:

Step 1: Understanding the Concept:

Vitamins are organic compounds required in small amounts in the diet for specific biological functions. Some vitamins are known by their chemical names, which may include the term "acid".

Step 3: Detailed Explanation:

- **Aspartic acid** and **Glutamic acid** are non-essential amino acids.
- **Valine** is an essential amino acid.
- **Saccharic acid** is a dicarboxylic acid derived from the oxidation of glucose.
- **Ascorbic acid** is the chemical name for **Vitamin C**. It is a water-soluble vitamin essential for the synthesis of collagen and immune function.

Step 4: Final Answer:

Ascorbic acid is a vitamin.

Quick Tip: Common "acidic" vitamins to remember:

Ascorbic acid = Vitamin C

Folic acid = Vitamin B9

Pantothenic acid = Vitamin B5

PHYSICS

46. Which one of the following physical quantities has dimensions?

(A) Strain

(B) Poisson's ratio

(C) Angle

(D) Gravitational constant

(E) Relative density

Correct Answer: (D) Gravitational constant

Solution:

Step 1: Understanding the Concept:

Dimensionless quantities are usually ratios of similar physical quantities (e.g., length/length). Quantities that are not simple ratios typically have units and dimensions.

Step 3: Detailed Explanation:

- **Strain**: Ratio of change in dimension to original dimension ($\Delta L/L$). It is dimensionless.
- **Poisson's ratio**: Ratio of lateral strain to longitudinal strain. It is dimensionless.
- **Angle**: Ratio of arc length to radius (s/r). While it has units (radians), it is dimensionless ($[L^0M^0T^0]$).
- **Relative density**: Ratio of density of a substance to density of water. It is dimensionless.
- **Gravitational constant (G)**: From Newton's law $F = G\frac{m_1m_2}{r^2}$.

$$G = \frac{Fr^2}{m_1m_2}$$

Dimensions of $G = \frac{[MLT^{-2}][L^2]}{[M^2]} = [M^{-1}L^3T^{-2}]$.

It clearly has dimensions.

Step 4: Final Answer:

The Gravitational constant has dimensions.

Quick Tip: Whenever a quantity is defined as a "ratio" of the same kind of physical quantities (like relative density or strain), it will be dimensionless.

---

47. A bus covers half of the total distance with a speed of 30 kmh^{-1} and other half with a speed of 60 kmh^{-1}. The average speed during the total journey is

(A) 35 kmh^{-1}

(B) 40 kmh^{-1}

(C) 45 kmh^{-1}

(D) 42 kmh^{-1}

(E) 50 kmh^{-1}

Correct Answer: (B) 40 kmh^{-1}

Solution:

Step 1: Understanding the Concept:

Average speed is defined as the total distance covered divided by the total time taken. When a journey is divided into two equal **distances** covered at different speeds, the average speed is the harmonic mean of the speeds.

Step 2: Key Formula or Approach:

If a body covers half distance at speed v_1 and the other half at speed v_2, then:

$$V_{avg} = \frac{2v_1v_2}{v_1 + v_2}$$

Step 3: Detailed Explanation:

Given:

$v_1 = 30\ \text{km/h}$

$v_2 = 60\ \text{km/h}$

Applying the formula:

$$V_{avg} = \frac{2 \times 30 \times 60}{30 + 60}$$

$$V_{avg} = \frac{3600}{90}$$

$$V_{avg} = 40 \text{ km/h}$$

Step 4: Final Answer:

The average speed during the total journey is 40 kmh^{-1}.

Quick Tip: Caution: Do not take the simple arithmetic mean $(30+60)/2 = 45$. This only works if the travel **times** are equal. For equal **distances**, always use the harmonic mean.

---

48. If a body starts from rest and moves with constant acceleration of 2 ms^{-2}, then the distance covered between the time intervals 5 s and 6 s is

(A) 8 m

(B) 15 m

(C) 11 m

(D) 18 m

(E) 6 m

Correct Answer: (C) 11 m

Solution:

Step 1: Understanding the Concept:

The distance covered in the n^{th} second of motion for a body starting with initial velocity u and constant acceleration a can be calculated using the specific kinematic equation for displacement in the n^{th} second.

Step 2: Key Formula or Approach:

$$S_n = u + \frac{a}{2}(2n-1)$$

Step 3: Detailed Explanation:

Given:

Initial velocity $(u) = 0$ (starts from rest)

Acceleration $(a) = 2\ \text{ms}^{-2}$

We need the distance between $t = 5\text{s}$ and $t = 6\text{s}$. This is exactly the distance covered in the **6th second** $(n = 6)$.

Substituting the values:

$$S_6 = 0 + \frac{2}{2}(2 \times 6 - 1)$$

$$S_6 = 1 \times (12 - 1)$$

$$S_6 = 11\ \text{m}$$

Alternatively:

Calculate S at $t = 6$ and S at $t = 5$ using $S = \frac{1}{2}at^2$:

$S_6 = \frac{1}{2}(2)(6^2) = 36\ \text{m}$

$S_5 = \frac{1}{2}(2)(5^2) = 25\ \text{m}$

$\Delta S = 36 - 25 = 11\ \text{m}.$

Step 4: Final Answer:

The distance covered is 11 m.

