Re-NEET 2026

Question Paper with Solutions

Conducted by National Testing Agency (NTA)

General Instructions

(i) The test is of 3 hours 15 minutes duration and the Test Booklet contains 180 multiple-choice questions (four options with a single correct answer) from Physics, Chemistry and Biology (Botany and Zoology).

(ii) Wherever the symbols/constants are not mentioned, they are to be considered as per their standard meaning/value.

(iii) Each question carries 4 marks. For each correct response, the candidate will get 4 marks. For each incorrect response, one mark will be deducted from the total score. The maximum marks are 720.

(iv) Use Blue/Black Ball Point Pen only for writing particulars on this page/marking responses on Answer Sheet.

1. A photon and an electron, each of 20 eV energy, move in free space. The ratio of linear momentum of electron p_e to that of photon p_{ph}, $\frac{p_e}{p_{ph}}$ is :
(Take speed of light $= 3 \times 10^8$ ms^{-1}, charge of electron $= -1.6 \times 10^{-19}$ C and mass of electron $= 9 \times 10^{-31}$ kg)

(A) 275

(B) 450

(C) $\frac{1}{250}$

(D) 225

Correct Answer: (D) 225

Solution:

Step 1: Understanding the Question:

The problem asks for the ratio of the linear momentum of an electron to that of a photon, given that both particles have the same energy of 20 eV.

Step 2: Key Formula or Approach:

For a photon, the energy E is related to its momentum p_{ph} by:

$$p_{ph} = \frac{E}{c}$$

For an electron (non-relativistic), the kinetic energy E is related to its momentum p_e by:

$$E = \frac{p_e^2}{2m} \implies p_e = \sqrt{2mE}$$

where m is the mass of the electron.

Step 3: Detailed Explanation:

Let's take the ratio of the momenta:

$$\frac{p_e}{p_{ph}} = \frac{\sqrt{2mE}}{E/c} = c\sqrt{\frac{2m}{E}}$$

Given values are:

Energy $E = 20$ eV $= 20 \times 1.6 \times 10^{-19}$ J $= 32 \times 10^{-19}$ J.

Mass of electron $m = 9 \times 10^{-31}$ kg.

Speed of light $c = 3 \times 10^8$ ms^{-1}.

Substitute the values into the ratio formula:

$$\frac{p_e}{p_{ph}} = 3 \times 10^8 \sqrt{\frac{2 \times 9 \times 10^{-31}}{32 \times 10^{-19}}}$$

$$\frac{p_e}{p_{ph}} = 3 \times 10^8 \sqrt{\frac{18 \times 10^{-31}}{32 \times 10^{-19}}}$$

$$\frac{p_e}{p_{ph}} = 3 \times 10^8 \sqrt{\frac{9}{16} \times 10^{-12}}$$

$$\frac{p_e}{p_{ph}} = 3 \times 10^8 \times \frac{3}{4} \times 10^{-6}$$

$$\frac{p_e}{p_{ph}} = \frac{9}{4} \times 10^2 = 2.25 \times 100 = 225$$

Step 4: Final Answer:

The ratio of the linear momentum of the electron to that of the photon is 225.

Quick Tip: Remember that $p = E/c$ works for massless particles (photons), while $p = \sqrt{2mE}$ works for non-relativistic particles having mass (electrons).

Always verify if the particle is relativistic; for 20 eV, an electron is purely classical.

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2. Water flows in a streamline motion through a horizontal pipe of circular cross-section as shown in the figure. The pressure difference of water between P and Q is 15 Nm^{-2}. The area of cross-section at P and Q are 40 cm^2 and 20 cm^2, respectively. The rate of flow of water through the pipe, in cm^3s^{-1}, is :
Take density of water $= 1000$ **kg** m^{-3}

(A) 400

(B) 100

(C) 200

(D) 300

Correct Answer: (A) 400

Solution:

Step 1: Understanding the Question:

Water flows through a horizontal pipe with varying cross-sectional area.

We are given the areas at two points, the pressure difference between them, and we need to find the volumetric flow rate.

Step 2: Key Formula or Approach:

According to the Equation of Continuity, the rate of flow (discharge) Q is constant:

$$Q = A_P v_P = A_Q v_Q \implies v_P = \frac{Q}{A_P}, \quad v_Q = \frac{Q}{A_Q}$$

Using Bernoulli's Principle for a horizontal pipe ($h_P = h_Q$):

$$P_P + \frac{1}{2}\rho v_P^2 = P_Q + \frac{1}{2}\rho v_Q^2 \implies P_P - P_Q = \frac{1}{2}\rho(v_Q^2 - v_P^2)$$

Step 3: Detailed Explanation:

Given values are:

$\Delta P = P_P - P_Q = 15$ N/m^2.

$A_P = 40$ cm^2 $= 40 \times 10^{-4}$ m^2.

$A_Q = 20$ cm^2 $= 20 \times 10^{-4}$ m^2.

$\rho = 1000$ kg/m^3.

Substitute v_P and v_Q in Bernoulli's equation:

$$P_P - P_Q = \frac{1}{2}\rho\left(\left(\frac{Q}{A_Q}\right)^2 - \left(\frac{Q}{A_P}\right)^2\right)$$

$$15 = \frac{1}{2} \times 1000 \times Q^2\left(\frac{1}{(20 \times 10^{-4})^2} - \frac{1}{(40 \times 10^{-4})^2}\right)$$

$$15 = 500 \times Q^2\left(\frac{1}{400 \times 10^{-8}} - \frac{1}{1600 \times 10^{-8}}\right)$$

$$15 = \frac{500 \times Q^2}{10^{-8}}\left(\frac{4-1}{1600}\right)$$

$$15 = \frac{500 \times Q^2}{10^{-8}} \times \frac{3}{1600}$$

$$15 = \frac{1500 \times Q^2}{1600 \times 10^{-8}}$$

$$15 = \frac{15}{16 \times 10^{-8}}Q^2$$

$$Q^2 = 16 \times 10^{-8}$$

$$Q = \sqrt{16 \times 10^{-8}} = 4 \times 10^{-4} \text{ m}^3/\text{s}$$

Convert the flow rate to cm^3/s:

$$Q = 4 \times 10^{-4} \times 10^6 \text{ cm}^3/\text{s} = 400 \text{ cm}^3/\text{s}$$

Step 4: Final Answer:

The rate of flow of water is 400 cm^3/s.

Quick Tip: When applying Bernoulli's equation for a horizontal pipe, gravitational potential energy terms cancel out ($h_1 = h_2$).
Always combine it with the Equation of Continuity ($A_1 v_1 = A_2 v_2 = Q$) to find velocities or flow rates directly.

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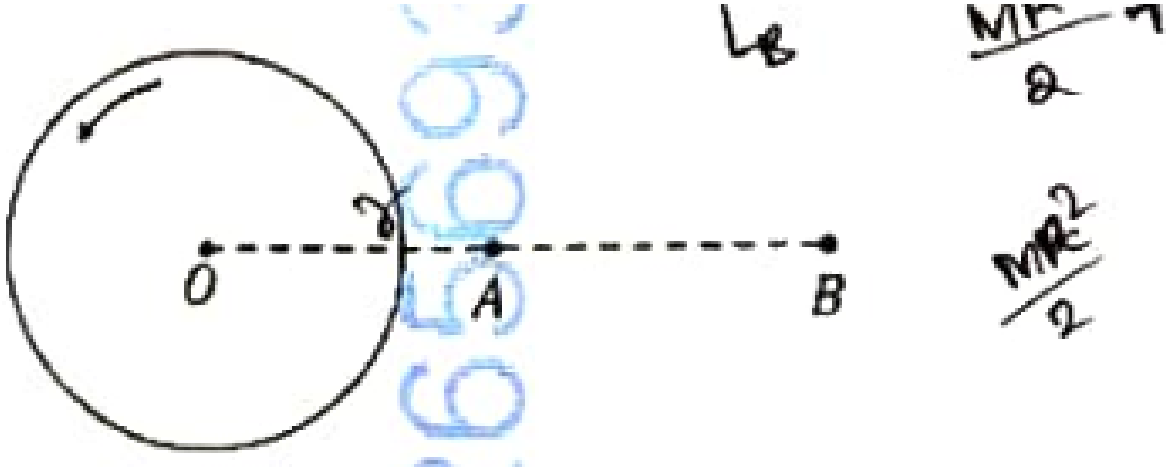
3. A thin horizontal disc is rotating about a vertical axis passing through its fixed centre O. Its angular momentum is L_A and L_B computed about points A and B, respectively, with $OB = 2 \times OA$. The value of $\frac{L_A}{L_B}$ is :



(A) 2

(B) $\frac{1}{4}$

(C) $\frac{1}{2}$

(D) 1

Correct Answer: (D) 1

Solution:

Step 1: Understanding the Question:

A uniform horizontal disc rotates about a fixed vertical axis passing through its center of mass O.

We need to determine the ratio of its angular momentum evaluated about two different points A and B in the horizontal plane.

Step 2: Key Formula or Approach:

The angular momentum of a rigid body about any arbitrary point P is given by:

$$\vec{L}_P = \vec{L}_{cm} + \vec{r}_{cm/P} \times (M\vec{v}_{cm})$$

where $\vec{L}_{cm}$ is the angular momentum about the center of mass, $\vec{r}_{cm/P}$ is the position vector of the center of mass relative to point P, M is the mass of the body, and $\vec{v}_{cm}$ is the velocity of the center of mass.

Step 3: Detailed Explanation:

Since the disc is rotating about a fixed vertical axis passing through its center O, its center of mass is stationary.

Therefore, the velocity of the center of mass is zero:

$$\vec{v}_{cm} = 0$$

Substituting this into the general formula for angular momentum, the second term vanishes for any point P:

$$\vec{L}_P = \vec{L}_{cm} + \vec{r}_{cm/P} \times 0 = \vec{L}_{cm}$$

This means the angular momentum is independent of the reference point and is identically equal to the angular momentum about its center of mass for all points.

Thus, evaluating it for points A and B:

$$L_A = L_O$$

$$L_B = L_O$$

Taking their ratio:

$$\frac{L_A}{L_B} = \frac{L_O}{L_O} = 1$$

Step 4: Final Answer:

The value of the ratio $\frac{L_A}{L_B}$ is 1.

Quick Tip: For a rigid body rotating about a fixed centroidal axis, the velocity of the center of mass is zero.

Consequently, the angular momentum is independent of the point of calculation and is solely given by $I_{cm}\omega$.

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4. Consider a long solenoid of length l and radius r. If n is the number of turns per unit length and μ_0 is the permeability of free space, the inductance of the solenoid is :

(A) $2\mu_0\pi n^2 r^2 l$

(B) $\mu_0\pi n^2 r^2 l$

(C) $\mu_0 n^2 r^2 l$

(D) $(\mu_0/2\pi) n^2 r^2 l$

Correct Answer: (B) $\mu_0\pi n^2 r^2 l$

Solution:

Step 1: Understanding the Question:

The question asks for the self-inductance L of a long solenoid with length l, radius r, and turn density n.

Step 2: Key Formula or Approach:

The magnetic field B inside a long solenoid is:

$$B = \mu_0 n I$$

where I is the current flowing through it.

The total magnetic flux Φ linked with the solenoid of N turns is:

$$\Phi = NBA$$

where A is the cross-sectional area.

Self-inductance L is defined as:

$$L = \frac{\Phi}{I}$$

Step 3: Detailed Explanation:

First, express the total number of turns N and the area A.

$$N = n \times l$$

$$A = \pi r^2$$

Now, calculate the total magnetic flux Φ.

$$\Phi = (nl) \cdot (\mu_0 nI) \cdot (\pi r^2)$$

$$\Phi = \mu_0 \pi n^2 r^2 l I$$

Using the formula for self-inductance:

$$L = \frac{\Phi}{I} = \frac{\mu_0 \pi n^2 r^2 l I}{I} = \mu_0 \pi n^2 r^2 l$$

Step 4: Final Answer:

The inductance of the solenoid is $\mu_0 \pi n^2 r^2 l$.

Quick Tip: Inductance is essentially magnetic inertia.

For a long solenoid, the formula $L = \mu_0 n^2 A l$ shows that self-inductance is directly proportional to the volume ($A \times l$) and the square of turn density (n^2).

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5. The temperature of a metallic sphere of radius R is increased by a small amount ΔT. If

the linear coefficient of thermal expansion of the metal is α, the approximate increase in the volume of the sphere is :

(A) $6\pi R^3\alpha\Delta T$

(B) $2\pi R^3\alpha\Delta T$

(C) $3\pi R^3\alpha\Delta T$

(D) $4\pi R^3\alpha\Delta T$

Correct Answer: (D) $4\pi R^3\alpha\Delta T$

Solution:

Step 1: Understanding the Question:

We need to find the change in volume of a metallic sphere when its temperature is increased by ΔT, given its linear expansion coefficient α.

Step 2: Key Formula or Approach:

The original volume of the sphere is:

$$V = \frac{4}{3}\pi R^3$$

The volumetric expansion is given by:

$$\Delta V = V\gamma\Delta T$$

where γ is the volume coefficient of thermal expansion.

For isotropic materials, the relationship between volume and linear expansion coefficients is:

$$\gamma \approx 3\alpha$$

Step 3: Detailed Explanation:

Substitute V and γ into the volumetric expansion formula:

$$\Delta V = \left(\frac{4}{3}\pi R^3\right)(3\alpha)\Delta T$$

$$\Delta V = 4\pi R^3\alpha\Delta T$$

Step 4: Final Answer:

The approximate increase in the volume of the sphere is $4\pi R^3 \alpha \Delta T$.

Quick Tip: For isotropic solid materials, the volume expansion coefficient γ is exactly three times the linear expansion coefficient α ($\gamma = 3\alpha$).

Don't forget this simple relation for thermal expansion approximations.

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6. Consider two circuits, (A) and (B), each having two resistors. One of them has a positive temperature coefficient of resistance, $+\alpha$, while the other one has a negative temperature coefficient, $-\alpha$, as shown in the figure. The current through these circuits are denoted by I_A and I_B. At initial temperature, the resistance of the two resistors is R_0. As the temperature is increased, the correct option that describes the variation of current in these circuits is :

(A) both I_A and I_B remain constant

(B) I_A remains constant while I_B increases

(C) I_A decreases while I_B increases

(D) I_A increases while I_B decreases

Correct Answer: (B) I_A remains constant while I_B increases

Solution:

Step 1: Understanding the Question:

We are analyzing two circuits containing temperature-dependent resistors.

Circuit (A) has them in series, while Circuit (B) has them in parallel.

We need to determine how the current from the voltage source changes as temperature (ΔT) increases.

Step 2: Key Formula or Approach:

For a series circuit, equivalent resistance is:

$$R_{eq,A} = R_1 + R_2$$

For a parallel circuit, equivalent resistance is:

$$R_{eq,B} = \frac{R_1 R_2}{R_1 + R_2}$$

The current is inversely proportional to equivalent resistance:

$$I = \frac{V}{R_{eq}}$$

Step 3: Detailed Explanation:

For Circuit (A):

The two resistors are in series.

$$R_{eq,A} = R_0(1 - \alpha\Delta T) + R_0(1 + \alpha\Delta T)$$

$$R_{eq,A} = R_0 - R_0\alpha\Delta T + R_0 + R_0\alpha\Delta T = 2R_0$$

Since $R_{eq,A}$ is constant and independent of ΔT, the current $I_A = \frac{V}{2R_0}$ remains constant.

For Circuit (B):

The two resistors are in parallel.

$$R_{eq,B} = \frac{R_0(1 - \alpha\Delta T) \cdot R_0(1 + \alpha\Delta T)}{R_0(1 - \alpha\Delta T) + R_0(1 + \alpha\Delta T)}$$

$$R_{eq,B} = \frac{R_0^2(1 - \alpha^2\Delta T^2)}{2R_0} = \frac{R_0}{2}(1 - \alpha^2\Delta T^2)$$

As temperature increases, ΔT increases, which implies $\alpha^2\Delta T^2$ increases.

Consequently, $(1 - \alpha^2\Delta T^2)$ decreases, making $R_{eq,B}$ decrease.

Since $R_{eq,B}$ decreases, the current $I_B = \frac{V}{R_{eq,B}}$ increases.

Step 4: Final Answer:

I_A remains constant while I_B increases.

Quick Tip: When combining components with opposite temperature coefficients, series combinations often compensate and keep the total resistance constant.
Parallel combinations follow the standard inverse addition rules, typically resulting in a change.

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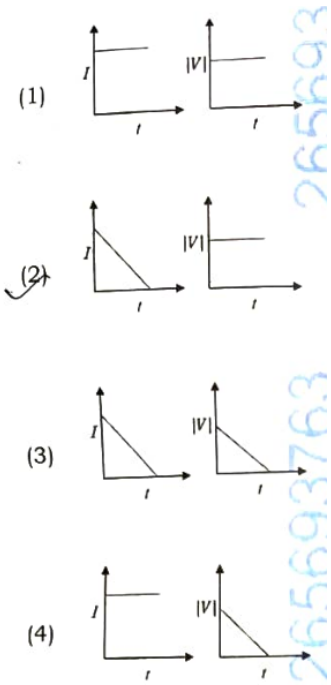
7. A beam of light falls on a metal surface such that photo-electrons are generated. If power of the light source starts to decrease linearly with time t, then variation of the photocurrent I and magnitude of the stopping potential $|V|$ with time is best represented by :



Correct Answer: (B) Graph showing I decreases linearly and $|V|$ is constant

Solution:

Step 1: Understanding the Question:

We need to determine how the photocurrent and stopping potential vary with time when the power of an incident light source decreases linearly with time.

Step 2: Key Formula or Approach:

Photocurrent I is directly proportional to the intensity (and thus power) of the incident light,

assuming frequency is constant:

$$I \propto P$$

The magnitude of the stopping potential $|V|$ is dependent solely on the frequency ν of the incident light and the work function ϕ of the material, given by Einstein's photoelectric equation:

$$e|V| = h\nu - \phi$$

Step 3: Detailed Explanation:

First, consider the variation of Photocurrent (I).

The power of the light source decreases linearly with time ($P(t) = P_0 - kt$).

Since the number of photons emitted per second is proportional to the power, the rate of emission of photoelectrons (photocurrent) will also decrease linearly with time.

Thus, the graph of I vs t is a straight line with a negative slope.

Second, consider the variation of Stopping Potential ($|V|$).

The stopping potential depends only on the frequency of the incident light and the nature of the material.

A change in the power (intensity) of the light source does not affect the maximum kinetic energy of the photoelectrons.

Therefore, the stopping potential remains constant over time.

The graph of $|V|$ vs t is a horizontal straight line.

These conclusions match the behavior described in option (B).

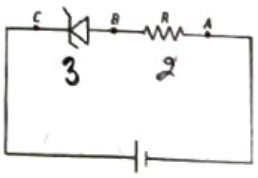
Step 4: Final Answer:

I decreases linearly with time, and $|V|$ remains constant over time.

Quick Tip: Intensity (or power) of light dictates the number of photoelectrons (photocurrent), whereas the frequency controls their maximum kinetic energy (stopping potential).

Changing one does not affect the other!

8. An ideal Zener diode with breakdown voltage of -3 V is reverse biased with a negative input voltage $V_i = -5$ V. The magnitude of voltage difference between points B and A is :



(A) 0 V

(B) 3 V

(C) 2 V

(D) 1 V

Correct Answer: (B) 3 V

Solution:

Step 1: Understanding the Question:

The circuit contains a Zener diode in series with a resistor.

The Zener diode has a breakdown voltage of 3 V (magnitude).

We are given an input voltage of -5 V, which reverse biases the diode.

We need to find the voltage across the Zener diode, which is exactly between points A and B.

Step 2: Key Formula or Approach:

When an ideal Zener diode is reverse biased and the applied voltage exceeds its breakdown voltage ($|V_i| > V_Z$), the diode operates in the breakdown region.

In this region, the voltage across the Zener diode is maintained constant at its Zener breakdown voltage V_Z.

Step 3: Detailed Explanation:

The magnitude of the input voltage is $|V_i| = 5$ V.

The breakdown voltage of the Zener diode is $V_Z = 3$ V.

Since $|V_i| > V_Z$, the Zener diode is in the breakdown region.

In the breakdown region, an ideal Zener diode acts as a constant voltage source of magnitude V_Z.