Quick Tip: The formula $S_n = u + \frac{a}{2}(2n - 1)$ is a shortcut for finding distance in a single specific second. It saves you the trouble of calculating two separate displacements and subtracting them.

49. FALSE statement about third law of motion is

(A) Forces in nature always occur between pairs of bodies
(B) If $\vec{F}$ is a force on body A by body B then -$\vec{F}$ is the force on B by body A
(C) Action and reaction forces are simultaneous forces
(D) Any of the two mutual forces can be called action and the other reaction
(E) There is cause-effect relation between action and reaction

Correct Answer: (E) There is cause-effect relation between action and reaction

Solution:

Step 1: Understanding the Concept:
Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction. These forces act on different bodies.

Step 3: Detailed Explanation:
- **Option A**: True. Forces always exist in pairs (interaction).
- **Option B**: True. $\vec{F}_{AB} = -\vec{F}_{BA}$.
- **Option C**: True. Action and reaction forces occur at the **same instant**. There is no time lag between them.
- **Option D**: True. Which force is called "action" and which is "reaction" is arbitrary.
- **Option E**: **False**. A "cause-effect" relationship implies that the action happens first and then the reaction follows after a small interval. In reality, they are simultaneous. There is no such thing as an action "causing" a reaction; they are just two parts of a single interaction.

Step 4: Final Answer:
Statement E is false.

Quick Tip: Always remember: Action and reaction **never act on the same body**. That's why they don't cancel each other out to zero net force on a single object.

50. A cyclist speeding at a velocity v on a level road takes a sharp circular turn of radius R. If μ is the static friction between the tyres and road, then the condition for the cyclist not to slip is

(A) $v^2 \geq \mu R$

(B) $v^2 \leq \mu Rg$

(C) $v \leq \mu Rg$

(D) $v = \frac{\mu R}{g}$

(E) $v^2 \geq \frac{\mu R}{g}$

Correct Answer: (B) $v^2 \leq \mu Rg$

Solution:

Step 1: Understanding the Concept:

When a vehicle takes a turn on a level (unbanked) road, the necessary centripetal force is provided by the friction between the tires and the road surface.

Step 2: Key Formula or Approach:

For no slipping:

Centripetal Force ≤ Maximum Static Frictional Force

$$\frac{mv^2}{R} \leq f_s(\text{max})$$

Step 3: Detailed Explanation:

On a level road, the normal force $N = mg$.

The maximum static friction is $f_s(\text{max}) = \mu N = \mu mg$.

Substituting this into the condition:

$$\frac{mv^2}{R} \leq \mu mg$$

Divide both sides by mass (m):

$$\frac{v^2}{R} \leq \mu g$$

Rearrange to solve for v^2:

$$v^2 \leq \mu R g$$

Alternatively, taking the square root: $v \leq \sqrt{\mu R g}$.

Step 4: Final Answer:

The condition for not slipping is $v^2 \leq \mu R g$.

Quick Tip: This formula tells you the **maximum safe speed** for a turn: $v_{max} = \sqrt{\mu R g}$. Slowing down (lower v) or increasing the radius (R) makes the turn safer.

---

51. If $\vec{F}$ and $\vec{S}$ represent the applied force and displacement of an object, then the work done is

(A) zero if $\vec{F}$ and $\vec{S}$ are in the same direction

(B) maximum if $\vec{F}$ and $\vec{S}$ are at right angles to each other

(C) the area under the graph between $\vec{F}$ and $\vec{S}$

(D) positive if the angle between $\vec{F}$ and $\vec{S}$ is obtuse

(E) negative if the angle between $\vec{F}$ and $\vec{S}$ is acute

Correct Answer: (C) the area under the graph between $\vec{F}$ and $\vec{S}$

Solution:

Step 1: Understanding the Concept:

Work done (W) by a force is defined as the dot product of the force vector ($\vec{F}$) and the displacement vector ($\vec{S}$).

It can be expressed as $W = FS\cos\theta$, where θ is the angle between the force and displacement.

Step 3: Detailed Explanation:

- **Option A**: If $\vec{F}$ and $\vec{S}$ are in the same direction, $\theta = 0°$. Since $\cos 0° = 1$, work is maximum, not zero.
- **Option B**: If they are at right angles, $\theta = 90°$. Since $\cos 90° = 0$, work is zero, not maximum.
- **Option C**: For a variable force, work is calculated by the integral $\int F \cdot dS$. Geometrically, this represents the **area under the force-displacement graph**.
- **Option D**: If the angle is obtuse $(90° < \theta \leq 180°)$, $\cos\theta$ is negative, so work is negative.
- **Option E**: If the angle is acute $(0° \leq \theta < 90°)$, $\cos\theta$ is positive, so work is positive.

Step 4: Final Answer:

The work done is represented by the area under the force-displacement graph.

Quick Tip: To remember the sign of work:

Same direction (0°) → Positive.

Opposite direction (180°) → Negative.

Perpendicular (90°) → Zero.

---

52. If a body at rest undergoes displacement under the action of force with constant acceleration, then the power delivered by the force at any time t is proportional to

(A) t

(B) $\sqrt{t}$

(C) t^2

(D) $1/t$

(E) t^3

Correct Answer: (A) t

Solution:

Step 1: Understanding the Concept:

Power (P) is the rate of doing work and is given by the product of force (F) and instantaneous velocity (v).

Step 2: Key Formula or Approach:

1. Newton's second law: $F = ma$.

2. Equation of motion: $v = u + at$.

3. Power: $P = F \cdot v$.

Step 3: Detailed Explanation:

Given the body starts from rest, initial velocity $u = 0$.

Under constant acceleration a, the velocity at time t is:

$$v = 0 + at = at$$

The force applied is constant since acceleration is constant:

$$F = ma$$

The instantaneous power P delivered is:

$$P = F \times v = (ma) \times (at) = ma^2 t$$

Since m and a are constant, we find:

$$P \propto t$$

Step 4: Final Answer:

Power is proportional to t.

Quick Tip: For constant acceleration:

Velocity $v \propto t$.

Displacement $S \propto t^2$.

Power $P \propto t$.

Work $W \propto t^2$.

---

53. If a ring of mass 50 g and radius 2cm is rolling on a smooth horizontal platform with its centre of mass moving with a speed of 50 cms^{-1}, then its total energy is

(A) 1.0×10^{-2} J

(B) 1.25×10^{-2} J

(C) 2.5×10^{-2} J

(D) 3.5×10^{-2} J

(E) 1.5×10^{-2} J

Correct Answer: (B) 1.25×10^{-2} J

Solution:

Step 1: Understanding the Concept:

For a body rolling without slipping, the total kinetic energy is the sum of translational kinetic energy and rotational kinetic energy.

Step 2: Key Formula or Approach:

$$KE_{\text{total}} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

For a ring, the moment of inertia $I = mR^2$ and $\omega = v/R$.

Step 3: Detailed Explanation:

Substitute I and ω into the total energy formula:

$$KE_{\text{total}} = \frac{1}{2}mv^2 + \frac{1}{2}(mR^2)\left(\frac{v}{R}\right)^2$$

$$KE_{\text{total}} = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 = mv^2$$

Given values in SI units:

Mass $m = 50 \text{ g} = 0.05 \text{ kg}$

Velocity $v = 50 \text{ cm/s} = 0.5 \text{ m/s}$

$$KE_{\text{total}} = 0.05 \times (0.5)^2$$

$$KE_{\text{total}} = 0.05 \times 0.25 = 0.0125 \text{ J}$$

This can be written as 1.25×10^{-2} J.

Step 4: Final Answer:

The total energy is 1.25×10^{-2} J.

Quick Tip: For a rolling ring, the translational and rotational kinetic energies are equal. Just calculate mv^2 to get the total energy instantly.

---

54. A couple produces a

(A) linear motion

(B) translational motion

(C) vibrational motion

(D) rotational motion

(E) both rotational and vibrational motion

Correct Answer: (D) rotational motion

Solution:

Step 1: Understanding the Concept:

A "couple" in physics refers to two equal and opposite forces whose lines of action do not coincide.

Step 3: Detailed Explanation:

Since the two forces are equal and opposite, the net external force (ΣF) acting on the body is zero.

Because the net force is zero, there is **no translational (linear) motion**.

However, because the forces act at different points, they create a net torque (τ).

This net torque causes the body to rotate about its center of mass.

Therefore, a couple produces **purely rotational motion**.

Step 4: Final Answer:

A couple produces rotational motion.

Quick Tip: Think of turning a screwdriver or the steering wheel of a car with both hands. You are applying a couple to cause rotation without moving the whole object to a new location.

---

55. The ratio of the escape velocities from the surface of two planets having densities and radii in the ratio 2 : 1 and 1 : 2 respectively is

(A) 1 : 1

(B) 1 : 2

(C) 1 : $\sqrt{2}$

(D) 1 : $\sqrt{3}$

(E) 1 : 4

Correct Answer: (C) 1 : $\sqrt{2}$

Solution:

Step 1: Understanding the Concept:

Escape velocity (v_e) is the minimum speed needed for an object to escape from the gravitational influence of a celestial body.

Step 2: Key Formula or Approach:

The standard formula for escape velocity is $v_e = \sqrt{\frac{2GM}{R}}$.

Expressing Mass (M) in terms of density (ρ): $M = \rho \times \frac{4}{3}\pi R^3$.

Substituting this gives: $v_e = \sqrt{\frac{2G(\rho\frac{4}{3}\pi R^3)}{R}} = \sqrt{\frac{8}{3}\pi G\rho R^2}$.

Thus, $v_e \propto R\sqrt{\rho}$.

Step 3: Detailed Explanation:

Given:

Ratio of densities $\rho_1/\rho_2 = 2/1$.

Ratio of radii $R_1/R_2 = 1/2$.

Using the proportionality:

$$\frac{v_{e1}}{v_{e2}} = \frac{R_1}{R_2} \times \sqrt{\frac{\rho_1}{\rho_2}}$$

$$\frac{v_{e1}}{v_{e2}} = \frac{1}{2} \times \sqrt{\frac{2}{1}} = \frac{\sqrt{2}}{2}$$

Simplifying the ratio:

$$\frac{v_{e1}}{v_{e2}} = \frac{1}{\sqrt{2}}$$

Step 4: Final Answer:

The ratio is $1 : \sqrt{2}$.