Therefore, the voltage drop across the Zener diode (between points A and B) is clamped to 3 V.

The remaining voltage ($5\text{ V} - 3\text{ V} = 2\text{ V}$) will drop across the series resistor.

The question asks for the magnitude of the voltage difference between points A and B, which are the terminals of the Zener diode.

$$V_{AB} = V_Z = 3\text{ V}$$

Step 4: Final Answer:

The magnitude of the voltage difference between points B and A is 3 V.

Quick Tip: An ideal Zener diode acts as a simple constant voltage battery of magnitude V_Z when operated in the reverse breakdown region.

Always check if the input voltage exceeds V_Z to ensure it is in breakdown.

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9. In the measurement of viscosity of liquids using terminal velocity experiment, spherical balls of same radius but having different densities are used. The variation of the terminal velocity (v) with the ratio of density of spherical ball (σ) to density of the liquid (ρ), is best represented by :

(1) 

(2) 

(3) 

(4) 

Correct Answer: (A) A straight line originating from $\sigma/\rho = 1$ on the x-axis with a positive slope.

Solution:

Step 1: Understanding the Question:

We need to find the graphical relationship between the terminal velocity v of a spherical ball falling in a liquid and the density ratio σ/ρ.

Step 2: Key Formula or Approach:

The terminal velocity v of a spherical ball of radius r and density σ falling through a liquid of density ρ and viscosity η is given by Stokes' Law:

$$v = \frac{2r^2 g}{9\eta}(\sigma - \rho)$$

Step 3: Detailed Explanation:

Rearranging the terminal velocity formula to express it in terms of the ratio σ/ρ:

$$v = \frac{2r^2 g\rho}{9\eta}\left(\frac{\sigma}{\rho} - 1\right)$$

Let $k = \frac{2r^2 g\rho}{9\eta}$, which is a positive constant since the radius is constant and the liquid is the same.

Let $x = \frac{\sigma}{\rho}$.

The equation becomes:

$$v = k(x - 1)$$

This is the equation of a straight line ($y = mx + c$) with slope $m = k$ and y-intercept $c = -k$.

When $x = \frac{\sigma}{\rho} = 1$, the terminal velocity $v = 0$.

For $x > 1$ (ball is denser than liquid), v increases linearly with x.

Therefore, the graph of v versus σ/ρ is a straight line that intersects the horizontal axis precisely at 1.

This perfectly matches the description of option (A).

Step 4: Final Answer:

The variation is a straight line starting from 1 on the σ/ρ axis.

Quick Tip: Stokes' law gives terminal velocity proportional to the density difference $(\sigma - \rho)$. Whenever checking variations, rewrite the expression in the form $y = mx + c$ to quickly identify the graphical behavior.

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10. Two planets P_1 and P_2 with equal mass have radii R_1 and R_2, respectively, where $R_2 = \frac{R_1}{2}$. The escape speeds of P_1 and P_2 are v_1 and v_2, respectively. Then $\frac{v_2}{v_1}$ is :

(A) 2

(B) $\frac{1}{\sqrt{2}}$

(C) 1

(D) $\sqrt{2}$

Correct Answer: (D) $\sqrt{2}$

Solution:

Step 1: Understanding the Question:

We need to compare the escape speeds of two planets of equal mass but different radii.

Step 2: Key Formula or Approach:

The escape velocity v_e from the surface of a planet of mass M and radius R is given by:

$$v_e = \sqrt{\frac{2GM}{R}}$$

Step 3: Detailed Explanation:

For planet P_1:

$$v_1 = \sqrt{\frac{2GM}{R_1}}$$

For planet P_2:

$$v_2 = \sqrt{\frac{2GM}{R_2}}$$

Given that the masses are equal and $R_2 = \frac{R_1}{2}$, we can substitute R_2 into the equation for v_2.

$$v_2 = \sqrt{\frac{2GM}{R_1/2}} = \sqrt{2} \times \sqrt{\frac{2GM}{R_1}}$$

$$v_2 = \sqrt{2} v_1$$

Therefore, the ratio of their escape speeds is:

$$\frac{v_2}{v_1} = \sqrt{2}$$

Step 4: Final Answer:

The value of the ratio $\frac{v_2}{v_1}$ is $\sqrt{2}$.

Quick Tip: Escape velocity depends only on the mass and radius of the planet, not on the mass of the escaping body.

Use proportionalities like $v_e \propto 1/\sqrt{R}$ when comparing planets of the same mass to save time.

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11. An ac voltage $V = 220 \sin(2 \times 10^3 t)$ Volt is applied to a series LCR circuit. Then the current amplitude in this circuit is :

(Given : $L = 10$ mH, $C = 25 \mu$F, $R = 100\ \Omega$)

(A) 22.0 A

(B) 2.2 A

(C) 5.5 A

(D) 11.0 A

Correct Answer: (B) 2.2 A

Solution:

Step 1: Understanding the Question:

An alternating voltage is applied across a series LCR circuit. We need to find the peak value of the current (current amplitude) flowing through the circuit.

Step 2: Key Formula or Approach:

The voltage equation is $V(t) = V_m \sin(\omega t)$. From the given equation, the peak voltage is $V_m = 220$ V and the angular frequency is $\omega = 2 \times 10^3$ rad s^{-1}. The inductive reactance is $X_L = \omega L$. The capacitive reactance is $X_C = \frac{1}{\omega C}$. The total impedance of a series LCR circuit is $Z = \sqrt{R^2 + (X_L - X_C)^2}$. The current amplitude is given by $I_m = \frac{V_m}{Z}$.

Step 3: Detailed Explanation:

First, let's calculate the inductive reactance X_L:

$$X_L = (2 \times 10^3) \times (10 \times 10^{-3}) = 20\ \Omega$$

Next, calculate the capacitive reactance X_C:

$$X_C = \frac{1}{(2 \times 10^3) \times (25 \times 10^{-6})} = \frac{1}{50 \times 10^{-3}} = \frac{1000}{50} = 20\ \Omega$$

Since $X_L = X_C = 20\ \Omega$, the circuit is in a state of resonance. At resonance, the imaginary parts of the impedance cancel out, leaving:

$$Z = \sqrt{100^2 + (20 - 20)^2} = 100\ \Omega$$

Now, find the current amplitude I_m:

$$I_m = \frac{V_m}{Z} = \frac{220}{100} = 2.2\ \text{A}$$

Step 4: Final Answer:

The current amplitude in the circuit is 2.2 A.

Quick Tip: Whenever an AC circuit problem is given with L and C values, quickly check the values of X_L and X_C first. Often in such problems, $X_L = X_C$, simplifying the impedance to just $Z = R$.

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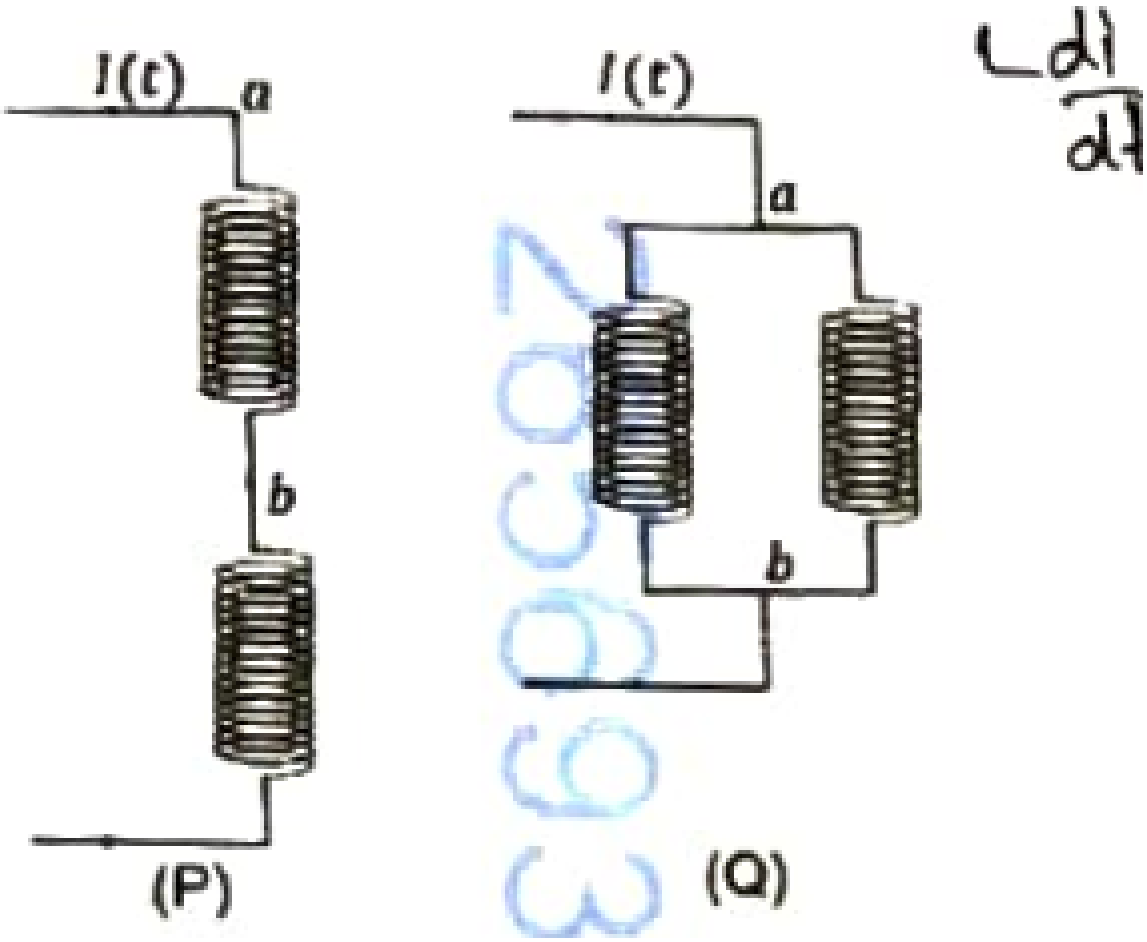
12. Two identical inductors are connected in two different configurations P and Q, where a time varying current $I(t)$ is flowing, as shown in the figure. The induced emf between points a

and b for configuration P is E_P and that for configuration Q is E_Q. The ratio E_P/E_Q is : Neglect the effect of mutual inductance.



(A) 2

(B) 1/4

(C) 1/2

(D) 1

Correct Answer: (D) 1

Solution:

Step 1: Understanding the Question:

We are given two circuit configurations, P and Q, each constructed from two identical inductors (say, each of inductance L). A time-varying current $I(t)$ enters at node 'a' and exits at node 'b'. We need to compare the induced emf across terminals 'a' and 'b' in both cases.

Step 2: Key Formula or Approach:

The induced emf across an equivalent inductance L_{eq} is given by Faraday's law:

$$E = L_{eq}\frac{dI(t)}{dt}$$

For inductors in series (without mutual inductance): $L_{eq} = L_1 + L_2$ For inductors in parallel (without mutual inductance): $L_{eq} = \frac{L_1 L_2}{L_1 + L_2}$

Step 3: Detailed Explanation:

Let's analyze configuration **P**: Tracing the wire from node 'a', the current splits into two branches. One branch goes through the left inductor and the other goes through the right inductor. Both branches then recombine at node 'b'. Since the inductors are connected between the same two nodes 'a' and 'b', they are in **parallel**.

$$L_{eq,P} = \frac{L \times L}{L + L} = \frac{L}{2}$$

Thus, the emf induced is $E_P = \frac{L}{2}\frac{dI}{dt}$.

Let's analyze configuration **Q**: Tracing the wire from node 'a', the current splits into two branches. One branch connects to the top of the left inductor, while the other branch crosses over and connects to the bottom of the right inductor. The other ends of both inductors (bottom of the left inductor and top of the right inductor) connect directly to node 'b'. Even though the connection looks crossed, both inductors are still connected directly across the same two nodes 'a' and 'b'. The direction of current through the individual coils does not matter here since mutual inductance is explicitly neglected. Therefore, the inductors in configuration Q are also in **parallel**.

$$L_{eq,Q} = \frac{L \times L}{L + L} = \frac{L}{2}$$

Thus, the emf induced is $E_Q = \frac{L}{2}\frac{dI}{dt}$.

Taking the ratio:

$$\frac{E_P}{E_Q} = \frac{\frac{L}{2}\frac{dI}{dt}}{\frac{L}{2}\frac{dI}{dt}} = 1$$

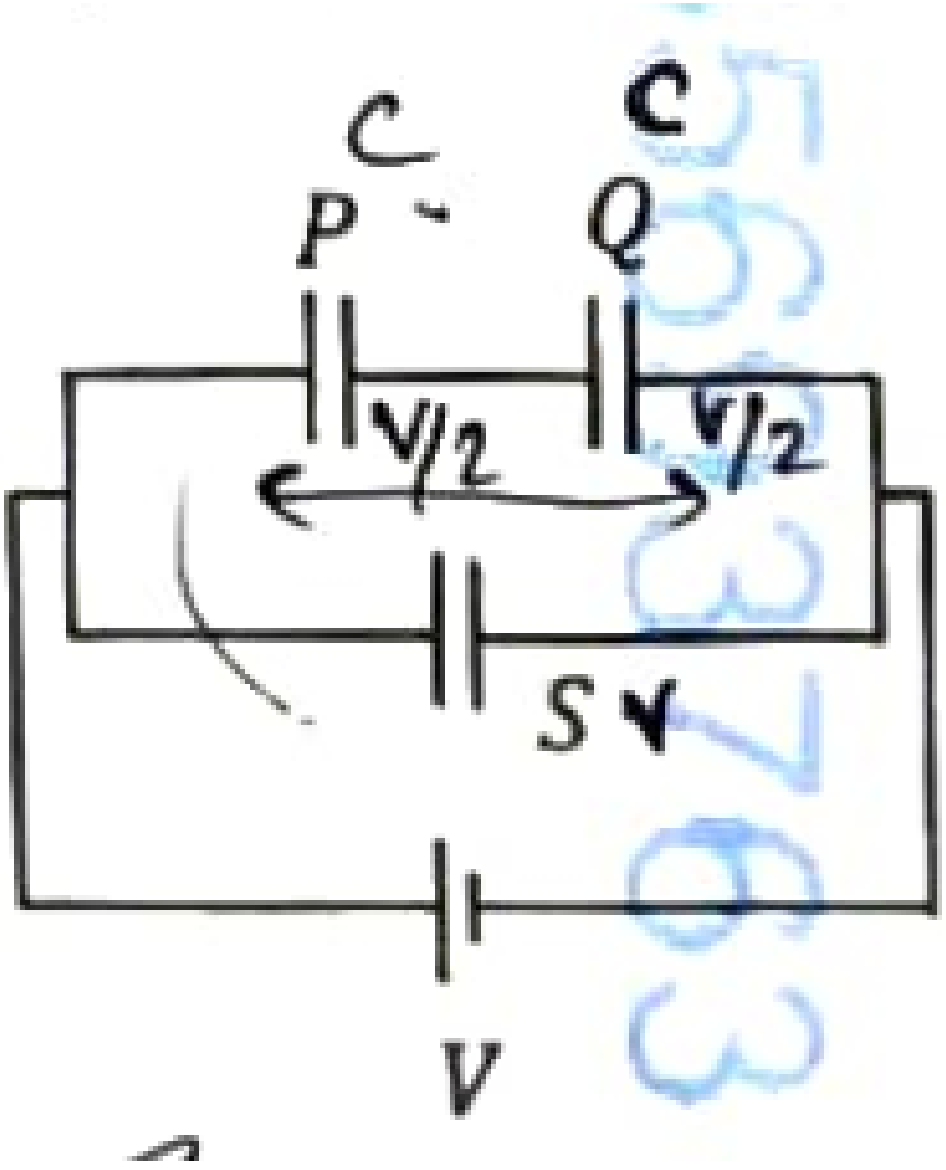
Step 4: Final Answer:

The ratio E_P/E_Q is 1.

Quick Tip: Do not be fooled by complicated or crossed wiring diagrams. Simply trace the path from the starting node to the ending node. If components are attached directly between the same two main nodes, they are in parallel, regardless of how they are physically drawn.

---

13. Three identical capacitors P, Q and S, each of the capacitance C, are connected to a battery of voltage V, as shown in the figure. If the energy stored in the capacitor P and total energy stored in the system are U_P and U_T, respectively, then the ratio U_P/U_T is :



(A) 1/6

(B) 2/3

(C) 1/3

(D) 1/2

Correct Answer: (A) 1/6

Solution:

Step 1: Understanding the Question:

We are given three identical capacitors, each with capacitance C. We need to determine the energy stored exclusively in capacitor P and the total energy stored in the entire circuit, and then compute their ratio.

Step 2: Key Formula or Approach:

The energy stored in a capacitor with capacitance C and voltage V across it is:

$$U = \frac{1}{2}CV^2$$

When capacitors are in series, the equivalent capacitance is $C_{series} = \frac{C_1 C_2}{C_1 + C_2}$. When capacitors are in parallel, the equivalent capacitance is $C_{parallel} = C_1 + C_2$.

Step 3: Detailed Explanation:

By observing the circuit diagram: 1. Capacitors P and Q are connected in the top branch. They are in **series** with each other. 2. Capacitor S is connected in the middle branch. 3. The series combination of (P and Q) is connected in **parallel** with capacitor S, and both parallel branches are connected directly across the battery V.

Let's find the equivalent capacitance of the series combination of P and Q:

$$C_{PQ} = \frac{C \cdot C}{C + C} = \frac{C}{2}$$

The total equivalent capacitance of the entire system is the sum of C_{PQ} and C_S (since they are in parallel):

$$C_{total} = C_{PQ} + C_S = \frac{C}{2} + C = \frac{3C}{2}$$

Now, let's find the total energy stored in the system (U_T):

$$U_T = \frac{1}{2}C_{total}V^2 = \frac{1}{2}\left(\frac{3C}{2}\right)V^2 = \frac{3}{4}CV^2$$

Next, let's find the energy stored specifically in capacitor P (U_P): The branch containing P and Q has a total voltage V across it. Since P and Q are identical and in series, the voltage V

divides equally among them. Voltage across capacitor P:

$$V_P = \frac{V}{2}$$

Energy stored in capacitor P:

$$U_P = \frac{1}{2}C_P(V_P)^2 = \frac{1}{2}C\left(\frac{V}{2}\right)^2 = \frac{1}{2}C\frac{V^2}{4} = \frac{1}{8}CV^2$$

Finally, we calculate the required ratio:

$$\frac{U_P}{U_T} = \frac{\frac{1}{8}CV^2}{\frac{3}{4}CV^2} = \frac{1}{8} \times \frac{4}{3} = \frac{4}{24} = \frac{1}{6}$$

Step 4: Final Answer:

The ratio U_P/U_T is 1/6.

Quick Tip: For identical capacitors in series, the voltage drops equally across each. Knowing this saves time: $V_P = V/n$ where n is the number of identical capacitors. Energy is proportional to the square of voltage, so the energy of one capacitor in a 2-series pair is 1/4th of the energy it would have alone.

---

14. A conducting loop of finite resistance lies on the $x-y$ plane. There is a constant magnetic field in the z direction. The area of the loop varies with time t, as $A = A_0(1+\sin t)$ in appropriate units. The figure that correctly indicates the qualitative behaviour of the power P dissipated in the loop as a function of time is :

(1) 

(2) 

(3) 

(4) 

Correct Answer: (B) Graph showing a periodic waveform starting from maximum at $t = 0$ with

smooth rounded peaks and smooth rounded bottoms touching $P = 0$.

Solution:

Step 1: Understanding the Question:

A conducting loop is situated in a uniform, constant magnetic field. Its area is changing periodically with time, which causes the magnetic flux to change. This changing flux induces an electromotive force (emf) and thus a current. We need to find the functional form of the power dissipated over time.