Quick Tip: Always simplify $\frac{\sqrt{x}}{x}$ as $\frac{1}{\sqrt{x}}$. It helps match the options in competitive exams.

---

56. If a cylinder is stretched by two equal forces applied normal to its cross-section, then the restoring force per unit area is called

(A) tensile stress
(B) tangential stress
(C) shearing stress
(D) compressive stress
(E) transvers stress

Correct Answer: (A) tensile stress

Solution:

Step 1: Understanding the Concept:
Stress is defined as the restoring force per unit area. Different types of stress occur based on the direction and effect of the applied forces.

Step 3: Detailed Explanation:
- When the applied forces act normal (perpendicular) to the cross-section and tend to **increase the length** of the body, the internal restoring force per unit area is called **tensile stress**.
- If the forces tend to decrease the length, it is called compressive stress.
- If the forces act parallel to the cross-sectional surface, it is called tangential or shearing stress.

Since the question mentions the cylinder is being "stretched" by forces normal to the surface, it is tensile stress.

Step 4: Final Answer:
The restoring force per unit area is tensile stress.

Quick Tip: Stretch → Tensile.

Squeeze → Compressive.

Slide/Twist → Shearing.

---

57. If the gauge pressure at a point well inside a liquid of density ρ in a tank is p, then the depth of the point from the surface of the liquid is (atmospheric pressure is P)

(A) $\frac{P-p}{\rho g}$
(B) $\frac{P+p}{\rho g}$
(C) $\frac{P}{\rho g}$
(D) $\frac{p}{\rho g}$
(E) $\frac{p^2}{\rho g}$

Correct Answer: (D) $\frac{p}{\rho g}$

Solution:

Step 1: Understanding the Concept:

The total pressure (P_{total}) at a depth h in a liquid is the sum of atmospheric pressure (P) and the pressure due to the liquid column ($h\rho g$).

Gauge pressure is defined as the difference between absolute (total) pressure and atmospheric pressure.

Step 3: Detailed Explanation:

The formula for total pressure at depth h is:

$$P_{total} = P + h\rho g$$

By definition, Gauge Pressure (p) is:

$$p = P_{total} - P$$

$$p = (P + h\rho g) - P = h\rho g$$

To find the depth h:

$$h = \frac{p}{\rho g}$$

Step 4: Final Answer:

The depth is $\frac{p}{\rho g}$.

Quick Tip: "Gauge pressure" specifically ignores atmospheric pressure. Whenever you see "gauge pressure" in a fluid problem, simply use the formula $p = h\rho g$.

---

58. If C_v is the specific heat capacity at constant volume of a gas, then the amount of heat required to increase the temperature of 2 moles of the gas from $27°\text{C}$ to $127°\text{C}$ at constant volume is

(A) $100C_v$
(B) $50C_v$
(C) $500C_v$
(D) $300C_v$
(E) $200C_v$

Correct Answer: (E) $200C_v$

Solution:

Step 1: Understanding the Concept:

At constant volume, the heat supplied (Q_v) goes entirely into increasing the internal energy of the gas.

Step 2: Key Formula or Approach:

The heat required at constant volume is given by:

$$Q_v = nC_v\Delta T$$

where n is the number of moles and ΔT is the change in temperature.

Step 3: Detailed Explanation:

Given:

Number of moles $n = 2$.

Initial temperature $T_1 = 27°\text{C}$.

Final temperature $T_2 = 127°\text{C}$.

Change in temperature $\Delta T = T_2 - T_1 = 127 - 27 = 100$ K (The magnitude of change is same in Celsius and Kelvin).

Substituting values:

$$Q_v = 2 \times C_v \times 100 = 200C_v$$

Step 4: Final Answer:

The amount of heat required is $200C_v$.

Quick Tip: Always remember that ΔT in degrees Celsius is equal to ΔT in Kelvin. You don't need to add 273 to both and then subtract; just subtract the Celsius values directly.

---

59. The INCORRECT assumption in the kinetic theory of gases is

(A) Interactions between molecules is negligible

(B) Collisions between molecules are elastic in nature

(C) Molecules move in straight lines between any two collisions

(D) During collisions total kinetic energy is not conserved

(E) Gas molecules are in incessant random motion

Correct Answer: (D) During collisions total kinetic energy is not conserved

Solution:

Step 1: Understanding the Concept:

The Kinetic Theory of Gases (KTG) is a theoretical model that describes the behavior of an ideal gas based on several postulates.

Step 3: Detailed Explanation:

- **Postulate A**: Ideal gas molecules have no forces of attraction or repulsion (Interactions are negligible). This is a **Correct** assumption of KTG.
- **Postulate B**: Collisions are perfectly elastic. This is a **Correct** assumption.
- **Postulate C**: Molecules move in straight lines at constant speed between collisions. This is a **Correct** assumption.
- **Postulate E**: Gas molecules move randomly and continuously in all directions. This is a **Correct** assumption.
- **Postulate D**: Because collisions are **perfectly elastic**, the total kinetic energy **must be conserved**. Therefore, stating that KE is "not conserved" is **Incorrect**.

Step 4: Final Answer:

Statement D is the incorrect assumption.

Quick Tip: "Elastic collision" by definition means kinetic energy is conserved. If you know collisions are elastic (Postulate B), then you immediately know Postulate D must be false.

---

60. When a tuning fork of frequency 256 Hz is sounded together with unknown tuning fork, 4 beats are heard in one second. The frequency of the unknown tuning fork can be

(A) 260 Hz or 252 Hz

(B) 258 Hz or 256 Hz

(C) 250 Hz or 256 Hz

(D) 248 Hz or 255 Hz

(E) 257 Hz or 215 Hz

Correct Answer: (A) 260 Hz or 252 Hz

Solution:

Step 1: Understanding the Concept:

Beats are produced when two sound waves of slightly different frequencies interfere. The beat frequency (n) is equal to the absolute difference between the two frequencies.

Step 2: Key Formula or Approach:

$$n = |f_1 - f_2|$$

or $f_2 = f_1 \pm n$.

Step 3: Detailed Explanation:

Given:

Known frequency $f_1 = 256$ Hz.

Beat frequency $n = 4$ beats per second.

The frequency of the unknown fork (f_2) can be either higher or lower than the known frequency by the value of the beat frequency.

Case 1 (Higher): $f_2 = 256 + 4 = 260$ Hz.

Case 2 (Lower): $f_2 = 256 - 4 = 252$ Hz.

Step 4: Final Answer:

The frequency can be 260 Hz or 252 Hz.

Quick Tip: Always use the ± sign for unknown frequency problems unless there is extra information (like "frequency increases on waxing" or "decreases on filing").

---

61. The magnitude and direction of acceleration change in the case of an object

(A) executing simple harmonic motion
(B) in circular motion at constant speed
(C) falling under gravity from lower altitudes
(D) falling under gravity from higher altitudes
(E) falling in a viscous liquid medium

Correct Answer: (A) executing simple harmonic motion

Solution:

Step 1: Understanding the Concept:

Acceleration is a vector quantity, meaning it has both magnitude and direction.

If either changes, the acceleration vector is considered to be changing.

Step 3: Detailed Explanation:

1. **Simple Harmonic Motion (SHM):** In SHM, the acceleration is given by $a = -\omega^2 x$.

The magnitude depends on the displacement x, so it changes as the object moves.

The direction is always towards the mean position, so it reverses whenever the object passes the mean position.

Thus, both magnitude and direction change.

2. **Uniform Circular Motion:** The magnitude of centripetal acceleration is constant (v^2/R), but its direction changes continuously (always towards the center).

3. **Falling under gravity (low altitude):** Both magnitude ($g \approx 9.8 \text{ m/s}^2$) and direction (downwards) are roughly constant.

4. **Viscous liquid:** As the object reaches terminal velocity, acceleration eventually becomes zero.

Step 4: Final Answer:

An object executing simple harmonic motion experiences changes in both the magnitude and direction of its acceleration.

Quick Tip: In SHM, acceleration is maximum at the extreme positions and zero at the mean position. Its direction always points opposite to the displacement.

---

62. If n electrons from a neutral solid sphere are transferred to another solid sphere having m electrons (m > n), then the charges on the respective spheres are (e = charge of an electron)

(A) +ne and -(m-n)e
(B) -ne and +(m-n)e
(C) +ne and +(m-n)e
(D) +ne and -(m+n)e
(E) -ne and -(m+n)e

Correct Answer: (D) +ne and -(m+n)e

Solution:

Step 1: Understanding the Concept:
Charging by friction or transfer involves the movement of electrons.
A body that loses electrons becomes positively charged, while a body that gains electrons becomes negatively charged.

Step 3: Detailed Explanation:
1. **Sphere 1:** Initially neutral (Charge = 0). It loses n electrons.
According to the principle of quantization of charge, its new charge is $q_1 = +ne$.
2. **Sphere 2:** Initially has m electrons. If we assume the sphere was neutral in terms of protons, its initial charge is $q_i = -me$.
It gains n more electrons from the first sphere.
The final charge $q_2 = q_i + (-ne) = -me - ne = -(m+n)e$.
Thus, the charges are $+ne$ and $-(m+n)e$.

Step 4: Final Answer:

The charges on the spheres are $+ne$ and $-(m+n)e$.

Quick Tip: Total charge is conserved.

Initial total charge $= 0 + (-me) = -me$.

Final total charge $= +ne + [-(m+n)e] = ne - me - ne = -me$.

This confirms the conservation of charge.

---

63. An isolated capacitor of capacitance 100 μF is charged to 32 C. If 16 C of charge is discharged from it, then its capacitance value is

(A) 50 μF

(B) 100 μF

(C) 5 μF

(D) 200 μF

(E) 32 μF

Correct Answer: (B) 100 μF

Solution:

Step 1: Understanding the Concept:

Capacitance (C) is an intrinsic property of a capacitor that depends on its physical dimensions (area of plates, distance between them) and the dielectric material between the plates.

Step 3: Detailed Explanation:

The relationship between charge (Q), capacitance (C), and potential difference (V) is given by $Q = CV$.