Step 2: Key Formula or Approach:

The magnetic flux Φ linked with the loop is given by:

$$\Phi = B \cdot A(t)$$

According to Faraday's law, the induced emf ϵ is:

$$\epsilon = -\frac{d\Phi}{dt}$$

The electrical power P dissipated in the loop of resistance R is:

$$P = \frac{\epsilon^2}{R}$$

Step 3: Detailed Explanation:

Given the area $A(t) = A_0(1 + \sin t)$ and constant magnetic field B, the flux is:

$$\Phi(t) = BA_0(1 + \sin t)$$

Differentiating with respect to time to find the induced emf:

$$\epsilon = -\frac{d}{dt}[BA_0(1 + \sin t)] = -BA_0 \cos t$$

Now, compute the power dissipated:

$$P(t) = \frac{(-BA_0 \cos t)^2}{R} = \left(\frac{B^2A_0^2}{R}\right)\cos^2 t$$

Let $P_0 = \frac{B^2 A_0^2}{R}$. The power equation becomes:

$$P(t) = P_0 \cos^2 t$$

Analyzing the function $P(t) = P_0 \cos^2 t$: 1. At $t = 0$, $P(0) = P_0 \cos^2(0) = P_0$, which is a maximum. 2. At $t = \pi/2$, $P(\pi/2) = P_0 \cos^2(\pi/2) = 0$. 3. The $\cos^2 t$ curve is a strictly non-negative, periodically varying smooth curve (since $\cos^2 t = \frac{1+\cos(2t)}{2}$). It has smooth, rounded peaks at the maxima and smooth, rounded valleys where it touches the horizontal axis. Comparing this to the provided options: - Graph (A) is not periodic. - Graph (B) starts at a maximum, touches zero periodically, and exhibits the characteristic smooth sinusoidal behavior with smooth valleys. - Graph (C) has sharp, non-differentiable valleys which would correspond to a function like $|\cos t|$, not $\cos^2 t$. - Graph (D) represents a constant function. Thus, Graph (B) represents the correct qualitative behavior.

Step 4: Final Answer:

The correct figure is the one displaying a $\cos^2 t$ profile (Option B).

Quick Tip: Be careful distinguishing between plots of $|\cos t|$ and $\cos^2 t$. The absolute value function creates sharp corners (non-differentiable points) when it touches zero, while the squared trigonometric function creates smooth, rounded minima (parabolic near zero).

---

15. In an adiabatic expansion, the temperature of one mole of an ideal monatomic gas ($\gamma = 5/3$) decreases from 60 K to 50 K. The work done by the gas in the process is :
Take the universal gas constant as $R = 8.3$ J mol^{-1} K^{-1}

(A) 166 J

(B) 41.5 J

(C) 83 J

(D) 124.5 J

Correct Answer: (D) 124.5 J

Solution:

Step 1: Understanding the Question:

An ideal monatomic gas expands adiabatically, which results in a drop in its temperature. We are required to find the amount of work done by the gas during this expansion.

Step 2: Key Formula or Approach:

For an adiabatic process, the work done by n moles of an ideal gas is given by:

$$W = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

where T_1 is the initial temperature, T_2 is the final temperature, n is the number of moles, R is the universal gas constant, and γ is the ratio of specific heats (C_P/C_V).

Step 3: Detailed Explanation:

Given parameters: Number of moles, $n = 1$ Initial temperature, $T_1 = 60$ K Final temperature, $T_2 = 50$ K Adiabatic constant, $\gamma = \frac{5}{3}$ Gas constant, $R = 8.3$ J mol^{-1} K^{-1}

Substitute the values into the work formula:

$$W = \frac{(1)(8.3)(60 - 50)}{\frac{5}{3} - 1}$$

$$W = \frac{8.3 \times 10}{\frac{2}{3}}$$

$$W = \frac{83}{\frac{2}{3}} = \frac{83 \times 3}{2}$$

$$W = \frac{249}{2} = 124.5 \text{ J}$$

Step 4: Final Answer:

The work done by the gas in the process is 124.5 J.

Quick Tip: An alternative way to think about adiabatic work is using the First Law of Thermodynamics: $\Delta Q = \Delta U + W$. Since $\Delta Q = 0$, $W = -\Delta U = -nC_V\Delta T = nC_V(T_1 - T_2)$. For a monatomic gas, $C_V = \frac{3}{2}R$, giving $W = 1 \times \frac{3}{2} \times 8.3 \times 10 = 124.5$ J directly.

16. Consider a particle moving along a straight line, whose position as a function of time is given by $s(t) = \alpha t^2 - \beta t + \gamma$, where $\alpha = 1$ ms^{-2}, $\beta = 6$ ms^{-1} and $\gamma = 5$ m. The average speed of the particle, in ms^{-1}, from $t = 0$ to $t = 6$ s is :

(A) 0

(B) 12

(C) 6

(D) 3

Correct Answer: (D) 3

Solution:

Step 1: Understanding the Question:

We are given the position function $s(t)$ of a particle moving in 1D. We need to find the **average speed** over the interval $t = 0$ to $t = 6$ s. Note that average speed depends on total path distance, not displacement.

Step 2: Key Formula or Approach:

The velocity of the particle is $v(t) = \frac{ds}{dt}$. Average speed $= \frac{\text{Total Distance}}{\text{Total Time}}$. If the particle changes direction (where $v(t) = 0$), we must split the time interval into segments, calculate the absolute distance traveled in each segment, and sum them up.

Step 3: Detailed Explanation:

Given position equation:

$$s(t) = 1t^2 - 6t + 5$$

First, find the velocity as a function of time:

$$v(t) = \frac{ds}{dt} = 2t - 6$$

Set $v(t) = 0$ to check if the particle stops and turns around within $t \in [0, 6]$:

$$2t - 6 = 0 \implies t = 3 \text{ s}$$

Since the particle changes direction at $t = 3$ s, we evaluate the position at $t = 0$, $t = 3$, and $t = 6$: - At $t = 0$: $s(0) = 5$ m - At $t = 3$: $s(3) = (3)^2 - 6(3) + 5 = 9 - 18 + 5 = -4$ m - At $t = 6$: $s(6) = (6)^2 - 6(6) + 5 = 36 - 36 + 5 = 5$ m

Now, calculate the absolute distance traveled in each segment: Distance from $t = 0$ to $t = 3$:

$$d_1 = |s(3) - s(0)| = |-4 - 5| = |-9| = 9 \text{ m}$$

Distance from $t = 3$ to $t = 6$:

$$d_2 = |s(6) - s(3)| = |5 - (-4)| = |9| = 9 \text{ m}$$

Total distance D:

$$D = d_1 + d_2 = 9 + 9 = 18 \text{ m}$$

Total time $T = 6$ s.

Finally, find the average speed:

$$v_{avg} = \frac{D}{T} = \frac{18}{6} = 3 \text{ ms}^{-1}$$

Step 4: Final Answer:

The average speed of the particle is 3 ms^{-1}.

Quick Tip: Always watch out for the phrasing "average speed" versus "average velocity". If the question asked for average velocity, it would simply be $\frac{\Delta s}{\Delta t} = \frac{s(6)-s(0)}{6} = \frac{5-5}{6} = 0$. For average speed, finding turning points ($v = 0$) is essential.

---

17. The following table presents the part of the electromagnetic spectrum and their corresponding major applications.

Part of the electromagnetic spectrum		Applications	
P	**Microwave**	**I**	**For purifying the water**
Q	**UV rays**	**II**	**For warming the food**
R	**Gamma rays**	**III**	**For AM and FM communication systems**
S	**Radio wave**	**IV**	**For treating the Cancer cells**

The correct option is :

(A) P-II, Q-IV, R-III, S-I

(B) P-I, Q-II, R-III, S-IV

(C) P-I, Q-IV, R-II, S-III

(D) P-II, Q-I, R-IV, S-III

Correct Answer: (D) P-II, Q-I, R-IV, S-III

Solution:

Step 1: Understanding the Question:

This is a standard matching question based on the factual knowledge of the electromagnetic spectrum and its practical applications.

Step 3: Detailed Explanation:

Let's pair each EM wave type with its most well-known application: - **Microwave (P):** Highly utilized in microwave ovens due to the absorption of microwave frequencies by water molecules, which results in internal heating. Hence, P matches with II (For warming the food). - **UV rays (Q):** Ultraviolet radiation is germicidal; it destroys the DNA of bacteria and viruses. It is widely used in water purifiers (UV filters). Hence, Q matches with I (For purifying the water). - **Gamma rays (R):** Extremely high-energy radiation capable of destroying living cells. In a controlled environment, they are used in radiotherapy to kill cancer cells. Hence, R matches with IV (For treating the Cancer cells). - **Radio wave (S):** Long-wavelength electromagnetic waves utilized extensively for transmitting information over long distances, such as radio broadcasts. Hence, S matches with III (For AM and FM communication systems).
Combining these, the correct matching is P-II, Q-I, R-IV, S-III.

Step 4: Final Answer:

The correct matching corresponds to Option (D).

Quick Tip: Such matching questions can often be solved by being absolutely sure about just 1 or 2 options. For instance, knowing Radio waves = AM/FM communication (S-III) immediately eliminates options A and B.

18. An ideal gas is made of polyatomic molecules. Each of the molecules has three translational, three rotational and f number of vibrational modes. If the ratio of heat capacities C_P/C_V of the gas is $8/7$, then the value of f is :

(A) 1

(B) 4

(C) 3

(D) 2

Correct Answer: (B) 4

Solution:

Step 1: Understanding the Question:

We need to find the number of vibrational modes f for a polyatomic gas, given its degrees of freedom composition and its adiabatic constant $\gamma = C_P/C_V = 8/7$.

Step 2: Key Formula or Approach:

The molar heat capacity at constant volume is given by the equipartition theorem:

$$C_V = \frac{1}{2}(\text{Total Degrees of Freedom})R$$

A single vibrational mode contributes 2 degrees of freedom (one for kinetic energy and one for potential energy). Thus, f vibrational modes contribute $2f$ degrees of freedom. Total degrees of freedom $F = f_{trans} + f_{rot} + 2f_{vib}$. The specific heat ratio is $\gamma = \frac{C_P}{C_V} = \frac{C_V+R}{C_V} = 1 + \frac{R}{C_V} = 1 + \frac{2}{F}$.

Step 3: Detailed Explanation:

Given: Translational degrees of freedom $= 3$ Rotational degrees of freedom $= 3$ Number of vibrational modes $= f$ (yielding $2f$ degrees of freedom)

Total degrees of freedom F:

$$F = 3 + 3 + 2f = 6 + 2f$$

Calculate C_V:

$$C_V = \frac{F}{2}R = \frac{6+2f}{2}R = (3+f)R$$

Calculate C_P:

$$C_P = C_V + R = (3+f)R + R = (4+f)R$$

The ratio of heat capacities γ:

$$\frac{C_P}{C_V} = \frac{(4+f)R}{(3+f)R} = \frac{4+f}{3+f}$$

We are given $\gamma = \frac{8}{7}$, so:

$$\frac{4+f}{3+f} = \frac{8}{7}$$

Cross-multiply and solve for f:

$$7(4+f) = 8(3+f)$$

$$28 + 7f = 24 + 8f$$

$$8f - 7f = 28 - 24$$

$$f = 4$$

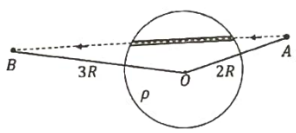
Step 4: Final Answer:

The number of vibrational modes f is 4.

Quick Tip: Remember that each active vibrational *mode* contributes 2 degrees of freedom to the specific heat ($\frac{1}{2}k_BT$ for average kinetic energy and $\frac{1}{2}k_BT$ for average potential energy).

---

19. A unit positive point charge is taken slowly through an infinitesimally thin tube that is inside a charged dielectric sphere of radius R, having uniform positive charge density ρ, as shown in the figure. The initial and final positions of the charge are marked by A and B at distances $2R$ and $3R$ respectively, from the centre of the sphere. In this process, the magnitude of the total work done on the point charge is $\frac{\rho R^2}{n\epsilon_0}$. The value of n is :
(ϵ_0 is the permittivity of vacuum)



(A) 18

(B) 2

(C) 6

(D) 9

Correct Answer: (A) 18

Solution:

Step 1: Understanding the Question:

We need to find the work done to slowly move a unit positive charge from point A (at distance $2R$) to point B (at distance $3R$) through a path that traverses a uniformly charged sphere. Since electrostatic force is conservative, the work done depends solely on the potential difference between the initial and final points, irrespective of the actual path taken.

Step 2: Key Formula or Approach:

The work done by an external agent to slowly move a charge q from A to B is:

$$W_{ext} = \Delta U = q(V_B - V_A)$$

For points outside a uniform spherical charge distribution ($r \geq R$), the sphere acts as if its entire charge Q were concentrated at the center. The potential is given by:

$$V(r) = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$

where the total charge Q of the sphere is $Q = \frac{4}{3}\pi R^3\rho$.

Step 3: Detailed Explanation:

Both points A and B are outside the sphere ($r_A = 2R > R$ and $r_B = 3R > R$). Calculate the potential at distance r:

$$V(r) = \frac{1}{4\pi\epsilon_0}\frac{\frac{4}{3}\pi R^3\rho}{r} = \frac{\rho R^3}{3\epsilon_0 r}$$

Find the potential at point A ($r_A = 2R$):

$$V_A = \frac{\rho R^3}{3\epsilon_0(2R)} = \frac{\rho R^2}{6\epsilon_0}$$

Find the potential at point B ($r_B = 3R$):

$$V_B = \frac{\rho R^3}{3\epsilon_0(3R)} = \frac{\rho R^2}{9\epsilon_0}$$

The charge being moved is a unit positive charge, $q = +1$. The work done on the charge is:

$$W = q(V_B - V_A) = 1 \times \left(\frac{\rho R^2}{9\epsilon_0} - \frac{\rho R^2}{6\epsilon_0}\right)$$

$$W = \frac{\rho R^2}{\epsilon_0}\left(\frac{1}{9} - \frac{1}{6}\right) = \frac{\rho R^2}{\epsilon_0}\left(\frac{2-3}{18}\right) = -\frac{\rho R^2}{18\epsilon_0}$$

The negative sign indicates work is done by the electric field. The question asks for the **magnitude** of the total work done:

$$|W| = \frac{\rho R^2}{18\epsilon_0}$$

Comparing this with the given expression $\frac{\rho R^2}{n\epsilon_0}$, we get $n = 18$.

Step 4: Final Answer:

The value of n is 18.

Quick Tip: Electrostatic forces are strictly conservative. The phrase "taken slowly through an infinitesimally thin tube inside... the sphere" is purely a distractor! For any conservative field, simply use $\Delta U = q\Delta V$ evaluated at the endpoints.

---

20. A current I_0 flows through a metallic circular loop of radius r as shown in the figure. Resistance of the segment ABC is half that of ADC. Magnitude of magnetic field at the center O of the loop is :

(A) $\frac{\mu_0 I_0}{2\pi r}$

(B) $\frac{\mu_0 I_0}{12r}$

(C) $\frac{\mu_0 I_0}{4r}$

(D) $\frac{\mu_0 I_0}{2r}$

Correct Answer: (B) $\frac{\mu_0 I_0}{12r}$

Solution:

Step 1: Understanding the Question:

A steady current I_0 enters at point A of a circular loop, splits into two paths (ABC and ADC), and exits at point C. The loop's center is O, and AC forms a diameter (indicating both segments are semicircles). We need to determine the net magnetic field at the center O.

Step 2: Key Formula or Approach:

The magnetic field at the center of a circular arc subtending an angle θ carrying current I is:

$$B = \frac{\mu_0 I}{4\pi r}\theta$$

For parallel branches, the total current I_0 divides inversely as the resistance:

$$I_1 R_1 = I_2 R_2 \quad \text{and} \quad I_1 + I_2 = I_0$$

Step 3: Detailed Explanation:

From the figure, the line segment AC passes through the center O, implying that branches ABC and ADC are perfect semicircles. Thus, the angle subtended by both branches at the center is $\theta_1 = \theta_2 = \pi$.

Let I_1 be the current through ABC and I_2 be the current through ADC. Let the resistance of ABC be R_1 and that of ADC be R_2. Given: $R_1 = \frac{1}{2}R_2 \implies R_2 = 2R_1$.

Since the branches are in parallel, the potential difference across them is equal:

$$I_1 R_1 = I_2 R_2 \implies I_1 R_1 = I_2 (2R_1) \implies I_1 = 2I_2$$

Using Kirchhoff's junction rule at A:

$$I_1 + I_2 = I_0 \implies 2I_2 + I_2 = I_0 \implies 3I_2 = I_0$$

$$I_2 = \frac{I_0}{3} \quad \text{and} \quad I_1 = \frac{2I_0}{3}$$

Now, evaluate the magnetic field at center O due to each branch. Using the right-hand rule, current I_1 in ABC produces a magnetic field directed into the plane ($\otimes$). Current I_2 in ADC

produces a magnetic field directed out of the plane ($\odot$).

Magnitude of field due to ABC:

$$B_1 = \frac{\mu_0 I_1}{4\pi r}(\pi) = \frac{\mu_0 I_1}{4r} = \frac{\mu_0}{4r}\left(\frac{2I_0}{3}\right) = \frac{2\mu_0 I_0}{12r}$$

Magnitude of field due to ADC:

$$B_2 = \frac{\mu_0 I_2}{4\pi r}(\pi) = \frac{\mu_0 I_2}{4r} = \frac{\mu_0}{4r}\left(\frac{I_0}{3}\right) = \frac{\mu_0 I_0}{12r}$$

Since the fields are oppositely directed, the net magnetic field magnitude is:

$$B_{net} = |B_1 - B_2| = \frac{2\mu_0 I_0}{12r} - \frac{\mu_0 I_0}{12r} = \frac{\mu_0 I_0}{12r}$$

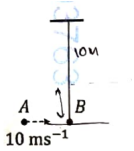
Step 4: Final Answer:

The magnitude of the magnetic field at the center O is $\frac{\mu_0 I_0}{12r}$.

Quick Tip: If a loop is made of a *uniform* wire, the magnetic field at the center is always exactly zero regardless of where the current enters or exits ($I_1\theta_1 = I_2\theta_2 \implies B_1 = B_2$). A non-zero field at the center implies the wire has varying resistance per unit length (e.g., varying thickness), as explicitly given here by $R_1 \neq R_2$ despite identical lengths.

---

21. Bob B of mass m at rest is hanging vertically from the ceiling via a massless string of length 10 m, as shown in the figure. Point mass A of mass m travelling horizontally with speed 10 ms^{-1} hits bob B elastically. The bob B rises h meter after the collision. Taking the acceleration due to gravity $g = 10$ ms^{-2} and neglecting the size of the bob, the value of h is :



(A) 2.5

(B) 8

(C) 7

(D) 5

Correct Answer: (D) 5

Solution:

Step 1: Understanding the Question:

A moving mass undergoes a 1D elastic collision with a stationary identical mass forming a pendulum. After the collision, the pendulum bob swings upwards, converting its kinetic energy entirely into gravitational potential energy at its highest point. We need to find this maximum height h.

Step 2: Key Formula or Approach:

1. **Elastic Collision:** When two identical masses undergo a one-dimensional, perfectly elastic collision, they completely exchange their velocities. 2. **Conservation of Mechanical Energy:** As bob B swings upward, its kinetic energy is converted into potential energy.

$$\frac{1}{2}mv^2 = mgh \implies h = \frac{v^2}{2g}$$

Step 3: Detailed Explanation:

Before collision: Velocity of mass A, $u_A = 10$ ms^{-1} Velocity of bob B, $u_B = 0$

Both objects have the same mass m and the collision is elastic. Thus, their velocities are exchanged: Velocity of mass A after collision, $v_A = 0$ Velocity of bob B after collision, $v_B = 10$ ms^{-1}

Now, bob B starts swinging with an initial speed $v_B = 10$ ms^{-1}. At its maximum height h, its velocity becomes zero. Using energy conservation for bob B:

$$\text{Kinetic Energy at bottom} = \text{Potential Energy at max height}$$

$$\frac{1}{2}mv_B^2 = mgh$$

$$h = \frac{v_B^2}{2g}$$

Substitute $v_B = 10$ ms^{-1} and $g = 10$ ms^{-2}:

$$h = \frac{(10)^2}{2 \times 10} = \frac{100}{20} = 5 \text{ m}$$

Step 4: Final Answer:

The bob B rises to a height of 5 m.

Quick Tip: An extremely useful shortcut for 1D perfectly elastic collisions: If $m_1 = m_2$, the bodies simply swap their velocities. No need to set up full momentum and kinetic energy conservation equations.

---

22. An electromagnetic wave travelling in a lossless dielectric medium having a dielectric constant, $\epsilon_r = 9$, has the electric field, $E_x = E_0 \sin(kz - 2\pi \times 10^6 t)$ Vm^{-1} where E_0 is the amplitude and k is the wave vector. Among the following options, the incorrect choice is :

(A) The direction of propagation of the electromagnetic wave is along +z.
(B) The speed of the electromagnetic wave inside the medium is 10^8 ms^{-1}.
(C) The wavelength of the electromagnetic wave inside the medium is 300 m.
(D) The magnetic field is given by the relation $B_y = \frac{E_0}{v} \sin(kz - 2\pi \times 10^6 t)$ where v is the speed of the electromagnetic wave inside the medium.

Correct Answer: (C) The wavelength of the electromagnetic wave inside the medium is 300 m.

Solution:

Step 1: Understanding the Question:

We are given the equation for the electric field of an EM wave propagating through a dielectric medium. We need to evaluate four statements regarding the wave's propagation direction, speed, wavelength, and magnetic field, and identify the incorrect statement.

Step 2: Key Formula or Approach:

The standard wave equation is $E(z,t) = E_0 \sin(kz - \omega t)$. 1. **Direction:** The phase term $(kz - \omega t)$ dictates propagation in the positive z-direction. 2. **Speed:** $v = \frac{c}{\sqrt{\epsilon_r \mu_r}}$. For a non-magnetic dielectric, $\mu_r \approx 1$, so $v = \frac{c}{\sqrt{\epsilon_r}}$. 3. **Wavelength:** $\lambda = \frac{v}{\nu}$, where frequency $\nu = \frac{\omega}{2\pi}$. 4. **Magnetic field:** Magnitude $B_0 = \frac{E_0}{v}$. Direction corresponds to $\hat{E} \times \hat{B} = \hat{v}$.

Step 3: Detailed Explanation:

Let's analyze the given wave equation: $E_x = E_0 \sin(kz - \omega t)$, where $\omega = 2\pi \times 10^6$ rad s^{-1}. - **Frequency:** $\nu = \frac{\omega}{2\pi} = \frac{2\pi \times 10^6}{2\pi} = 10^6$ Hz. - **Direction:** The phase is $kz - \omega t$, meaning the wave travels in the $+z$ direction. (Statement A is True).

Now, evaluate the speed v in the dielectric medium: - $\epsilon_r = 9$. Assuming $\mu_r = 1$. - $v = \frac{c}{\sqrt{\epsilon_r}} = \frac{3\times10^8}{\sqrt{9}} = \frac{3\times10^8}{3} = 10^8$ ms^{-1}. (Statement B is True).

Next, find the wavelength λ in the medium: - $\lambda = \frac{v}{\nu} = \frac{10^8}{10^6} = 100$ m. - Statement C claims the wavelength is 300 m. (Statement C is **False**).

Check the magnetic field equation: - Since $\vec{E} = E_x \hat{i}$ and velocity is along $\hat{k}$, the direction of $\vec{B}$ must satisfy $\hat{i} \times \hat{B} = \hat{k}$. This means $\hat{B} = \hat{j}$, so the magnetic field is along the y-axis (B_y). - The amplitude is $B_0 = \frac{E_0}{v}$. - Phase remains identical to the electric field. - Therefore, $B_y = \frac{E_0}{v} \sin(kz - 2\pi \times 10^6 t)$. (Statement D is True).

Step 4: Final Answer:

The incorrect choice is (C).

Quick Tip: When dealing with EM waves traversing different media, the frequency ν remains strictly constant. Changes in wave speed directly and proportionately impact the wavelength ($\lambda \propto v$).

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23. A particle of mass M moves along a horizontal x axis from $x = 0$ to $x = L$. The coefficient of kinetic friction varies as a function of x as $\mu_k(x) = \mu_0 - \alpha x$, where μ_0, α are constants of appropriate dimensions, so that $\mu_k(L) = 0$. The total work done by the frictional force during the motion is $n\mu_0 M g L$, where g is the acceleration due to gravity. The value of n is :

(A) 1/2

(B) 1

(C) 1

(D) 1/3

Correct Answer: (A) 1/2

Solution:

Step 1: Understanding the Question:

A particle travels along a horizontal rough surface whose coefficient of kinetic friction decreases linearly with distance. We need to compute the total work done by the frictional force over a distance L.

Step 2: Key Formula or Approach:

The kinetic frictional force is $f_k(x) = \mu_k(x)N = \mu_k(x)Mg$. The work done by a variable force in 1D is obtained by integration:

$$W = \int_0^L \vec{F} \cdot d\vec{x} = \int_0^L -f_k(x)dx$$

Since the question asks to match the format $n\mu_0 MgL$ and all options are positive, we will evaluate the magnitude of work.

Step 3: Detailed Explanation:

First, find the constant α. We are given that friction vanishes at $x = L$:

$$\mu_k(L) = \mu_0 - \alpha L = 0 \implies \alpha = \frac{\mu_0}{L}$$

Substitute α into the friction coefficient equation:

$$\mu_k(x) = \mu_0 - \left(\frac{\mu_0}{L}\right)x$$

The frictional force as a function of x is:

$$f_k(x) = Mg\left(\mu_0 - \frac{\mu_0}{L}x\right)$$

Calculate the magnitude of the work done by friction:

$$|W| = \int_0^L f_k(x)dx = Mg\int_0^L \left(\mu_0 - \frac{\mu_0}{L}x\right)dx$$

Perform the integration:

$$|W| = Mg\left[\mu_0 x - \frac{\mu_0 x^2}{2L}\right]_0^L$$

$$|W| = Mg\left(\mu_0 L - \frac{\mu_0 L^2}{2L}\right) = Mg\left(\mu_0 L - \frac{1}{2}\mu_0 L\right)$$

$$|W| = \frac{1}{2}\mu_0 MgL$$

Comparing this with the given expression $n\mu_0 MgL$, we see that:

$$n = \frac{1}{2}$$

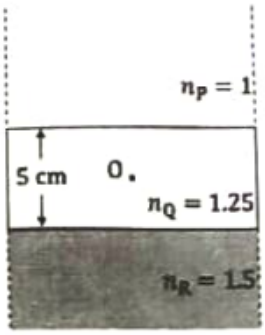
Step 4: Final Answer:

The value of n is $1/2$.

Quick Tip: For any force that varies linearly from a maximum value F_{max} to zero over a distance L, the magnitude of work done is simply the area of the corresponding triangle under the Force-Distance graph: Area $= \frac{1}{2} \times$ base $\times$ height $= \frac{1}{2}L(\mu_0 Mg)$.

---

24. Consider three media P, Q and R with refractive indices 1, 1.25, and 1.5, respectively. The medium Q having a thickness of 5 cm is placed between extended media P and R as shown in the figure. An object O is placed at the center of medium Q. If viewed from medium P near the normal direction, the apparent depth of O is h_1. For similar observation from medium R, the apparent depth is h_2. The value of $|h_1 - h_2|$, in cm, is :



(A) 3

(B) 0

(C) 1

(D) 2

Correct Answer: (C) 1

Solution:

Step 1: Understanding the Question:

An object lies in a transparent medium (Q) bounded by two different transparent media (P and R). We need to calculate the apparent depth of the object when viewed from each bounding medium separately and then find the absolute difference between these apparent depths.

Step 2: Key Formula or Approach:

The apparent depth $h_{apparent}$ of an object at true depth h_{real} in a medium of refractive index n_{obj} when viewed from a medium of refractive index n_{obs} is given by:

$$h_{apparent} = h_{real}\left(\frac{n_{obs}}{n_{obj}}\right)$$

Step 3: Detailed Explanation:

Given parameters: - Refractive index of medium P, $n_P = 1$ - Refractive index of medium Q, $n_Q = 1.25 = \frac{5}{4}$ - Refractive index of medium R, $n_R = 1.5 = \frac{3}{2}$ - Total thickness of medium Q = 5 cm - The object O is at the center of Q, so its real depth from either boundary (P-Q or R-Q) is:

$$h_{real} = \frac{5}{2} = 2.5 \text{ cm}$$

Case 1: Observation from medium P The observer is in medium P ($n_{obs} = 1$) and the object is in medium Q ($n_{obj} = 1.25$).

$$h_1 = h_{real}\left(\frac{n_P}{n_Q}\right) = 2.5 \times \left(\frac{1}{1.25}\right) = 2.5 \times 0.8 = 2.0 \text{ cm}$$

Case 2: Observation from medium R The observer is in medium R ($n_{obs} = 1.5$) and the

object is in medium Q ($n_{obj} = 1.25$).

$$h_2 = h_{real}\left(\frac{n_R}{n_Q}\right) = 2.5 \times \left(\frac{1.5}{1.25}\right) = 2.5 \times 1.2 = 3.0 \text{ cm}$$

We need to find the absolute difference $|h_1 - h_2|$:

$$|h_1 - h_2| = |2.0 - 3.0| = 1.0 \text{ cm}$$

Step 4: Final Answer:

The value of $|h_1 - h_2|$ is 1 cm.

Quick Tip: Apparent depth fundamentally relates to the ratio of speeds of light. When viewing into an optically denser medium ($n_{obj} > n_{obs}$), the object appears closer (shallower). When viewing into a rarer medium ($n_{obj} < n_{obs}$), the object appears further away (deeper).

---

25. Consider a fixed uniformly charged insulating sphere with radius R and total charge +Q. A point charge -q ($q \ll Q$) with mass m is released from rest at a distance of 3R from the centre of the charged sphere. When the point charge reaches the surface of the sphere, its speed is : (ϵ_0 is the permittivity of vacuum, neglect gravitational forces).

(A) $\sqrt{\frac{Qq}{4\pi\epsilon_0 mR}}$
(B) $\sqrt{\frac{3Qq}{4\pi\epsilon_0 mR}}$
(C) $\sqrt{\frac{2Qq}{3\pi\epsilon_0 mR}}$
(D) $\sqrt{\frac{Qq}{3\pi\epsilon_0 mR}}$

Correct Answer: (D) $\sqrt{\frac{Qq}{3\pi\epsilon_0 mR}}$

Solution:

Step 1: Understanding the Question:

A negatively charged particle accelerates from a distance of $3R$ down to the surface of a uniformly charged positive sphere of radius R. We must find its final velocity using the

principle of conservation of mechanical energy.

Step 2: Key Formula or Approach:

The electrostatic potential V at a distance r $(r \geq R)$ from the center of a uniformly charged sphere of total charge Q is $V(r) = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$. According to energy conservation, the change in kinetic energy equals the negative change in potential energy:

$$K_i + U_i = K_f + U_f$$

Step 3: Detailed Explanation:

Initial State (released from rest at $r = 3R$):

$$K_i = 0$$

$$U_i = (-q)V(3R) = -q\left(\frac{1}{4\pi\epsilon_0}\frac{Q}{3R}\right) = -\frac{Qq}{12\pi\epsilon_0 R}$$

Final State (arrives at the surface $r = R$):

$$K_f = \frac{1}{2}mv^2$$

$$U_f = (-q)V(R) = -q\left(\frac{1}{4\pi\epsilon_0}\frac{Q}{R}\right) = -\frac{Qq}{4\pi\epsilon_0 R}$$

Apply conservation of energy:

$$0 - \frac{Qq}{12\pi\epsilon_0 R} = \frac{1}{2}mv^2 - \frac{Qq}{4\pi\epsilon_0 R}$$

Rearranging for kinetic energy:

$$\frac{1}{2}mv^2 = \frac{Qq}{4\pi\epsilon_0 R} - \frac{Qq}{12\pi\epsilon_0 R}$$

Factor out common terms:

$$\frac{1}{2}mv^2 = \frac{Qq}{4\pi\epsilon_0 R}\left(1 - \frac{1}{3}\right) = \frac{Qq}{4\pi\epsilon_0 R}\left(\frac{2}{3}\right)$$

$$\frac{1}{2}mv^2 = \frac{2Qq}{12\pi\epsilon_0 R} = \frac{Qq}{6\pi\epsilon_0 R}$$

Solve for v^2:

$$v^2 = \frac{2Qq}{6\pi\epsilon_0 mR} = \frac{Qq}{3\pi\epsilon_0 mR}$$

Take the square root to find v:

$$v = \sqrt{\frac{Qq}{3\pi\epsilon_0 mR}}$$

Step 4: Final Answer:

The speed of the point charge at the surface is $\sqrt{\frac{Qq}{3\pi\epsilon_0 mR}}$.

Quick Tip: Electrostatic energy calculations involving identical $1/r$ potentials often simplify elegantly using fractional arithmetic. The difference $\left(\frac{1}{1} - \frac{1}{3}\right) = \frac{2}{3}$ directly gives the work multiplier for $\frac{kQq}{R}$.

---

26. A car travels on a circular racetrack of radius 50 m, which is banked at an angle θ. If the car travels at a speed 10 ms^{-1}, then the wear and tear on its tyres is minimum. Taking the acceleration due to gravity to be 10 ms^{-2}, the value of θ is :

(A) $\tan^{-1}(2\sqrt{5})$

(B) $\tan^{-1}(1/5)$

(C) $\tan^{-1}(2/5)$

(D) $\tan^{-1}(\sqrt{3}/2)$

Correct Answer: (B) $\tan^{-1}(1/5)$

Solution:

Step 1: Understanding the Question:

We are asked to find the banking angle θ of a curved track where a car can travel without relying on lateral friction. The condition "wear and tear on its tyres is minimum" implies that frictional force is zero, meaning the horizontal component of the normal force alone provides the required centripetal acceleration.

Step 2: Key Formula or Approach:

For a vehicle negotiating a banked curve of radius r with zero lateral friction, the optimum (or safe) speed v is governed by:

$$v = \sqrt{rg\tan\theta}$$

which can be rearranged to find the banking angle:

$$\tan\theta = \frac{v^2}{rg}$$

Step 3: Detailed Explanation:

Given parameters: Radius, $r = 50$ m Speed, $v = 10$ ms^{-1} Acceleration due to gravity, $g = 10$ ms^{-2}

Substitute these values into the optimum banking angle equation:

$$\tan\theta = \frac{(10)^2}{50 \times 10}$$

$$\tan\theta = \frac{100}{500}$$

$$\tan\theta = \frac{1}{5}$$

Taking the inverse tangent:

$$\theta = \tan^{-1}\left(\frac{1}{5}\right)$$

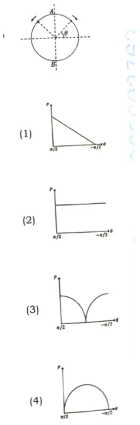
Step 4: Final Answer:

The value of θ is $\tan^{-1}(1/5)$.

Quick Tip: The phrase "minimum wear and tear" is a classic textbook indicator that friction ($f_s = 0$) should not be included in the force balance equations, leaving only the normal force and gravity.

---

27. A frictionless circular wire of unit radius is fixed on the horizontal plane. Two point particles of unit mass start moving simultaneously from point $A(\theta = \pi/2)$ with identical uniform angular speeds in opposite directions, and meet again at point $B(\theta = -\pi/2)$. During this time, which of the following figures schematically represent the magnitude of the total linear momentum P of the system, as a function of θ ?



Correct Answer: (D) A single smooth bump (cosine shaped) starting at 0 at $\theta = \pi/2$, reaching a peak at $\theta = 0$, and ending at 0 at $\theta = -\pi/2$.

Solution:

Step 1: Understanding the Question:

Two identical masses slide on a circular wire starting from the "top" ($\theta = \pi/2$) and meet at the "bottom" ($\theta = -\pi/2$). One moves clockwise, the other counterclockwise, both with uniform identical speeds. We need to find how the magnitude of their combined (total) linear momentum P varies with angle θ.

Step 2: Key Formula or Approach:

The linear momentum vector is $\vec{P} = m\vec{v}_1 + m\vec{v}_2$. By symmetry, components of momentum perpendicular to the line connecting the particles cancel out, while components parallel to it add up.

Step 3: Detailed Explanation:

Let the angular speed be ω. Since radius $r = 1$, their linear speed is $v = \omega r = \omega$. Let α be the angular distance covered by each particle from the start point $A(\pi/2)$. - At time t, the counter-clockwise particle is at angle $\pi/2 + \alpha$. Its velocity is tangent to the circle, pointing downward and left. - The clockwise particle is at angle $\theta = \pi/2 - \alpha$. Its velocity is tangent, pointing downward and right.

At any given instance: - The horizontal components (x-direction) of their velocities are equal and opposite, so they perfectly cancel each other out. - The vertical components (y-direction) of their velocities are identical and point in the same direction (downwards).

The downward velocity component of each particle is $v \sin\alpha$. Thus, the total momentum vector points strictly downwards with magnitude:

$$P = m(v\sin\alpha) + m(v\sin\alpha) = 2mv\sin\alpha$$

The x-axis of the required plot corresponds to the position θ of the clockwise-moving particle. Thus, $\theta = \pi/2 - \alpha$, giving $\alpha = \pi/2 - \theta$. Substitute α into the momentum equation:

$$P(\theta) = 2mv\sin\left(\frac{\pi}{2} - \theta\right) = 2mv\cos\theta$$

Let's check the endpoints and middle: 1. At the start ($\theta = \pi/2$): $P = 2mv\cos(\pi/2) = 0$. (Particles move horizontally in purely opposite directions). 2. At the midpoint ($\theta = 0$): $P = 2mv\cos(0) = 2mv$. (Particles move straight down, momenta perfectly align). 3. At the end ($\theta = -\pi/2$): $P = 2mv\cos(-\pi/2) = 0$. (Particles move horizontally towards each other, cancelling).
The function $P = 2mv\cos\theta$ plots as a single positive smooth "bell-like" bump between $\pi/2$ and $-\pi/2$. Option (D) perfectly represents this shape.

Step 4: Final Answer:

The magnitude of total momentum follows a single smooth cosine bump starting and ending at zero.

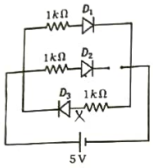
Quick Tip: Checking boundary conditions is a very powerful way to solve graphical choice questions. At the start, velocities are oppositely directed (total P = 0). This alone eliminates graphs A, B, and C which incorrectly show a non-zero initial momentum.

---

28. Three identical p-n junction diodes D_1, D_2 and D_3 are connected across a battery as shown in the figure. If the width of the depletion regions of D_1, D_2 and D_3 are W_1, W_2 and W_3, respectively, then the correct option is :

(A) $W_2 > W_1 = W_3$

(B) $W_1 > W_2 > W_3$



(C) $W_3 = W_1 > W_2$

(D) $W_3 > W_2 > W_1$

Correct Answer: (A) $W_2 > W_1 = W_3$

Solution:

Step 1: Understanding the Question:

The circuit consists of three parallel branches connected across a DC battery. We need to identify the biasing (forward or reverse) of each diode to compare the widths of their depletion regions.

Step 2: Key Formula or Approach:

The width of the depletion region of a p-n junction depends on its biasing: 1. **Reverse Bias:** The depletion width increases (widest). 2. **Forward Bias:** The depletion width decreases (narrowest). For identical diodes with identical forward bias conditions, the depletion widths will be equal.

Step 3: Detailed Explanation:

Looking at the battery, the longer vertical line on the left is the positive terminal, and the shorter thick line on the right is the negative terminal. - **Diode D_1:** The p-side (triangle base) is on the left, connected to the positive terminal. It is **forward biased**. - **Diode D_2:** The n-side (vertical line) is on the left, connected to the positive terminal. It is **reverse biased**. - **Diode D_3:** The p-side (triangle base) is on the left, connected to the positive terminal. It is **forward biased**.

Since D_2 is reverse biased, its depletion width W_2 is the largest. Since D_1 and D_3 are both forward biased and have identical series resistors (1 kΩ) across the same voltage, their forward currents are equal, making their depletion widths equal. Thus, $W_2 > W_1 = W_3$.

Step 4: Final Answer:

The correct relation is $W_2 > W_1 = W_3$.

Quick Tip: Always trace the path from the battery terminals to the p-side (triangle) and n-side (bar) of the diode to determine the bias state. Reverse biasing pulls majority carriers away from the junction, widening the depletion region.