However, $C = Q/V$ does not mean that the capacitance depends on the charge.

Just as the capacity of a bucket to hold water does not change whether it is full or half-empty, the capacitance of a capacitor remains constant regardless of the amount of charge stored in it.

Since the physical structure of the isolated capacitor has not changed, its capacitance remains

100 μF.

Step 4: Final Answer:

The capacitance value remains 100 μF.

Quick Tip: Capacitance $C = \epsilon_0 A/d$.

Unless you change the area (A), the distance (d), or the dielectric (ϵ_r), the capacitance will not change.

---

64. In an electric circuit, if 2A , 5 A and 4 A are the currents entering a junction and Ix , 2A and 3A are the currents leaving the junction, then the current value Ix is

(A) 2A
(B) 3A
(C) 4A
(D) 5A
(E) 6A

Correct Answer: (E) 6A

Solution:

Step 1: Understanding the Concept:

Kirchhoff's Current Law (KCL), also known as the Junction Rule, states that the algebraic sum of currents at any junction in a circuit is zero.
This is based on the law of conservation of electric charge.

Step 2: Key Formula or Approach:

$$\sum I_{\text{entering}} = \sum I_{\text{leaving}}$$

Step 3: Detailed Explanation:

Sum of currents entering the junction:

$$I_{\text{in}} = 2\text{ A} + 5\text{ A} + 4\text{ A} = 11\text{ A}$$

Sum of currents leaving the junction:

$$I_{\text{out}} = I_x + 2\text{ A} + 3\text{ A} = I_x + 5\text{ A}$$

Equating the two:

$$11 = I_x + 5$$

$$I_x = 11 - 5 = 6\text{ A}$$

Step 4: Final Answer:

The value of current I_x is 6A.

Quick Tip: KCL is just a common-sense check: Charge cannot accumulate at a junction. Whatever goes in must come out.

---

65. If three tube lights with power 10 W, 25 W and 50 W are connected in parallel to a source voltage V, then the effective power of the combination is

(A) 8 W

(B) 85 W

(C) 28.3 W

(D) 50 W

(E) 6.25 W

Correct Answer: (B) 85 W

Solution:

Step 1: Understanding the Concept:

When electrical appliances are connected in parallel, the total power consumed is the sum of the individual powers of each appliance.

Step 2: Key Formula or Approach:

For parallel combination:

$$P_{\text{total}} = P_1 + P_2 + P_3 + \dots$$

Step 3: Detailed Explanation:

Given power ratings:

$P_1 = 10$ W

$P_2 = 25$ W

$P_3 = 50$ W

Calculating effective power:

$$P_{\text{eff}} = 10 + 25 + 50 = 85 \text{ W}$$

Step 4: Final Answer:

The effective power of the combination is 85 W.

Quick Tip: In series, the effective power is calculated like parallel resistors: $\frac{1}{P_{\text{eff}}} = \frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3}$. In parallel, it is simple addition.

66. The current that has to pass through a single circular loop of radius 10 cm to produce a magnetic field of μ_0 tesla at its centre is

(A) 1 A
(B) 0.2 A
(C) 0.4A
(D) 0. 5A
(E) 0.3A

Correct Answer: (B) 0.2 A

Solution:

Step 1: Understanding the Concept:

The magnetic field (B) at the center of a circular loop of radius R carrying current I is given by the Biot-Savart Law.

Step 2: Key Formula or Approach:

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

Step 3: Detailed Explanation:

Given:
Magnetic field $B = \mu_0$ T
Radius $R = 10$ cm $= 0.1$ m
Substituting into the formula:

$$\mu_0 = \frac{\mu_0 I}{2(0.1)}$$

The term μ_0 cancels out from both sides:

$$1 = \frac{I}{0.2}$$

$$I = 0.2 \text{ A}$$

Step 4: Final Answer:

The required current is 0.2 A.

Quick Tip: Always convert the radius to meters before performing calculations.

10 cm = 0.1 m.

---

67. As temperature increases, at Curie temperature

(A) paramagnet becomes ferromagnet

(B) diamagnet becomes ferromagnet

(C) diamagnet becomes paramagnet

(D) ferromagnet becomes paramagnet

(E) ferromagnet becomes diamagnet

Correct Answer: (D) ferromagnet becomes paramagnet

Solution:

Step 1: Understanding the Concept:

Magnetic properties of substances change with temperature.

In ferromagnetic materials, individual atomic dipoles are aligned in domains.

Step 3: Detailed Explanation:

As the temperature of a ferromagnetic material increases, the thermal agitation begins to disrupt the alignment of domains.

At a specific temperature called the **Curie temperature** (T_c), the thermal energy becomes high enough to completely randomize the domain structure.

At this point, the material loses its strong spontaneous magnetization and behaves like a paramagnetic substance.

Above T_c, the magnetic susceptibility follows the Curie-Weiss law: $\chi = \frac{C}{T-T_c}$.

Step 4: Final Answer:

At Curie temperature, a ferromagnet becomes a paramagnet.

Quick Tip: Curie temperature for Iron is about 1043 K.

Once cooled below this temperature, it regains its ferromagnetic properties.

---

68. In a transformer circuit it is possible to

(A) increase ac current

(B) increase ac power

(C) increase ac voltage

(D) decrease ac current

(E) decrease ac voltage

Correct Answer: (B) increase ac power

Solution:

Step 1: Understanding the Concept:

A transformer is a device used to change the voltage and current of an alternating current (AC) signal through electromagnetic induction.

Step 3: Detailed Explanation:

Ideally, in a transformer, the input power is equal to the output power ($P_{\text{in}} = P_{\text{out}}$).

A step-up transformer increases voltage while decreasing current, and a step-down transformer decreases voltage while increasing current.

The provided answer key specifies **Option B** (increase ac power). While an ideal transformer does not increase total power, this option might refer to the capability of a transformer to manage power delivery more efficiently in a distribution circuit.

However, the most standard physical function of a transformer is increasing or decreasing voltage/current. Based on the exam's key, we select B.

Step 4: Final Answer:

According to the answer key, a transformer circuit makes it possible to increase ac power.

Quick Tip: Remember that Transformers only work with AC, not DC, because they rely on changing magnetic flux.

---

69. Identify the two electromagnetic waves A and B having respective wavelengths 2 cm and 580 nm

(A) A is microwave and B is visible light

(B) A is infrared and B is ultraviolet ray

(C) A is radio wave and B is visible light

(D) A is infrared and B is visible light

(E) A is radio wave and B ultraviolet ray

Correct Answer: (A) A is microwave and B is visible light

Solution:

Step 1: Understanding the Concept:

The electromagnetic (EM) spectrum is categorized by wavelength or frequency.

Step 3: Detailed Explanation:

1. **Wave A (2 cm):** Wavelengths in the centimeter to millimeter range correspond to **microwaves**. Radio waves generally have much larger wavelengths (meters to kilometers).
2. **Wave B (580 nm):** The visible light spectrum ranges from approximately 400 nm (violet) to 700 nm (red). A wavelength of 580 nm falls within this range (yellow region). Therefore, B is **visible light**.

Step 4: Final Answer:

A is a microwave and B is visible light.

Quick Tip: Order of EM spectrum (decreasing wavelength):

Radio > Microwave > Infrared > Visible > UV > X-ray > Gamma ray.

---

70. If a thin lens of focal length 20 cm is in contact with another lens of power 4 D, then the effective power of the combination is

(A) 9 D

(B) 6 D

(C) 5 D

(D) 10 D

(E) 11 D

Correct Answer: (A) 9 D

Solution:

Step 1: Understanding the Concept:

When two or more thin lenses are in contact, the total power of the combination is the algebraic sum of the powers of individual lenses.

Step 2: Key Formula or Approach:

Power $P = 1/f$ (where f is in meters).

$P_{\text{eff}} = P_1 + P_2$.

Step 3: Detailed Explanation:

Given:

Focal length of lens 1, $f_1 = 20$ cm $= 0.2$ m.

Power of lens 1, $P_1 = 1/0.2 = 5$ D.

Power of lens 2, $P_2 = 4$ D.

Total effective power:

$$P_{\text{eff}} = 5\text{ D} + 4\text{ D} = 9\text{ D}$$

Step 4: Final Answer:

The effective power of the combination is 9 D.

Quick Tip: Always check the focal length unit! If given in cm, use $P = 100/f$.

$100/20 = 5$ D.

---

71. The optical elements are matched with their optical phenomenon. The FALSE match is

(C) Glass prism : Dispersion

(A) Optical fibre : Total internal reflection

(B) Thin plastic sheets : Polarization

(D) Concave mirror : Interference

(E) Glass slab : Refraction

Correct Answer: (D) Concave mirror : Interference

Solution:

Step 1: Understanding the Concept:

Optical phenomena describe how light interacts with different materials and surfaces based on the principles of wave and ray optics.

Step 3: Detailed Explanation:

Let us evaluate each pair:

1. **Optical fibre**: Works on the principle of **Total Internal Reflection (TIR)** to transmit light signals over long distances. (True)

2. **Thin plastic sheets**: Certain plastic sheets (polaroids) are used for the **Polarization** of light by restricting vibrations to a single plane. (True)

3. **Glass prism**: When white light passes through a prism, it splits into its constituent colors, a phenomenon known as **Dispersion**. (True)

4. **Glass slab**: When light enters a glass slab, it bends at the interface, which is known as **Refraction**. (True)

5. **Concave mirror**: The primary phenomenon associated with a concave mirror is **Reflection**. Interference is a wave phenomenon requiring two coherent sources overlapping, which is not the basic function of a mirror. (False)

Step 4: Final Answer:

The false match is Concave mirror : Interference.

Quick Tip: Interference usually involves thin films (like oil on water), double slits (Young's experiment), or diffraction gratings.

Mirrors and lenses are primarily associated with reflection and refraction.

---

72. If the de Broglie wavelengths of proton p and alpha particle α are same, then

(A) both have same momentum

(B) both have same energy

(C) momentum of p is twice that of α

(D) momentum of α is twice that of p

(E) energy of p is twice that of α

Correct Answer: (A) both have same momentum

Solution:

Step 1: Understanding the Concept:

The de Broglie hypothesis states that every moving particle has an associated wave character, with a wavelength inversely proportional to its momentum.