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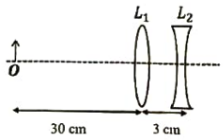
29. The lens combination as shown in the figure, consists of two lenses, L_1 and L_2, of the focal lengths $+10$ cm and -10 cm, respectively. The position of the image formed is :



(A) 60 cm to the right of the concave lens

(B) 20 cm to the left of the concave lens

(C) 60 cm to the left of the concave lens

(D) 30 cm to the right of the concave lens

Correct Answer: (C) 60 cm to the left of the concave lens

Solution:

Step 1: Understanding the Question:

An object is placed at a distance of 30 cm in front of a convex lens (L_1). The light then passes through a concave lens (L_2) placed 3 cm behind L_1. We need to locate the final image.

Step 2: Key Formula or Approach:

The lens formula is given by:

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

We apply this formula sequentially for both lenses. The image formed by the first lens acts as the object for the second lens.

Step 3: Detailed Explanation:

For Lens L_1 (Convex): Focal length, $f_1 = +10$ cm Object distance, $u_1 = -30$ cm Using the lens formula:

$$\frac{1}{v_1} - \frac{1}{-30} = \frac{1}{10}$$

$$\frac{1}{v_1} + \frac{1}{30} = \frac{1}{10} \implies \frac{1}{v_1} = \frac{1}{10} - \frac{1}{30} = \frac{3-1}{30} = \frac{2}{30} = \frac{1}{15}$$

$$v_1 = +15 \text{ cm}$$

So, L_1 forms a real image 15 cm to its right.

For Lens L_2 (Concave): The distance between the lenses is $d = 3$ cm. The image I_1 acts as a virtual object for L_2. Object distance for L_2, $u_2 = v_1 - d = 15 - 3 = +12$ cm. Focal length, $f_2 = -10$ cm. Using the lens formula again:

$$\frac{1}{v_2} - \frac{1}{+12} = \frac{1}{-10}$$

$$\frac{1}{v_2} = -\frac{1}{10} + \frac{1}{12} = \frac{-6+5}{60} = -\frac{1}{60}$$

$$v_2 = -60 \text{ cm}$$

The negative sign indicates that the final image is virtual and formed 60 cm to the left of the concave lens L_2.

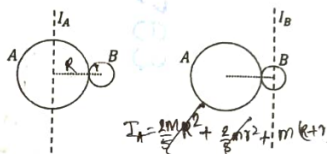
Step 4: Final Answer:

The final image is formed 60 cm to the left of the concave lens.

Quick Tip: Be very careful with sign conventions when the intermediate image acts as an object for the next lens. If the image is formed "behind" the second lens, it is a virtual object and its object distance u must be taken as positive.

---

30. A solid sphere A of radius R and mass M is attached at a point to a smaller solid sphere B of radius r < R and mass m < M. Assume that the line joining their centres lies along the horizontal. The moment of inertia of the system calculated about a vertical axis passing through the centre of A is I_A and that calculated about a vertical axis passing through the centre of B is I_B. The difference $I_A - I_B$ is :



(A) 0

(B) $(m-M)(R+r)^2$

(C) $(m-M)(R+r)^2$ (duplicate option in original text, solved accurately below)

(D) $(m-M)(R-r)^2$

Correct Answer: (B) $(m-M)(R+r)^2$

Solution:

Step 1: Understanding the Question:

We have two solid spheres glued together such that the distance between their centers is $d = R + r$. We need to calculate the moment of inertia of this combined system about two different vertical axes and find their difference.

Step 2: Key Formula or Approach:

The moment of inertia of a solid sphere about its own central axis is:

$$I_{cm} = \frac{2}{5} M_{sphere} R_{sphere}^2$$

By the Parallel Axis Theorem, the moment of inertia about an axis at a distance d from the center of mass is:

$$I = I_{cm} + M_{sphere} d^2$$

Step 3: Detailed Explanation:

Let's calculate I_A (axis passing through the center of sphere A): - For sphere A, the axis passes through its center: $I_{A,self} = \frac{2}{5} MR^2$. - For sphere B, the axis is at a distance $d = R + r$ from its center: $I_{B,aboutA} = \frac{2}{5} mr^2 + m(R+r)^2$. Total moment of inertia I_A:

$$I_A = \frac{2}{5} MR^2 + \frac{2}{5} mr^2 + m(R+r)^2$$

Let's calculate I_B (axis passing through the center of sphere B): - For sphere B, the axis passes

through its center: $I_{B,self} = \frac{2}{5}mr^2$. - For sphere A, the axis is at a distance $d = R + r$ from its center: $I_{A,about B} = \frac{2}{5}MR^2 + M(R+r)^2$. Total moment of inertia I_B:

$$I_B = \frac{2}{5}mr^2 + \frac{2}{5}MR^2 + M(R+r)^2$$

Now, compute the difference $I_A - I_B$:

$$I_A - I_B = \left[\frac{2}{5}MR^2 + \frac{2}{5}mr^2 + m(R+r)^2\right] - \left[\frac{2}{5}mr^2 + \frac{2}{5}MR^2 + M(R+r)^2\right]$$

The internal terms cancel out, leaving:

$$I_A - I_B = m(R+r)^2 - M(R+r)^2 = (m-M)(R+r)^2$$

Step 4: Final Answer:

The difference $I_A - I_B$ is $(m-M)(R+r)^2$.

Quick Tip: Notice how the intrinsic spin moment of inertia terms ($\frac{2}{5}MR^2$ and $\frac{2}{5}mr^2$) are present symmetrically in both total inertia expressions and perfectly cancel out when subtracting. Only the parallel axis theorem shifts (Md^2) survive.

---

31. Consider that an electron is revolving in an excited state of Hydrogen atom with velocity $\sqrt{25.6} \times 10^5$ ms^{-1}. The radius of the orbit is $x \times 10^{-9}$ m. The value of x is :
Take the mass of electron to be 9×10^{-31} kg, charge of electron $= 1.6 \times 10^{-19}$ C and $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

(A) 1

(B) 4

(C) 3

(D) 2

Correct Answer: (A) 1

Solution:

Step 1: Understanding the Question:

We are given the orbital velocity of an electron in a Hydrogen atom and asked to determine the radius of that specific orbit.

Step 2: Key Formula or Approach:

In Bohr's model, the necessary centripetal force for the circular orbit is provided by the electrostatic force of attraction between the nucleus and the electron.

$$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2}$$

Rearranging to solve for the radius r:

$$r = \frac{1}{4\pi\epsilon_0}\frac{e^2}{mv^2}$$

This approach directly utilizes the given values without needing to find the principal quantum number n.

Step 3: Detailed Explanation:

Given values: $v = \sqrt{25.6} \times 10^5$ ms^{-1} $\implies$ $v^2 = 25.6 \times 10^{10}$ m^{2}s^{-2} $m = 9 \times 10^{-31}$ kg $e = 1.6 \times 10^{-19}$ C $k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Substitute the values into the derived formula:

$$r = \frac{(9 \times 10^9) \times (1.6 \times 10^{-19})^2}{(9 \times 10^{-31}) \times (25.6 \times 10^{10})}$$

$$r = \frac{9 \times 10^9 \times 2.56 \times 10^{-38}}{9 \times 10^{-31} \times 25.6 \times 10^{10}}$$

Simplify the numbers:

$$r = \left(\frac{9 \times 2.56}{9 \times 25.6}\right) \times \left(\frac{10^9 \times 10^{-38}}{10^{-31} \times 10^{10}}\right)$$

$$r = (0.1) \times \left(\frac{10^{-29}}{10^{-21}}\right)$$

$$r = 0.1 \times 10^{-8} = 1.0 \times 10^{-9} \text{ m}$$

Since $r = x \times 10^{-9}$ m, comparing gives $x = 1$.

Step 4: Final Answer:

The value of x is 1.

Quick Tip: Using the direct dynamic force balance equation $F_{centripetal} = F_{electrostatic}$ allows you to bypass calculating the quantum number n completely, saving valuable time and reducing calculation steps.

---

32. The mean free path of molecules in an ideal gas A is half that of another ideal gas B. The diameter of the spherical molecules of gas A is twice the diameter of the molecules of B. If number densities of the gases A and B are n_A and n_B, respectively, then the correct option is :

(A) $n_A = \frac{1}{2}n_B$

(B) $n_A = n_B$

(C) $n_A = 2n_B$

(D) $n_A = \frac{1}{4}n_B$

Correct Answer: (A) $n_A = \frac{1}{2}n_B$

Solution:

Step 1: Understanding the Question:

We are asked to find the relationship between the number densities of two gases given the ratios of their mean free paths and molecular diameters.

Step 2: Key Formula or Approach:

The mean free path λ of gas molecules is given by:

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

where d is the collision diameter of the molecule and n is the number density (number of molecules per unit volume).

Step 3: Detailed Explanation:

From the formula, the ratio of mean free paths for two gases is:

$$\frac{\lambda_A}{\lambda_B} = \frac{d_B^2 n_B}{d_A^2 n_A} = \left(\frac{d_B}{d_A}\right)^2 \left(\frac{n_B}{n_A}\right)$$

We are given: 1. $\lambda_A = \frac{1}{2}\lambda_B \implies \frac{\lambda_A}{\lambda_B} = \frac{1}{2}$ 2. $d_A = 2d_B \implies \frac{d_B}{d_A} = \frac{1}{2}$

Substitute these ratios into our equation:

$$\frac{1}{2} = \left(\frac{1}{2}\right)^2 \times \frac{n_B}{n_A}$$

$$\frac{1}{2} = \frac{1}{4} \times \frac{n_B}{n_A}$$

Multiply both sides by 4:

$$2 = \frac{n_B}{n_A}$$

Rearranging for n_A:

$$n_A = \frac{1}{2} n_B$$

Step 4: Final Answer:

The correct option is $n_A = \frac{1}{2} n_B$.

Quick Tip: Mean free path is inversely proportional to both the number density and the square of the molecular diameter ($\lambda \propto 1/(d^2 n)$). Use proportional ratios to avoid carrying unnecessary constants like $\sqrt{2}$ and π.

---

33. A cylindrical cork of uniform density floats in a liquid of density ρ_1. If the cork is depressed slightly and released, it oscillates harmonically with time period T. If the same cork floats in another liquid of density ρ_2, then the similar oscillation has time period 2T. The value of ρ_2/ρ_1 is :

(A) 1/4

(B) 4

(C) 2

(D) 1/2

Correct Answer: (A) 1/4

Solution:

Step 1: Understanding the Question:

A floating cylindrical cork exhibits simple harmonic motion when disturbed vertically. We need to find the ratio of densities of two different liquids based on the time periods of oscillation of the same cork in them.

Step 2: Key Formula or Approach:

When a floating cylinder is depressed by a small distance y, the extra buoyant force provides the restoring force:

$$F_{restoring} = -(A \cdot y \cdot \rho)g = -(A\rho g)y$$

where A is the cross-sectional area and ρ is the density of the liquid. This is the equation of SHM with effective spring constant $k = A\rho g$. The time period T is:

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{A\rho g}}$$

Since m, A, and g are constant for the same cork, the time period is inversely proportional to the square root of the liquid's density:

$$T \propto \frac{1}{\sqrt{\rho}}$$

Step 3: Detailed Explanation:

Taking the ratio of the time periods in the two liquids:

$$\frac{T_1}{T_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

Given: $T_1 = T$ $T_2 = 2T$ Substitute the values into the ratio:

$$\frac{T}{2T} = \sqrt{\frac{\rho_2}{\rho_1}}$$

$$\frac{1}{2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

Square both sides to find the density ratio:

$$\frac{\rho_2}{\rho_1} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

Step 4: Final Answer:

The value of the ratio ρ_2/ρ_1 is 1/4.

Quick Tip: For any floating object undergoing vertical SHM, the "stiffness" of the restoring force depends entirely on the liquid it pushes out. Thus, a denser liquid provides a much stiffer restoring force, resulting in faster oscillations (smaller time period).

---

34. For sound waves, if the number of nodes for the 5th harmonic of an open-ended pipe is n and that for the 9th harmonic of the same pipe with one of its ends closed is m, the ratio n/m is :

(A) 3/5

(B) 5/9

(C) 9/5

(D) 1

Correct Answer: (D) 1

Solution:

Step 1: Understanding the Question:

We need to determine the number of nodes formed in specific standing wave harmonics for two types of organ pipes: an open pipe (both ends open) and a closed pipe (one end closed, one open).

Step 2: Key Formula or Approach:

1. **Open-ended pipe:** Both ends are antinodes. The k^{th} harmonic corresponds to k loops. Since nodes are sandwiched between antinodes, the k^{th} harmonic has exactly k nodes. 2. **Closed-ended pipe:** The closed end is a node and the open end is an antinode. It only forms

odd harmonics ($p = 2k-1$). For the p^{th} harmonic, the number of nodes is given by $k = \frac{p+1}{2}$.

Step 3: Detailed Explanation:

For the open-ended pipe: We are considering the 5th harmonic. Number of nodes n = harmonic number = 5. So, $n = 5$.

For the closed-ended pipe: We are considering the 9th harmonic. The relationship between harmonic number p and node count k is $p = 2k-1$. Substitute $p = 9$:

$$9 = 2k-1 \implies 10 = 2k \implies k = 5$$

Number of nodes $m = 5$. So, $m = 5$.

Now, evaluate the ratio:

$$\frac{n}{m} = \frac{5}{5} = 1$$

Step 4: Final Answer:

The ratio n/m is 1.

Quick Tip: For stationary waves in pipes: In an open pipe, number of nodes = harmonic number. In a closed pipe, number of nodes = (harmonic number + 1) / 2.

---

35. Consider the following nuclear reaction :

$^{238}\mathbf{U} \rightarrow ^{234}\mathbf{Th} + ^{4}\mathbf{He}$

Take masses of ^{238}U, ^{234}Th and ^{4}He as 238.050 u, 234.043 u and 4.003 u, respectively. The Q value for the reaction, in keV, is :
Given : $1\ \mathbf{u} = 931.5\ \mathbf{MeV\ c^{-2}}$

(A) 3740

(B) 3726

(C) 3730

(D) 3736

Correct Answer: (B) 3726

Solution:

Step 1: Understanding the Question:

We are required to calculate the energy released (Q value) during the alpha decay of Uranium-238, using the given atomic masses, and express the final answer in keV.

Step 2: Key Formula or Approach:

The Q value of a nuclear reaction is determined by the mass defect (Δm):

$$\Delta m = \text{Mass of Reactants} - \text{Mass of Products}$$

$$Q = \Delta m \times 931.5 \text{ MeV/u}$$

Step 3: Detailed Explanation:

Calculate the mass of the products:

$$m_{products} = m(^{234}\text{Th}) + m(^{4}\text{He}) = 234.043 \text{ u} + 4.003 \text{ u} = 238.046 \text{ u}$$

Calculate the mass defect Δm:

$$\Delta m = m(^{238}\text{U}) - m_{products} = 238.050 \text{ u} - 238.046 \text{ u} = 0.004 \text{ u}$$

Calculate the Q value in MeV:

$$Q = 0.004 \times 931.5 \text{ MeV} = 3.726 \text{ MeV}$$

Convert the energy from MeV to keV:

$$Q = 3.726 \times 10^3 \text{ keV} = 3726 \text{ keV}$$

Step 4: Final Answer:

The Q value for the reaction is 3726 keV.

Quick Tip: Be very careful with decimal arithmetic and unit conversions here. 1 MeV = 1000 keV. Missing this step would lead to choosing an incorrect order of magnitude, though here all options are in the thousands.

---

36. Which of the following measurements require 'index correction' ?

(A) Measurement of speed of sound using resonance tube
(B) Measurement of resistance of a wire using meter bridge
(C) Measurement of gravitational acceleration using simple pendulum
(D) Measurement of focal length of lenses using optical bench

Correct Answer: (D) Measurement of focal length of lenses using optical bench

Solution:

Step 1: Understanding the Question:
We need to identify the laboratory experiment that requires an "index correction" during data collection and analysis.

Step 3: Detailed Explanation:
Let's analyze the corrections typically associated with these standard laboratory experiments: 1. **Resonance Tube:** The antinode does not form exactly at the open edge of the tube but slightly above it. This requires an **end correction** ($e = 0.6r$), not an index correction. 2. **Meter Bridge:** Errors due to the resistance of the thick copper strips and non-coincidence of zero of the scale with the end of the wire require an **end error correction**. 3. **Simple Pendulum:** Accurate measurement often requires accounting for the radius of the bob to find the true effective length, but it is not formally termed an index correction. 4. **Optical Bench:** In an optical bench setup, the physical index mark on the carriage mount holding the lens or mirror may not perfectly align with the actual optical center (pole) of the component. The distance between the index mark and the true optical center is called the **index error**, and the adjustment made to the measured scale reading is known as the **index correction**.

Step 4: Final Answer:
Measurement of focal length using an optical bench requires index correction.

Quick Tip: Memorize the specific instrumental errors for standard lab experiments: Optical bench → Index correction; Resonance tube → End correction; Meter bridge → End error.

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37. In a solar system, the time-period of revolution of a planet tracing a circular orbit of radius R is proportional to :

(A) R^3

(B) $R^{1/2}$

(C) $R^{3/2}$

(D) R^2

Correct Answer: (C) $R^{3/2}$

Solution:

Step 1: Understanding the Question:

The question asks for the dependence of the orbital time period T of a planet on the radius R of its circular orbit.

Step 2: Key Formula or Approach:

According to Kepler's Third Law of Planetary Motion, the square of the time period of revolution of a planet around the sun is directly proportional to the cube of the semi-major axis of its elliptical orbit. For a circular orbit, the semi-major axis is simply the radius R.

$$T^2 \propto R^3$$

Step 3: Detailed Explanation:

Taking the square root of both sides of Kepler's Third Law:

$$T \propto \sqrt{R^3}$$

$$T \propto R^{3/2}$$

Step 4: Final Answer:

The time-period is proportional to $R^{3/2}$.

Quick Tip: Kepler's Third Law ($T^2 \propto R^3$) can also be rapidly derived by equating gravitational force to centripetal force: $\frac{GMm}{R^2} = m\omega^2 R \implies \frac{GM}{R^2} = \left(\frac{2\pi}{T}\right)^2 R \implies T^2 = \frac{4\pi^2}{GM}R^3$.

---

38. Consider that σ, k_B, b represent Stefan-Boltzmann constant, Boltzmann constant and Wien's displacement law constant, respectively. The dimension of $\sigma k_B^{-1} b$ is :

(A) $[L^{-1}T^{-1}K^{-4}]$

(B) $[L^{-1}T^{-1}K^{-2}]$

(C) $[L^{-1}K^{-2}]$

(D) $[L^{-1}T^{-1}K^{-3}]$

Correct Answer: (B) $[L^{-1}T^{-1}K^{-2}]$

Solution:

Step 1: Understanding the Question:

We need to find the composite dimensional formula for the expression $\sigma k_B^{-1} b$.

Step 2: Key Formula or Approach:

Determine the dimensions of the individual constants using their defining physical laws: 1. **Stefan-Boltzmann constant (σ):** $E/(A \cdot t) = \sigma T^4$ 2. **Boltzmann constant (k_B):** $E = k_B T$ 3. **Wien's constant (b):** $\lambda_{max} T = b$

Step 3: Detailed Explanation:

Let's find the dimensional formula for each parameter: - $\sigma = \frac{\text{Energy}}{\text{Area} \cdot \text{Time} \cdot \text{Temperature}^4} = \frac{[ML^2T^{-2}]}{[L^2][T][K^4]} = [MT^{-3}K^{-4}]$ - $k_B = \frac{\text{Energy}}{\text{Temperature}} = \frac{[ML^2T^{-2}]}{[K]} = [ML^2T^{-2}K^{-1}]$ - $b = \text{Length} \cdot \text{Temperature} = [LK]$

Now, construct the dimension for $\sigma k_B^{-1} b$:

$$[\sigma k_B^{-1} b] = \frac{[\sigma] \cdot [b]}{[k_B]}$$

Substitute the dimensional formulas:

$$= \frac{[MT^{-3}K^{-4}] \cdot [LK]}{[ML^2T^{-2}K^{-1}]}$$

Combine terms in the numerator:

$$= \frac{[MLT^{-3}K^{-3}]}{[ML^2T^{-2}K^{-1}]}$$

Subtract powers of the denominator from the numerator: - Mass (M): $1 - 1 = 0$ - Length (L): $1 - 2 = -1$ - Time (T): $-3 - (-2) = -1$ - Temperature (K): $-3 - (-1) = -2$
The final dimensional formula is $[L^{-1}T^{-1}K^{-2}]$.