Step 2: Key Formula or Approach:

The de Broglie wavelength (λ) is given by:

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

where h is Planck's constant and p is the linear momentum.

Step 3: Detailed Explanation:

Given that the wavelengths are the same:

$$\lambda_p = \lambda_\alpha$$

Substituting the formula:

$$\frac{h}{p_p} = \frac{h}{p_\alpha}$$

Canceling the constant h from both sides:

$$p_p = p_\alpha$$

This means that regardless of their masses or velocities, if their de Broglie wavelengths are identical, their momenta must be identical.

Step 4: Final Answer:

Both have the same momentum.

Quick Tip: Wavelength is purely a function of momentum in de Broglie's theory.

If $\lambda_1 = \lambda_2$, then $p_1 = p_2$.

If you need to compare kinetic energy (K), use $K = p^2/2m$. Since masses differ, their energies would be different even with the same momentum.

---

73. Nucleons in nucleus are bound by

(A) electromagnetic forces
(B) electrostatic forces
(C) long-range nuclear forces
(D) short-range nuclear forces
(E) gravitational forces

Correct Answer: (D) short-range nuclear forces

Solution:

Step 1: Understanding the Concept:

Nucleons (protons and neutrons) are packed tightly within a very small volume in the nucleus. Since protons are positively charged, they experience strong electrostatic repulsion. A much stronger attractive force must exist to hold the nucleus together.

Step 3: Detailed Explanation:

The force responsible for binding nucleons is the **Strong Nuclear Force**.

Key characteristics of this force include:

1. It is much stronger than the electrostatic force.
2. It is charge-independent (acts between $p-p$, $n-n$, and $p-n$).
3. It is a **short-range force**, acting only over distances of about 10^{-15} m (1 femtometer).
4. Beyond this distance, the force drops to zero rapidly.

Step 4: Final Answer:

Nucleons are bound by short-range nuclear forces.

Quick Tip: Remember:

Gravitational force = Weakest, infinite range.

Electromagnetic force = Strong, infinite range.

Strong Nuclear force = Strongest, very short range.

---

74. The angular momentum and the energy of the electron in the second Bohr's orbit are respectively

(A) $\frac{h}{\pi}$ and -13.6 eV
(B) $\frac{2h}{\pi}$ and -1.5 eV
(C) $\frac{h}{\pi}$ and -3.4eV
(D) $\frac{h}{2\pi}$ and - 3.4 eV
(E) $\frac{2h}{\pi}$ and -3.4 Ev

Correct Answer: (C) $\frac{h}{\pi}$ and -3.4eV

Solution:

Step 1: Understanding the Concept:

Bohr's model of the atom quantizes both the angular momentum and the energy levels of electrons in hydrogen-like atoms.

Step 2: Key Formula or Approach:

1. Angular momentum (L): $L = n\frac{h}{2\pi}$
2. Energy (E): $E_n = -\frac{13.6}{n^2}$ eV

Step 3: Detailed Explanation:

For the **second Bohr orbit**, the principal quantum number $n = 2$.

Calculating Angular Momentum (L):

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

Calculating Energy (E):

$$E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4 \text{ eV}$$

Comparing with the options, Option (C) provides both values correctly.

Step 4: Final Answer:

The angular momentum is h/π and the energy is -3.4 eV.

Quick Tip: Memorize the energy levels of Hydrogen for quick calculations:

$n = 1 \rightarrow -13.6$ eV

$n = 2 \rightarrow -3.4$ eV

$n = 3 \rightarrow -1.51$ eV

$n = 4 \rightarrow -0.85$ eV

---

75. The INCORRECT statement is

(A) The lattice structure of Ge is called diamond like structure

(B) The number of electrons in the outermost orbit of Si is 4

(C) The energy band gap of semiconductors is less than 3 eV

(D) The number of free electrons is equal to number of holes in Ge

(E) The energy band gap of Ge is greater than 4 eV

Correct Answer: (E) The energy band gap of Ge is greater than 4 eV

Solution:

Step 1: Understanding the Concept:

Semiconductors like Germanium (Ge) and Silicon (Si) have specific electronic and physical properties that distinguish them from conductors and insulators.

Step 3: Detailed Explanation:

Evaluate each statement:

- **Option A**: Both Ge and Si crystallize in a diamond cubic lattice structure. (True)
- **Option B**: Si is a Group 14 element and has 4 valence electrons. (True)
- **Option C**: Semiconductors are defined by a narrow energy band gap, typically less than 3 eV. (True)
- **Option D**: In an intrinsic (pure) semiconductor like Ge, every electron that jumps to the conduction band leaves a hole in the valence band, so $n_e = n_h$. (True)
- **Option E**: The energy band gap of Ge is actually about **0.67 eV** at room temperature. A gap greater than 4 eV would characterize an insulator, not a semiconductor. (False)

Step 4: Final Answer:

The incorrect statement is that the energy band gap of Ge is greater than 4 eV.

Quick Tip: Key band gaps to remember at 300K:

Silicon (Si) $\approx$ 1.1 eV.

Germanium (Ge) $\approx$ 0.7 eV.

Gallium Arsenide (GaAs) $\approx$ 1.4 eV.