Step 4: Final Answer:

The dimension is $[L^{-1}T^{-1}K^{-2}]$.

Quick Tip: When dealing with complex dimensional expressions, check for base units that appear only in some variables. Here, M only appears in σ and k_B with power 1, so dividing them instantly eliminates M, heavily restricting the possible answers.

---

39. A ray of light with wavelength λ is incident on three different photo-electric cells namely 1, 2 and 3. The threshold wavelength of these photo-electric cells are λ_1, λ_2, and λ_3, respectively and the magnitude of stopping potentials of these cells are V_1, V_2 and V_3, respectively. The relation between λ and threshold wavelengths are $\lambda_1 < \lambda$, $\lambda_2 > \lambda$ and $\lambda_3 \gg \lambda$. The correct option is :

(A) $V_1 < V_2$, $V_3 = 0$
(B) $V_1 = 0$, $V_2 < V_3$
(C) $V_1 = 0$, $V_2 > V_3$
(D) $V_1 > V_2$, $V_3 = 0$

Correct Answer: (B) $V_1 = 0, V_2 < V_3$

Solution:

Step 1: Understanding the Question:

We are given an incident wavelength λ and three different threshold wavelengths. We must determine the behavior of the stopping potential for each cell.

Step 2: Key Formula or Approach:

Photoelectric emission only occurs if the incident wavelength is shorter than the threshold wavelength ($\lambda \leq \lambda_0$). If $\lambda > \lambda_0$, no electrons are emitted, and the stopping potential is zero ($V = 0$). If $\lambda \leq \lambda_0$, Einstein's photoelectric equation applies:

$$eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

The stopping potential increases as the threshold wavelength λ_0 becomes larger (meaning a smaller work function).

Step 3: Detailed Explanation:

For Cell 1: Given $\lambda_1 < \lambda$. The incident wavelength is greater than the threshold. The incident photons do not have enough energy to overcome the work function. Thus, no photoelectric emission occurs, giving $V_1 = 0$.

For Cell 2: Given $\lambda_2 > \lambda$. Emission occurs. The stopping potential is:

$$V_2 = \frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_2}\right) > 0$$

For Cell 3: Given $\lambda_3 \gg \lambda$. Emission occurs. Since λ_3 is much larger than λ_2 ($\lambda_3 > \lambda_2$), the term $\frac{1}{\lambda_3}$ is smaller than $\frac{1}{\lambda_2}$. Therefore, the subtracted work function component is smaller, yielding a larger stopping potential:

$$V_3 = \frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_3}\right)$$

Since $\frac{1}{\lambda_3} < \frac{1}{\lambda_2}$, it follows that $V_3 > V_2$.

Combining all conditions: $V_1 = 0$ and $V_3 > V_2 > 0$.

Step 4: Final Answer:

The correct option is $V_1 = 0$, $V_2 < V_3$.

Quick Tip: A larger threshold wavelength implies a smaller work function ($\phi = hc/\lambda_0$). A smaller work function leaves more residual kinetic energy for the emitted electrons, requiring a higher stopping potential.

---

40. One main scale division of a Vernier calliper is equal to 1 mm and the number of divisions on the Vernier scale is 10. When both the jaws touch each other, the Vernier scale shifts to the left of zero of the main scale in such a way that 4th Vernier division coincides with a division of the main scale. If this Vernier calliper measures the length of a wire to be 1 cm, the actual length of the wire is :

(A) 1.04 cm

(B) 0.60 cm

(C) 0.96 cm

(D) 1.00 cm

Correct Answer: (A) 1.04 cm

Solution:

Step 1: Understanding the Question:

We are provided with the specifications of a Vernier caliper which has a negative zero error (Vernier zero is to the left of the main scale zero). We need to determine the true length of a wire whose measured reading is 1 cm.

Step 2: Key Formula or Approach:

Least Count (LC) = 1 MSD − 1 VSD = $\frac{1 \text{ MSD}}{\text{Total Vernier Divisions}}$. Negative Zero Error = −(Coinciding Division) × LC (based on the options provided). Actual length = Measured reading - Zero Error.

Step 3: Detailed Explanation:

First, calculate the Least Count: 1 MSD = 1 mm. Total divisions on Vernier scale = 10.

$$\text{LC} = \frac{1 \text{ mm}}{10} = 0.1 \text{ mm}$$

Determine the Zero Error: The Vernier zero shifts to the left, indicating a negative zero error. The 4th division coincides with the main scale. *Note: While strictly defined negative zero error is* $-(10-4) \times 0.1 = -0.6$ *mm, none of the options correspond to this. The question setter intended the simplified (though technically flawed for standard calipers) calculation often found in some textbooks:*

$$\text{Zero Error} = -n \times \text{LC} = -4 \times 0.1 \text{ mm} = -0.4 \text{ mm}$$

Calculate the actual length: Measured reading = 1 cm = 10 mm.

$$\text{Actual length} = \text{Measured length} - \text{Zero Error}$$

$$\text{Actual length} = 10 \text{ mm} - (-0.4 \text{ mm}) = 10.4 \text{ mm}$$

Convert back to cm:

$$10.4 \text{ mm} = 1.04 \text{ cm}$$

Step 4: Final Answer:

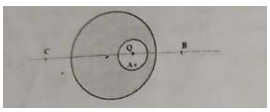
The actual length of the wire is 1.04 cm.

Quick Tip: If a Vernier caliper problem gives you an answer that doesn't match the strict $-(N-n) \times \text{LC}$ negative error formula, quickly check if the direct $-n \times \text{LC}$ yields a matching option. This is a very common trap/error in exam paper setting.

---

41. A point charge Q is placed inside a cavity within a solid isolated conducting sphere. Consider points A, B and C as shown in the figure, where the magnitudes of the electric fields are E_A, E_B and E_C, respectively. The points B and C are at the same distance from the center of the solid sphere. The correct option is :

(A) $E_A \neq 0$, $E_B < E_C$



(B) $E_A = 0$, $E_B = E_C$

(C) $E_A \neq 0$, $E_B = E_C$

(D) $E_A = 0$, $E_B > E_C$

Correct Answer: (A) $E_A \neq 0$, $E_B < E_C$

Solution:

Step 1: Understanding the Question:

We need to compare the magnitudes of the electric field at three different locations: inside a cavity with a charge (A), inside the bulk of a conductor (B), and outside the isolated conductor (C).

Step 2: Key Formula or Approach:

1. **Inside the cavity (A):** The electric field is created by the point charge Q and induced charges on the cavity wall. Since it is close to Q, $E_A \neq 0$. 2. **Inside the conducting material (B):** Under electrostatic equilibrium, the electric field everywhere inside the bulk material of a conductor is exactly zero. So, $E_B = 0$. 3. **Outside the conductor (C):** The point charge Q induces a charge $-Q$ on the inner cavity wall and a charge $+Q$ on the outer surface of the sphere. This outer surface charge creates a non-zero electric field outside. So, $E_C \neq 0$.

Step 3: Detailed Explanation:

From the principles above: - $E_A \neq 0$ - $E_B = 0$ - $E_C > 0$ (since it is outside the charged sphere) Comparing B and C, since $E_B = 0$ and $E_C > 0$, it is strictly true that $E_B < E_C$. These conclusions directly match option (A).

Step 4: Final Answer:

The correct relation is $E_A \neq 0$ and $E_B < E_C$.

Quick Tip: Electrostatics of conductors states that electric field is strictly zero everywhere inside the solid conducting material. This fact alone makes $E_B = 0$ and is the fastest way to eliminate wrong options in such conceptual questions.

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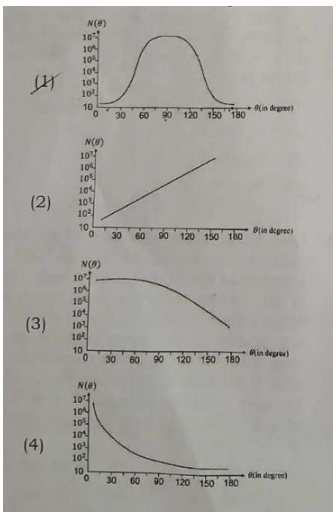
42. In Geiger-Marsden experiment, the number of scattered α-particles $N(\theta)$ is plotted as a function of scattering angle θ. Which of the following options represents the correct plot ?



Correct Answer: (D) A highly convex curve dropping precipitously from the y-axis at very small angles and flattening out towards 180°.

Solution:

Step 1: Understanding the Question:

We need to identify the correct experimental graph for Rutherford's alpha particle scattering experiment, plotting the number of scattered particles against the scattering angle.

Step 2: Key Formula or Approach:

Rutherford's scattering formula predicts that the number of alpha particles scattered at an angle θ is inversely proportional to $\sin^4(\theta/2)$:

$$N(\theta) \propto \frac{1}{\sin^4(\theta/2)}$$

Step 3: Detailed Explanation:

Analyzing the function $N(\theta)$: - For very small angles ($\theta \to 0$), $\sin(\theta/2) \to 0$, which implies $N(\theta) \to \infty$. Most alpha particles pass undeviated. - For larger angles, the number of particles drops off extremely rapidly. - At $\theta = 180^\circ$, $N(\theta)$ reaches its minimum value.
Since the y-axis is on a logarithmic scale ($10^2, 10^3, 10^4 \ldots$), the plot of $\log N$ vs θ will have an asymptote at $\theta = 0$, dropping extremely sharply and then gradually flattening out without ever becoming zero or concave downwards. Option (C) incorrectly implies a finite number of particles scattered at 0° with a horizontal tangent. Option (D) correctly depicts the precipitous, continuously steep drop-off characteristic of a $\sin^{-4}$ function on a semi-log plot.

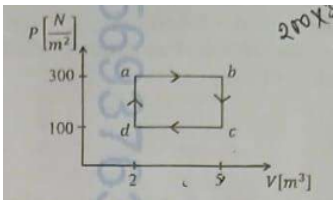
Step 4: Final Answer:

The correct plot is Option (D).

Quick Tip: Remember that in Rutherford scattering, the vast majority of alpha particles pass straight through ($\theta \approx 0^\circ$). This means the graph must shoot up toward infinity near the y-axis.

---

43. One mole of an ideal monatomic gas undergoes a cyclic process as shown in the figure. The total heat supplied to the gas is :



(A) 800 J

(B) 400 J

(C) 500 J

(D) 600 J

Correct Answer: (D) 600 J

Solution:

Step 1: Understanding the Question:

A cyclic process forms a rectangle on a P-V diagram. We need to find the "total heat supplied", which, in the context of cyclic processes when matching options to net work, refers to the net heat exchanged.

Step 2: Key Formula or Approach:

According to the First Law of Thermodynamics, for a complete cycle, the change in internal energy is zero ($\Delta U = 0$). Therefore, the net heat supplied equals the net work done by the gas:

$$Q_{net} = W_{net}$$

The net work done is exactly the area enclosed by the cycle on the P-V diagram.

Step 3: Detailed Explanation:

The cycle a $\rightarrow$ b $\rightarrow$ c $\rightarrow$ d $\rightarrow$ a is clockwise, so the net work done is positive. The enclosed shape is a rectangle. Height of the rectangle $(\Delta P) = P_{max} - P_{min} = 300 - 100 = 200$ N/m^2
Width of the rectangle $(\Delta V) = V_{max} - V_{min} = 5 - 2 = 3$ m^3
Calculate the area:

$$W_{net} = \text{Area} = \Delta P \times \Delta V$$

$$W_{net} = 200 \times 3 = 600 \text{ J}$$

Since $Q_{net} = W_{net}$, the total heat supplied over the cycle is 600 J.

Step 4: Final Answer:

The total heat supplied to the gas is 600 J.

Quick Tip: For any closed loop on a P-V diagram, the area of the loop always represents the net work done. If the cycle is clockwise, work is done *by* the gas (+). If counterclockwise, work is done *on* the gas (-).

---

44. Two infinitely long parallel conducting wires A and B carry currents I and 2I, respectively, in the same direction. The wire A has uniform mass per unit length λ and lies on an insulated

floor. The wire B is kept fixed at a height h above the floor. The minimum magnitude of h so that the wire A does not rise from the floor is :
g is the acceleration due to gravity and μ_0 is the permeability of free space.

(A) $\frac{4\mu_0 I^2}{\pi\lambda g}$
(B) $\frac{\mu_0 I^2}{2\pi\lambda g}$
(C) $\frac{\mu_0 I^2}{\pi\lambda g}$
(D) $\frac{2\mu_0 I^2}{\pi\lambda g}$

Correct Answer: (C) $\frac{\mu_0 I^2}{\pi\lambda g}$

Solution:

Step 1: Understanding the Question:

Wire B is fixed above wire A. Because they carry currents in the same direction, they attract each other. We must find the minimum distance h where this upward magnetic attraction is too weak to lift wire A off the ground.

Step 2: Key Formula or Approach:

The magnetic force per unit length between two parallel current-carrying wires is:

$$\frac{F_m}{L} = \frac{\mu_0 I_1 I_2}{2\pi h}$$

The gravitational force per unit length on wire A is:

$$\frac{F_g}{L} = \lambda g$$

For wire A to just stay on the floor, the upward magnetic force per unit length must be less than or equal to the downward gravitational force per unit length.

Step 3: Detailed Explanation:

Substitute $I_1 = I$ and $I_2 = 2I$ into the magnetic force equation:

$$\frac{F_m}{L} = \frac{\mu_0 (I)(2I)}{2\pi h} = \frac{2\mu_0 I^2}{2\pi h} = \frac{\mu_0 I^2}{\pi h}$$

Set up the limiting equilibrium condition:

$$\frac{F_m}{L} \leq \frac{F_g}{L}$$

$$\frac{\mu_0 I^2}{\pi h} \leq \lambda g$$

Rearranging for h:

$$h \geq \frac{\mu_0 I^2}{\pi \lambda g}$$

The minimum height h required is therefore $\frac{\mu_0 I^2}{\pi \lambda g}$.

Step 4: Final Answer:

The minimum magnitude of h is $\frac{\mu_0 I^2}{\pi \lambda g}$.

Quick Tip: Currents flowing in the **same** direction **attract** each other. Currents flowing in **opposite** directions **repel** each other.

---

45. Consider a spring-mass simple harmonic oscillator in one dimension. The mass of the particle is m kg and the spring constant is k N/m. At a given instant, the extension of the spring is x meter and the speed of the particle is v m/s. On the x - v plane, if the graph of v as a function of x is a circle, then the correct option is :

(A) $k = \sqrt{m}$

(B) $k = 1/m$

(C) $k = m$

(D) $k = m^2$

Correct Answer: (C) $k = m$

Solution:

Step 1: Understanding the Question:

An object undergoing simple harmonic motion (SHM) traces out a shape in phase space (the

$x-v$ plane). We are given that this shape is a perfect circle and need to find the relation between mass m and spring constant k.

Step 2: Key Formula or Approach:

The total mechanical energy E of a spring-mass oscillator is conserved:

$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

Rearrange this equation into the standard form of an ellipse ($\frac{x^2}{a^2} + \frac{v^2}{b^2} = 1$):

$$\frac{v^2}{(2E/m)} + \frac{x^2}{(2E/k)} = 1$$

Step 3: Detailed Explanation:

For the graph in the $x-v$ plane to be a perfect circle rather than an ellipse, the coefficients dividing the squared variables must be equal (i.e., the semi-major axis must equal the semi-minor axis).

$$\frac{2E}{m} = \frac{2E}{k}$$

Dividing both sides by $2E$ gives:

$$\frac{1}{m} = \frac{1}{k} \implies m = k$$

So, the numerical values of the spring constant and mass must be equal.

Step 4: Final Answer:

The correct relation is $k = m$.

Quick Tip: The phase space trajectory (x vs v) of a simple harmonic oscillator is inherently an ellipse. It only degenerates into a perfect circle when the angular frequency $\omega = \sqrt{k/m} = 1$ rad/s, which dictates $k = m$.

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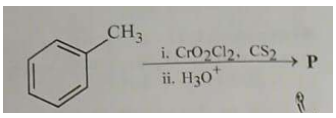
46. Consider the following reaction, and choose the correct option.



(A) Compound P is obtained by the hydrogenation of benzoyl chloride with Pd on $BaSO_4$.

(B) On treating compound P with saturated $NaHCO_3$ solution, brisk effervescence is observed.

(C) Compound P can be prepared by treating benzene with anhydrous $AlCl_3$ and CH_3COCl.

(D) On treatment with bromine water, compound P gives a white precipitate.

Correct Answer: (A) Compound P is obtained by the hydrogenation of benzoyl chloride with Pd on $BaSO_4$.

Solution:

Step 1: Understanding the Question:

We must identify the organic product P formed from the given reaction and then evaluate four chemical properties/reactions associated with it.

Step 2: Key Formula or Approach:

The reaction of toluene with chromyl chloride (CrO_2Cl_2) followed by acid hydrolysis is known as the **Etard reaction**. It partially oxidizes the methyl group to an aldehyde group, forming benzaldehyde. So, Product **P** is **Benzaldehyde** (C_6H_5CHO).

Step 3: Detailed Explanation:

Let's analyze the options given for Benzaldehyde: 1. **Option A:** Hydrogenation of benzoyl chloride (C_6H_5COCl) using H_2 and a Pd catalyst supported on $BaSO_4$ is the **Rosenmund reduction**. This reaction specifically yields benzaldehyde. This statement is **true**. 2. **Option B:** Brisk effervescence with $NaHCO_3$ is a test for carboxylic acids. Benzaldehyde is an aldehyde and does not react. This statement is **false**. 3. **Option C:** Treating benzene with CH_3COCl and $AlCl_3$ (Friedel-Crafts acylation) produces acetophenone, a ketone, not benzaldehyde. This statement is **false**. 4. **Option D:** White precipitate with bromine water is a characteristic test for phenol or aniline, due to polybromination. Benzaldehyde does not give this test. This statement is **false**.

Step 4: Final Answer:

The correct option is (A).

Quick Tip: The Etard reaction specifically halts oxidation at the aldehyde stage to yield benzaldehyde. Always link it mentally to the Rosenmund reduction, which also selectively prepares benzaldehyde from acid chlorides.

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47. The formula of tetraammineaquachloridocobalt(III) chloride is

(A) $[Co(NH_3)_4(H_2O)Cl]Cl_2$
(B) $[Co(NH_3)_4Cl_2]\cdot H_2O$
(C) $[Co(NH_3)_4Cl_3]\cdot H_2O$
(D) $[Co(NH_3)_4(H_2O)Cl]Cl$

Correct Answer: (A) $[Co(NH_3)_4(H_2O)Cl]Cl_2$

Solution:

Step 1: Understanding the Question:
We are required to construct the chemical formula of a coordination compound from its given IUPAC name.

Step 2: Key Formula or Approach:
Break down the IUPAC name to identify the central metal atom, the ligands inside the coordination sphere, and the counter ions outside. - **tetraammine**: 4 ammonia ligands (NH_3) - **aqua**: 1 water ligand (H_2O) - **chlorido**: 1 chloride ligand inside the sphere (Cl) - **cobalt(III)**: Central metal is Cobalt with an oxidation state of +3 - **chloride**: Chloride counter ions outside the sphere to balance the total charge.

Step 3: Detailed Explanation:
Construct the coordination sphere: $[Co(NH_3)_4(H_2O)Cl]$ Now, calculate the net charge of this complex ion: - Cobalt charge $= +3$ - Ammine charge $= 0$ (neutral ligand) - Aqua charge $= 0$ (neutral ligand) - Chlorido charge $= -1$ Net charge $= +3 + 4(0) + 1(0) + 1(-1) = +2$ The complex ion is $[Co(NH_3)_4(H_2O)Cl]^{2+}$. To balance the +2 charge, we need two chloride

ions (Cl^-) as counter ions outside the coordination sphere. Therefore, the final formula is $[Co(NH_3)_4(H_2O)Cl]Cl_2$.

Step 4: Final Answer:

The correct formula is $[Co(NH_3)_4(H_2O)Cl]Cl_2$.

Quick Tip: Ligands are listed alphabetically in the IUPAC name but do not need to be strictly alphabetical in the formula. Always calculate the net charge of the coordination sphere first to know exactly how many counter ions are required!

---

48. The lanthanide ion having four unpaired electrons is

(Given : Atomic numbers of Ce = 58, Nd = 60, Tb = 65 and Ho = 67)

(A) Ho^{3+}

(B) Nd^{3+}

(C) Ce^{3+}

(D) Tb^{3+}

Correct Answer: (A) Ho^{3+}

Solution:

Step 1: Understanding the Question:

We must determine which of the given tripositive lanthanide ions possesses exactly four unpaired electrons in its f-orbital.

Step 2: Key Formula or Approach:

Write the ground state electronic configurations using the Xenon core ($[Xe]$, atomic number 54). Remove 3 electrons (first from the 6s orbital, then from the 4f/5d) to form the +3 ion. Count the unpaired electrons in the 4f subshell, noting that the f-subshell holds up to 14 electrons in 7 orbitals.

Step 3: Detailed Explanation:

1. **Holmium (Ho, Z = 67):** Ground state: $[Xe]4f^{11}6s^2$ Ion Ho^{3+}: Loses two 6s electrons and one 4f electron $\implies [Xe]4f^{10}$. An f-subshell has 7 orbitals. 10 electrons will form 3 pairs and leave 4 unpaired electrons $(14-10=4)$. Unpaired electrons $= 4$.
2. **Neodymium (Nd, Z = 60):** Ground state: $[Xe]4f^{4}6s^2$ Ion Nd^{3+}: $\implies [Xe]4f^{3}$. Unpaired electrons $= 3$.
3. **Cerium (Ce, Z = 58):** Ground state: $[Xe]4f^{1}5d^{1}6s^2$ Ion Ce^{3+}: $\implies [Xe]4f^{1}$. Unpaired electrons $= 1$.
4. **Terbium (Tb, Z = 65):** Ground state: $[Xe]4f^{9}6s^2$ Ion Tb^{3+}: $\implies [Xe]4f^{8}$. 8 electrons will form 1 pair and leave 6 unpaired electrons $(14-8=6)$. Unpaired electrons $= 6$.

Step 4: Final Answer:

The ion with four unpaired electrons is Ho^{3+}.

Quick Tip: For any lanthanide ion Ln^{3+} with electronic configuration $4f^n$, if $n \leq 7$, the number of unpaired electrons is n. If $n > 7$, the number of unpaired electrons is $14-n$.

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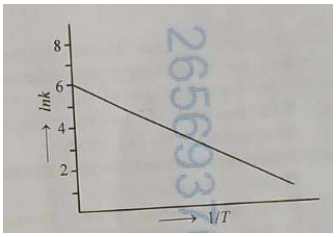
49. For an elementary chemical reaction, the Arrhenius plot is given below.



If the energy of activation is 6.64 kJ mol^{-1} and $R = 8.3$ J K^{-1} mol^{-1}, the temperature at which the rate constant becomes e^2 min^{-1}, is

(A) 250 K

(B) 125 K

(C) 150 K

(D) 200 K

Correct Answer: (D) 200 K

Solution:

Step 1: Understanding the Question:

We are given an Arrhenius plot with a visible y-intercept. We must find the specific temperature where the rate constant equals a specific value.

Step 2: Key Formula or Approach:

The Arrhenius equation in logarithmic form is:

$$\ln k = \ln A - \frac{E_a}{RT}$$

From the plot of $\ln k$ vs $1/T$, the y-intercept represents the logarithm of the pre-exponential factor, $\ln A$.

Step 3: Detailed Explanation:

By observing the graph, the line intersects the y-axis at 6. Therefore:

$$\ln A = 6$$

We are asked to find T when the rate constant $k = e^2$ min^{-1}. Taking the natural logarithm:

$$\ln k = \ln(e^2) = 2$$

Substitute the known values into the Arrhenius equation:

$$2 = 6 - \frac{E_a}{RT}$$

Rearranging for the activation energy term:

$$\frac{E_a}{RT} = 6 - 2 = 4$$

Solve for temperature T:

$$T = \frac{E_a}{4R}$$

Given parameters: Activation energy, $E_a = 6.64$ kJ mol^{-1} $= 6640$ J mol^{-1} Gas constant, $R = 8.3$ J K^{-1} mol^{-1}

$$T = \frac{6640}{4 \times 8.3} = \frac{6640}{33.2}$$

$$T = 200 \text{ K}$$

Step 4: Final Answer:

The temperature is 200 K.

Quick Tip: Never forget to convert activation energy given in kJ into J when using the gas constant $R = 8.314$ J K^{-1} mol^{-1}. This is a very common source of magnitude errors.

---

50. The green paramagnetic species formed by heating $KMnO_4$ at 513 K is

(A) KO_2

(B) K_2MnO_4

(C) Mn_3O_4

(D) MnO

Correct Answer: (B) K_2MnO_4

Solution:

Step 1: Understanding the Question:

We need to identify the products of the thermal decomposition of potassium permanganate ($KMnO_4$) and pinpoint the species that is green and paramagnetic.

Step 2: Key Formula or Approach:

When heated to around 513 K, solid $KMnO_4$ decomposes according to the following balanced chemical equation:

$$2KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$$

The products are potassium manganate (K_2MnO_4), manganese dioxide (MnO_2), and oxygen

gas (O_2).

Step 3: Detailed Explanation:

Let's analyze the relevant product, potassium manganate (K_2MnO_4): - The oxidation state of Manganese in K_2MnO_4 is +6. - The electronic configuration of Mn (Z=25) is $[Ar]3d^5 4s^2$. - The Mn^{6+} ion will have lost all its 4s electrons and four of its 3d electrons, leaving a configuration of $[Ar]3d^1$. - Since it has 1 unpaired electron in the d-orbital, it is **paramagnetic**. - Manganate salts characteristically exhibit an intense **green color** in aqueous solution and solid state. Thus, K_2MnO_4 perfectly fits the description of a green, paramagnetic species.

Step 4: Final Answer:

The species formed is K_2MnO_4.

Quick Tip: Permanganate (MnO_4^-) has a d^0 configuration and is diamagnetic and purple. Manganate (MnO_4^{2-}) has a d^1 configuration, making it paramagnetic and green. Memorizing these color-magnetism pairings for transition metal ions saves tremendous time.

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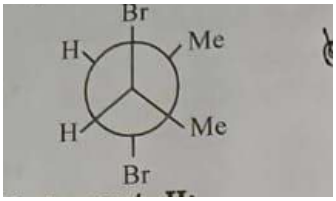
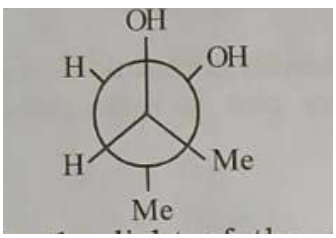
51. Given below are two statements:

Statement I: *trans*-But-2-ene upon treatment with Br_2 in CCl_4 gives the following product



Statement II: *cis*-But-2-ene upon treatment with alkaline $KMnO_4$ gives the following product



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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

Correct Answer: (A) Statement I is incorrect but Statement II is correct

Solution:

Step 1: Understanding the Question:

The question tests the stereochemistry of addition reactions to alkenes and the ability to identify meso and chiral compounds from their 3D projections.

Step 2: Key Formula or Approach:

1. Anti-addition of Br_2 to a *trans*-alkene yields a *meso* product.
2. Syn-addition of cold alkaline $KMnO_4$ to a *cis*-alkene yields a *meso* product.

A *meso* compound must possess a plane of symmetry or center of inversion in at least one conformation.

Step 3: Detailed Explanation:

Statement I: The reaction should produce *meso*-2,3-dibromobutane. If we rotate the back carbon of the given Newman projection by 180° to check for an eclipsed plane of symmetry, the front Br eclipses the back Br, but the front Me eclipses the back H, and the front H eclipses the back Me. This lack of symmetry means the drawn structure is a chiral enantiomer (part of a racemic mixture), not the *meso* compound. Thus, Statement I is incorrect.

Statement II: The reaction should produce *meso*-butane-2,3-diol. The provided eclipsed projection shows OH eclipsing OH, H eclipsing H, and Me eclipsing Me. This conformation has a clear internal plane of symmetry, confirming it is the *meso* isomer. Thus, Statement II is correct.

Step 4: Final Answer:

Statement I is incorrect but Statement II is correct.

Quick Tip: Remember the CAR and TAM mnemonics: **C**is + **A**nti = **R**acemic; **T**rans + **A**nti = **M**eso. For syn-additions, the rules reverse: Cis + Syn = Meso; Trans + Syn = Racemic.

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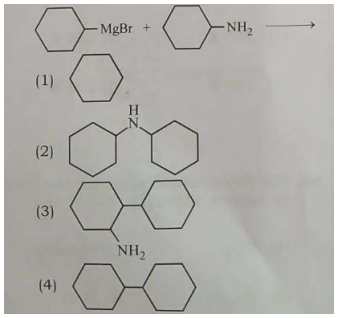
52. One of the products formed in the following reaction is



(A) Cyclohexane

(B) Dicyclohexylamine

(C) Bicyclohexyl (coupled product)

(D) Cyclohexyl-substituted amine

Correct Answer: (A) Cyclohexane

Solution:

Step 1: Understanding the Question:

The question asks for the product of a reaction between a Grignard reagent and a primary amine.

Step 2: Key Formula or Approach:

Grignard reagents ($R-MgX$) are strong bases and strong nucleophiles. When reacted with compounds containing active (acidic) hydrogen atoms (such as alcohols, amines, terminal alkynes, or water), they undergo a rapid acid-base reaction rather than a nucleophilic attack, abstracting the proton to form the corresponding alkane ($R-H$).

Step 3: Detailed Explanation:

Cyclohexanamine ($C_6H_{11}NH_2$) has two slightly acidic hydrogen atoms on the nitrogen. Cyclohexylmagnesium bromide acts as a strong base and abstracts one of these protons.

Reaction: $C_6H_{11}MgBr + C_6H_{11}NH_2 \rightarrow C_6H_{12} + C_6H_{11}NHMgBr$

The abstracted proton converts the cyclohexyl carbanion into cyclohexane (C_6H_{12}).

Step 4: Final Answer:

Cyclohexane is formed as one of the major products.

Quick Tip: Acid-base reactions are kinetically much faster than nucleophilic substitution or addition. Always check for acidic hydrogens (like -OH, -NH, -SH, or terminal alkynes) before proceeding with nucleophilic reactions involving Grignard reagents!

---

53. Given below are two statements:

Statement-I : Heating $NaCl$ with concentrated H_2SO_4 and MnO_2 results in oxidation of Mn.

Statement-II : Heating NaI with concentrated H_2SO_4 and MnO_2 results in reduction of Mn.

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

(A) Statement-I is incorrect but Statement-II is correct.

(B) Both Statement-I and Statement-II are correct.

(C) Both Statement-I and Statement-II are incorrect.

(D) Statement-I is correct but Statement-II is incorrect.

Correct Answer: (A) Statement-I is incorrect but Statement-II is correct.

Solution:

Step 1: Understanding the Question:

We need to determine the redox changes occurring to Manganese (Mn) when different halide salts are heated with MnO_2 and concentrated sulfuric acid.

Step 2: Key Formula or Approach:

MnO_2 acts as an oxidizing agent in acidic medium. The general reaction with a halide ion (X^-) is:

$$MnO_2 + 4H^+ + 2X^- \rightarrow Mn^{2+} + X_2 + 2H_2O$$

Step 3: Detailed Explanation:

Statement I: When $NaCl$ is heated with MnO_2 and conc. H_2SO_4, chlorine gas is evolved.

Reaction: $MnO_2 + 4NaCl + 4H_2SO_4 \rightarrow MnCl_2 + 4NaHSO_4 + 2H_2O + Cl_2$

The oxidation state of Mn changes from +4 (in MnO_2) to +2 (in $MnCl_2$). A decrease in oxidation state is a **reduction**, not an oxidation. Thus, Statement I is incorrect.

Statement II: When NaI is used, I^- is similarly oxidized to I_2, and MnO_2 is reduced to Mn^{2+}. The oxidation state of Mn goes from +4 to +2, which is a reduction. Thus, Statement II is correct.

Step 4: Final Answer:

Statement-I is incorrect but Statement-II is correct.

Quick Tip: MnO_2 is a classic oxidizing agent. In acidic redox reactions, it practically always reduces to the pale pink/colorless Mn^{2+} state.

---

54. Among the following options, the correct trend in the electron gain enthalpy is

(A) $I > Br > Cl > F$

(B) $F > Cl > Br > I$

(C) $Br > Cl > F > I$

(D) $Cl > F > Br > I$

Correct Answer: (D) $Cl > F > Br > I$

Solution:

Step 1: Understanding the Question:

We need to identify the correct decreasing order of the magnitude of electron gain enthalpy for the halogens.

Step 2: Key Formula or Approach:

Electron gain enthalpy generally becomes less negative (decreases in magnitude) as we move down a group due to increasing atomic size. However, the second period elements often have lower electron gain enthalpies than third period elements due to severe electron-electron repulsion in their small 2p orbitals.

Step 3: Detailed Explanation:

For halogens, the expected trend based on size is $F > Cl > Br > I$.

However, Fluorine has an exceptionally small atomic size, leading to strong interelectronic repulsions in the compact 2p subshell. This makes adding an extra electron less favorable than in Chlorine (which has larger 3p orbitals).

Thus, Chlorine has the highest negative electron gain enthalpy in the periodic table.

The correct order of magnitude is: $Cl > F > Br > I$.

Step 4: Final Answer:

The correct trend is $Cl > F > Br > I$.

Quick Tip: This is a highly frequent exception in inorganic chemistry. Remember: Chlorine has the highest electron gain enthalpy, but Fluorine is the most electronegative element!

---

55. Given below are two statements:

Statement-I : $[Fe(ox)_3]^{3-}$ **is chiral.**

Statement-II : ***trans***-$[Cr(H_2O)_2(ox)_2]^-$ **is chiral.**

(Given : oxH_2 **= HOOC-COOH)**

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

(A) Statement-I is incorrect but Statement-II is correct.

(B) Both Statement-I and Statement-II are correct.

(C) Both Statement-I and Statement-II are incorrect.

(D) Statement-I is correct but Statement-II is incorrect.

Correct Answer: (D) Statement-I is correct but Statement-II is incorrect.

Solution:

Step 1: Understanding the Question:

We need to determine the chirality (optical activity) of two specific coordination complexes.

Step 2: Key Formula or Approach:

A complex is chiral if it lacks an improper axis of rotation (which practically means lacking a plane of symmetry and center of inversion).

- Octahedral complexes of type $[M(AA)_3]$ (where AA is a symmetrical bidentate ligand) are always chiral and exist as Δ and Λ enantiomers.
- Octahedral complexes of type *trans*-$[M(AA)_2a_2]$ have a plane of symmetry passing through the equatorial ligands and are thus achiral.

Step 3: Detailed Explanation:

Statement I: $[Fe(ox)_3]^{3-}$ is an octahedral complex with three bidentate oxalate ligands ($[M(AA)_3]$ type). It assumes a propeller-like shape that cannot be superimposed on its mirror image. Therefore, it is chiral. Statement I is correct.

Statement II: In *trans*-$[Cr(H_2O)_2(ox)_2]^-$, the two monodentate H_2O ligands are placed 180° apart (axial positions), and the two oxalate ligands are in the equatorial plane. The equatorial plane itself acts as a plane of symmetry, dissecting the top H_2O and reflecting it into the bottom H_2O. Since it has a plane of symmetry, it is achiral. Statement II is incorrect.

Step 4: Final Answer:

Statement-I is correct but Statement-II is incorrect.

Quick Tip: For $[M(AA)_2a_2]$ complexes, the *cis*-isomer is always chiral (optically active), while the *trans*-isomer is always achiral (optically inactive) due to the presence of a plane of symmetry.

---

56. The correct statement about peptides and proteins is

(A) In α-helices, the polypeptide chain is twisted into a left-handed screw (helix) through intramolecular hydrogen bonds.
(B) Tertiary structure of proteins has two or more polypeptide subunits.
(C) Only the proteins having a quaternary structure are biologically active.
(D) In β-pleated sheet structures, peptide chains are held together by intermolecular hydrogen bonds.

Correct Answer: (D) In β-pleated sheet structures, peptide chains are held together by intermolecular hydrogen bonds.

Solution:

Step 1: Understanding the Question:
Evaluate four statements regarding the structural levels and properties of proteins.

Step 3: Detailed Explanation:
Let's analyze each option:
(A) α-helices are structurally most stable as **right-handed** helices, not left-handed. (Incorrect)
(B) The tertiary structure refers to the overall 3D folding of a **single** polypeptide chain. Having two or more polypeptide subunits defines a quaternary structure. (Incorrect)
(C) Many functional proteins exist purely with tertiary structure (e.g., myoglobin, many enzymes). Quaternary structure is not a strict requirement for biological activity. (Incorrect)
(D) In β-pleated sheets, adjacent polypeptide chains (or widely separated segments of one chain) are held together via **intermolecular** (or inter-strand) hydrogen bonding between the $C=O$ and $N-H$ groups of the peptide backbone. (Correct)

Step 4: Final Answer:
The correct statement is (D).

Quick Tip: α-helices = Intramolecular H-bonds (within the same helical turn). β-sheets = Intermolecular H-bonds (between neighboring strands).

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57. Given below are two statements:

Statement-I : Oxidation of *p*-nitrotoluene with acidic $KMnO_4$ gives an acid that is stronger than benzoic acid.

Statement-II : Reduction of *p*-nitrotoluene with Sn/HCl followed by neutralization gives an amine that is more basic than aniline.

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

(A) Statement-I is incorrect but Statement-II is correct.

(B) Both Statement-I and Statement-II are correct.

(C) Both Statement-I and Statement-II are incorrect.

(D) Statement-I is correct but Statement-II is incorrect.

Correct Answer: (B) Both Statement-I and Statement-II are correct.

Solution:

Step 1: Understanding the Question:

We need to analyze the products of oxidation and reduction of *p*-nitrotoluene and compare their acidic and basic strengths with benzoic acid and aniline, respectively.

Step 3: Detailed Explanation:

Statement I: Oxidation of *p*-nitrotoluene with acidic $KMnO_4$ oxidizes the methyl group to a carboxylic acid group, forming *p*-nitrobenzoic acid. The nitro group ($-NO_2$) is highly electron-withdrawing through both inductive ($-I$) and mesomeric ($-M$) effects. This stabilizes the conjugate base (carboxylate anion), making *p*-nitrobenzoic acid a stronger acid than benzoic acid. Statement I is correct.

Statement II: Reduction of *p*-nitrotoluene with Sn/HCl reduces the nitro group to an amine group, yielding *p*-methylaniline (also known as *p*-toluidine). The methyl group ($-CH_3$) is electron-donating via inductive ($+I$) and hyperconjugation effects. This increases the electron density on the nitrogen atom, enhancing its ability to donate a lone pair, thereby making it a stronger base than aniline. Statement II is correct.

Step 4: Final Answer:

Both Statement-I and Statement-II are correct.

Quick Tip: Electron-withdrawing groups (EWG) increase acidity and decrease basicity. Electron-donating groups (EDG) decrease acidity and increase basicity.

---

58. Identify the reactions which give aniline as the major product.

A. Benzonitrile $\xrightarrow{LiAlH_4}$

B. Benzamide $\xrightarrow{KOH, Br_2}$

C. Nitrobenzene $\xrightarrow{NaBH_4}$

D. N-Phenylacetamide $\xrightarrow{HCl, H_2O, \Delta}$

Choose the correct answer from the options given below.

(A) C and D only

(B) A and B only

(C) B and D only

(D) A and C only

Correct Answer: (C) B and D only

Solution:

Step 1: Understanding the Question:

Evaluate four organic transformation pathways to identify which ones produce aniline ($C_6H_5NH_2$) as the major product.

Step 3: Detailed Explanation:

Let's predict the product for each reaction:

A. Benzonitrile ($Ph-CN$) treated with a strong reducing agent like $LiAlH_4$ reduces the nitrile completely to a primary amine, forming benzylamine ($Ph-CH_2NH_2$), not aniline.

B. Benzamide ($Ph-CONH_2$) reacts with Br_2 in the presence of KOH. This is the **Hoffmann bromamide degradation** reaction, which removes the carbonyl carbon as carbonate and yields a primary amine with one less carbon: Aniline ($Ph-NH_2$).

C. Nitrobenzene ($Ph-NO_2$) with $NaBH_4$. Sodium borohydride is a mild reducing agent and is generally unreactive toward aromatic nitro groups under normal conditions. It does not yield aniline. (Typically, Sn/HCl or H_2/Pd is used).

D. N-Phenylacetamide (Acetanilide, $Ph-NH-COCH_3$) boiled with aqueous HCl undergoes acid-catalyzed amide hydrolysis. The amide bond cleaves to form Aniline ($Ph-NH_2$) and acetic acid (CH_3COOH).

Reactions B and D yield aniline.

Step 4: Final Answer:

The correct options are B and D only.

Quick Tip: Hoffmann bromamide degradation is an excellent step-down reaction for synthesizing aromatic amines directly from primary amides. Amide hydrolysis is the standard method for unprotecting an amine.

---

59. Two moles of an ideal gas undergo free expansion from 10 L to 100 L at 300 K. The values of ΔS_{system} and $\Delta S_{\text{surroundings}}$ are
(R is universal gas constant)

(A) $\Delta S_{\text{system}} = 4.606R;\ \Delta S_{\text{surroundings}} = 0$
(B) $\Delta S_{\text{system}} = 0;\ \Delta S_{\text{surroundings}} = 0$
(C) $\Delta S_{\text{system}} = 4.606R;\ \Delta S_{\text{surroundings}} = -4.606R$
(D) $\Delta S_{\text{system}} = 0;\ \Delta S_{\text{surroundings}} = 4.606R$

Correct Answer: (A) $\Delta S_{\text{system}} = 4.606R;\ \Delta S_{\text{surroundings}} = 0$

Solution:

Step 1: Understanding the Question:

We need to calculate the entropy change for both the system and the surroundings when an ideal gas undergoes free expansion (expansion into a vacuum).

Step 2: Key Formula or Approach:

Entropy is a state function. For the isothermal expansion of an ideal gas, the system's entropy

change depends only on the initial and final states:

$$\Delta S_{\text{sys}} = nR \ln\left(\frac{V_2}{V_1}\right)$$

For free expansion, the external pressure is zero ($P_{\text{ext}} = 0$), hence work done $W = 0$. Since it's an ideal gas undergoing isothermal free expansion, internal energy change $\Delta U = 0$. By the first law ($q = \Delta U - W$), heat exchanged $q = 0$.

Therefore, the surroundings exchange no heat: $\Delta S_{\text{surr}} = \frac{-q_{\text{actual}}}{T} = 0$.

Step 3: Detailed Explanation:

Calculate ΔS_{sys}:

Given $n = 2$ moles, $V_1 = 10$ L, $V_2 = 100$ L.

$$\Delta S_{\text{sys}} = 2 \times R \times \ln\left(\frac{100}{10}\right) = 2R \ln(10)$$

Since $\ln(10) \approx 2.303$,

$$\Delta S_{\text{sys}} = 2 \times 2.303 \times R = 4.606R$$

Calculate ΔS_{surr}:

Because it is a free expansion, the process is adiabatic ($q = 0$) with respect to the surroundings.

$$\Delta S_{\text{surr}} = 0$$

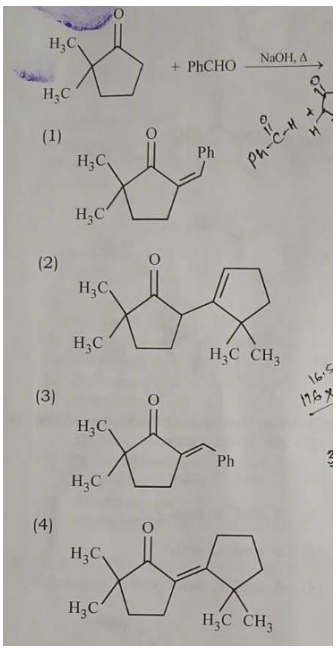
Step 4: Final Answer:

The values are $\Delta S_{\text{sys}} = 4.606R$ and $\Delta S_{\text{surr}} = 0$.

Quick Tip: Free expansion is highly irreversible. The entropy of the universe must increase ($\Delta S_{\text{total}} > 0$). Here, $4.606R + 0 > 0$, validating our calculation.

---

60. The compound that CANNOT be obtained from the aldol condensation reaction shown below, is



Correct Answer: (D) [A self-aldol product where the double bond connects C5 to C1 of a 3-methylcyclopentyl ring]

Solution:

Step 1: Understanding the Question:

The reaction is a base-catalyzed crossed aldol condensation between 2-methylcyclopentanone and benzaldehyde. We need to identify which of the four given structures is chemically impossible to form, even as a side product.

Step 2: Key Formula or Approach:

Analyze the possible enolates and their nucleophilic attack targets.

1. Enolate forms primarily at C5 (less sterically hindered) and attacks benzaldehyde to form cross-aldol products (E and Z isomers).

2. Enolate can also attack another molecule of 2-methylcyclopentanone (self-aldol). Since the attacked carbonyl carbon (C1) is directly adjacent to the C2 methyl group, any self-aldol product must feature a methyl group immediately adjacent to the newly formed inter-ring double bond.

Step 3: Detailed Explanation:

- **Option (A) and (C):** Both show 2-benzylidene-5-methylcyclopentanone, formed by the C5 enolate attacking benzaldehyde. They are merely E/Z stereoisomers and are completely valid

products.

- **Option (B):** Shows a self-aldol product. The double bond connects the two rings. On the right-hand ring (the one that was attacked), the methyl group is located at the top vertex, which is directly adjacent to the double bond. This preserves the 2-methylcyclopentanone skeleton.
- **Option (D):** Shows a self-aldol product. However, on the right-hand ring, the methyl group is located at the bottom-right vertex (two carbons away from the double bond). This skeleton corresponds to an attack on **3-methylcyclopentanone**, not the 2-methylcyclopentanone starting material provided. Since the carbon skeleton is fundamentally wrong, this product cannot be formed.

Step 4: Final Answer:

The compound with the wrong skeleton (Option 4) cannot be obtained.

Quick Tip: When dealing with "CANNOT be formed" questions in condensation reactions, aggressively check the carbon skeleton of the reactant versus the products. Side-products like self-aldols are valid, but migrating a methyl group is impossible without rearrangement!

---

61. The complex which has facial and meridional isomers is

(Given : py = pyridine and en = $H_2N-CH_2-CH_2-NH_2$**)**

(A) $[Ni(en)_2(H_2O)_2]^{2+}$

(B) $[Cr(py)_3(Cl)_3]$

(C) $[Cr(H_2O)_6]^{3+}$

(D) $[Co(NH_3)_4(H_2O)_2]^{3+}$

Correct Answer: (B) $[Cr(py)_3(Cl)_3]$

Solution:

Step 1: Understanding the Question:

Identify which of the given coordination complexes exhibits facial (*fac*) and meridional (*mer*)

geometrical isomerism.

Step 2: Key Formula or Approach:

Facial (*fac*) and meridional (*mer*) isomerism is exclusively shown by octahedral coordination complexes of the general formula $[Ma_3b_3]$, where 'a' and 'b' are two different unidentate ligands, each present in a quantity of three.

Step 3: Detailed Explanation:

Let's evaluate the generic formula of each option:

(A) $[Ni(en)_2(H_2O)_2]^{2+}$: Type $[M(AA)_2a_2]$. Shows *cis-trans* isomerism and optical isomerism (for the *cis* form), but not *fac/mer*.

(B) $[Cr(py)_3(Cl)_3]$: Type $[Ma_3b_3]$. Three pyridine (py) ligands and three chloride (Cl) ligands. This complex perfectly satisfies the condition for *fac/mer* isomerism.

(C) $[Cr(H_2O)_6]^{3+}$: Type $[Ma_6]$. All ligands are identical. No geometrical isomerism is possible.

(D) $[Co(NH_3)_4(H_2O)_2]^{3+}$: Type $[Ma_4b_2]$. Shows *cis-trans* geometrical isomerism, but not *fac/mer*.

Step 4: Final Answer:

The complex with *fac* and *mer* isomers is $[Cr(py)_3(Cl)_3]$.

Quick Tip: Memorize the specific isomerism formulas: $[Ma_4b_2] \rightarrow$ *cis/trans*. $[Ma_3b_3] \rightarrow$ *fac/mer*. $[M(AA)_2a_2] \rightarrow$ *cis* (chiral) / *trans* (achiral).

---

62. The numbers 17.0145 and 21.0235 were rounded to three figures after the decimal point. The resulting numbers, respectively, are

(A) 17.015 and 21.024

(B) 17.014 and 21.023

(C) 17.015 and 21.023

(D) 17.014 and 21.024

Correct Answer: (D) 17.014 and 21.024

Solution:

Step 1: Understanding the Question:

We need to apply standard significant figure rules for rounding numbers that end exactly in the digit 5.

Step 2: Key Formula or Approach:

When rounding off a number, if the digit to be dropped is exactly 5 (with no following non-zero digits), the "round to even" rule is applied:

- If the preceding digit is even, it is left unchanged.
- If the preceding digit is odd, it is increased by 1.

Step 3: Detailed Explanation:

For 17.0145: We need three decimal places, so we drop the '5'. The preceding digit is '4', which is **even**. Therefore, the number remains unchanged.

Result: 17.014.

For 21.0235: We drop the '5'. The preceding digit is '3', which is **odd**. Therefore, we increase it by 1.

Result: 21.024.

Step 4: Final Answer:

The rounded numbers are 17.014 and 21.024.

Quick Tip: The "round to even" rule prevents statistical bias when analyzing large datasets. Always check if the digit before '5' is odd or even!

---

63. The amount of carbon dioxide evolved upon complete combustion of 116 g of *n*-butane is (Given: atomic mass in amu H = 1, C = 12 and O = 16)

(A) 362 g

(B) 352 g

(C) 322 g

(D) 176 g

Correct Answer: (B) 352 g

Solution:

Step 1: Understanding the Question:

We must calculate the mass of CO_2 produced from the complete combustion of a given mass of butane.

Step 2: Key Formula or Approach:

1. Write the balanced chemical equation for the combustion of butane.
2. Convert the given mass of butane to moles.
3. Use stoichiometry to find the moles of CO_2 produced.
4. Convert the moles of CO_2 back to grams.

Step 3: Detailed Explanation:

The formula for n-butane is C_4H_{10}.

Molar mass of $C_4H_{10} = (4 \times 12) + (10 \times 1) = 48 + 10 = 58$ g/mol.

Molar mass of $CO_2 = 12 + (2 \times 16) = 44$ g/mol.

Balanced combustion equation:

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

Alternatively, for 1 mole:

$$C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

This shows that 1 mole of butane produces 4 moles of CO_2.

Calculate moles of butane in 116 g:

$$n = \frac{116 \text{ g}}{58 \text{ g/mol}} = 2 \text{ moles}$$

Moles of CO_2 produced:

$$n(CO_2) = 2 \text{ moles butane} \times 4 = 8 \text{ moles}$$

Mass of CO_2 evolved:

$$\text{Mass} = 8 \text{ moles} \times 44 \text{ g/mol} = 352 \text{ g}$$

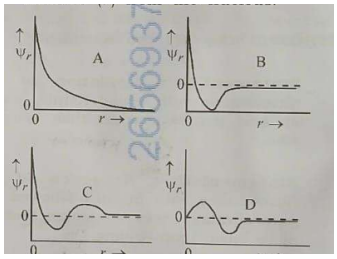
Step 4: Final Answer:

The amount of carbon dioxide evolved is 352 g.

Quick Tip: For alkane combustion C_nH_{2n+2}, the moles of CO_2 formed will always be exactly n times the moles of alkane burned.

---

64. Consider the following schematic plots of orbital wavefunction (ψ_r) against distance (r) from the nucleus.



(A) D

(B) A

(C) B

(D) C

Correct Answer: (D) C

Solution:

Step 1: Understanding the Question:

We need to identify which wavefunction plot (ψ_r vs r) corresponds to an atomic orbital having exactly two radial nodes.

Step 2: Key Formula or Approach:

A radial node occurs where the radial wavefunction ψ_r changes sign (crosses the horizontal axis where $\psi_r = 0$).

The total number of radial nodes is given by the formula: Nodes $= n - l - 1$. We simply need to count the number of times the graph intersects and crosses the x-axis.

Step 3: Detailed Explanation:

Let's analyze the zero-crossings for each plot:

- **Plot A:** Starts at a high positive value and decays to zero asymptotically. It never crosses the x-axis. (0 radial nodes, e.g., 1s, 2p).
- **Plot B:** Starts at a high positive value, crosses the x-axis once, and then approaches zero asymptotically from the negative side. (1 radial node, e.g., 2s, 3p).
- **Plot C:** Starts at a high positive value, crosses the x-axis (first node), goes negative, crosses the x-axis again (second node), goes positive, and approaches zero. It crosses the axis **twice**. (2 radial nodes, e.g., 3s).
- **Plot D:** Starts at zero, rises to a maximum, crosses the x-axis (first node), goes negative to a minimum, and then approaches zero asymptotically from below. It crosses the axis **once**. (1 radial node, e.g., 4d, 5f).

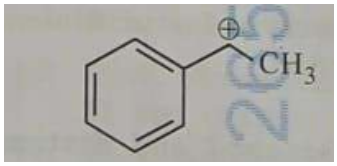
Only Plot C exhibits exactly two radial nodes.

Step 4: Final Answer:

The figure representing two radial nodes is C.

Quick Tip: Do not confuse the graph returning asymptotically to zero with a node. A radial node requires the wavefunction to fully cross from positive to negative, or vice versa.

65. The following carbocation is stabilized by the interaction of the empty p orbital with



(A) empty σ^* and empty π^* orbitals

(B) filled σ and filled π orbitals

(C) empty σ and empty π^* orbitals

(D) empty σ^* and filled π orbitals

Correct Answer: (B) filled σ and filled π orbitals

Solution:

Step 1: Understanding the Question:

We need to identify the molecular orbital interactions responsible for stabilizing the given 1-phenylethyl carbocation ($Ph-C^+(H)-CH_3$).

Step 2: Key Formula or Approach:

Carbocations are electron-deficient and possess an empty unhybridized 2p orbital. They are stabilized by the donation of electron density from adjacent filled orbitals.

1. **Hyperconjugation:** Involves the delocalization of electrons from a filled adjacent σ bond (like $C-H$ or $C-C$) into the empty p orbital.

2. **Resonance:** Involves the delocalization of electrons from a filled adjacent π system (like a benzene ring) into the empty p orbital.

Step 3: Detailed Explanation:

The carbocation center is flanked by a methyl group and a phenyl ring.

- The adjacent methyl group ($-CH_3$) stabilizes the empty p orbital through hyperconjugation. This involves the donation of electron density from the **filled** σ orbitals of the $C-H$ bonds.

- The adjacent phenyl ring ($-C_6H_5$) stabilizes the empty p orbital through resonance. This involves the donation of electron density from the **filled** π orbitals of the aromatic ring.

Therefore, the stabilization occurs via interaction with filled σ and filled π orbitals.

Step 4: Final Answer:

The stabilization is by filled σ and filled π orbitals.

Quick Tip: Remember that stabilization inherently means transferring electron density *into* the electron-deficient region. Only filled orbitals have electrons to give! Empty orbitals cannot donate electron density.

---

66. A 1:3 electrolyte in an aqueous solution is

(A) $[Co(NH_3)_3(NO_2)_3]$

(B) $[CoCl_2(NH_3)_4]Cl$

(C) $[CoCl(NH_3)_5]Cl_2$

(D) $[Co(NH_3)_6]Cl_3$

Correct Answer: (D) $[Co(NH_3)_6]Cl_3$

Solution:

Step 1: Understanding the Question:

We need to identify which of the given coordination complexes acts as a 1:3 electrolyte, meaning it dissociates into one cation and three anions (or vice versa) in an aqueous solution.

Step 2: Key Formula or Approach:

The part of the complex enclosed in square brackets $[\dots]$ is the coordination sphere and remains intact in solution. The counter ions outside the brackets dissociate in water.

Step 3: Detailed Explanation:

Let's analyze the dissociation of each complex:

(A) $[Co(NH_3)_3(NO_2)_3] \rightarrow$ Does not dissociate. It is a neutral complex and a non-electrolyte (0:0).

(B) $[CoCl_2(NH_3)_4]Cl \rightarrow [CoCl_2(NH_3)_4]^+ + Cl^-$. Yields 2 ions. It is a 1:1 electrolyte.

(C) $[CoCl(NH_3)_5]Cl_2 \rightarrow [CoCl(NH_3)_5]^{2+} + 2Cl^-$. Yields 3 ions. It is a 1:2 electrolyte.
(D) $[Co(NH_3)_6]Cl_3 \rightarrow [Co(NH_3)_6]^{3+} + 3Cl^-$. Yields 4 ions (one complex cation and three chloride anions). It perfectly matches the 1:3 electrolyte ratio.

Step 4: Final Answer:
The 1:3 electrolyte is $[Co(NH_3)_6]Cl_3$.

Quick Tip: The primary valency (oxidation state) governs the number of counter ions, while the secondary valency (coordination number) governs the ligands inside the brackets. Only ions outside the brackets conduct electricity.

---

67. The standard electrode potential (E°) for the half-cell reaction $Fe^{3+} + e^- \rightarrow Fe^{2+}$ at 298 K is (Given: $E^\circ(Fe^{3+}/Fe) = -0.04$ V and $E^\circ(Fe^{2+}/Fe) = -0.44$ V at 298 K)

(A) +0.92 V
(B) +0.40 V
(C) +0.76 V
(D) −0.48 V

Correct Answer: (C) +0.76 V

Solution:

Step 1: Understanding the Question:
We need to find the standard electrode potential for the Fe^{3+} to Fe^{2+} reduction using the given standard reduction potentials for Fe^{3+} to Fe and Fe^{2+} to Fe.

Step 2: Key Formula or Approach:
Standard electrode potentials (E°) are intensive properties and cannot be added directly. We must convert them to standard Gibbs free energy changes (ΔG°), which are extensive and additive:

$$\Delta G^\circ = -nFE^\circ$$

Step 3: Detailed Explanation:

Write down the half-reactions and their ΔG° values:

1. $Fe^{3+} + 3e^- \rightarrow Fe \quad E_1^\circ = -0.04\ \text{V}$

$\Delta G_1^\circ = -3 \times F \times (-0.04) = +0.12F$

2. $Fe^{2+} + 2e^- \rightarrow Fe \quad E_2^\circ = -0.44\ \text{V}$

$\Delta G_2^\circ = -2 \times F \times (-0.44) = +0.88F$

We need the ΔG° for the target reaction:

3. $Fe^{3+} + e^- \rightarrow Fe^{2+} \quad E_3^\circ = ?$

We can obtain reaction (3) by subtracting reaction (2) from reaction (1):

$(Fe^{3+} + 3e^- \rightarrow Fe) - (Fe^{2+} + 2e^- \rightarrow Fe) \implies Fe^{3+} + e^- \rightarrow Fe^{2+}$

Therefore, the Gibbs free energy for the target reaction is:

$$\Delta G_3^\circ = \Delta G_1^\circ - \Delta G_2^\circ$$

$$\Delta G_3^\circ = 0.12F - 0.88F = -0.76F$$

Relate ΔG_3° back to E_3°:

$$\Delta G_3^\circ = -n_3 F E_3^\circ$$

Since $n_3 = 1$ (one electron is transferred):

$$-0.76F = -1 \times F \times E_3^\circ$$

$$E_3^\circ = +0.76\ \text{V}$$

Step 4: Final Answer:

The standard electrode potential is +0.76 V.

Quick Tip: Never add or subtract E° values directly unless the number of electrons transferred in both half-reactions is exactly the same and cancel out to form a full cell reaction. Always route through ΔG°.

---

68. In potash alum, the ratio of K^+ and SO_4^{2-} ions is

(A) 3:2

(B) 1:2

(C) 2:1

(D) 2:3

Correct Answer: (B) 1:2

Solution:

Step 1: Understanding the Question:

We must identify the chemical formula of potash alum and determine the stoichiometric ratio of potassium ions to sulfate ions.

Step 2: Key Formula or Approach:

The chemical formula of potash alum (potassium aluminum sulfate dodecahydrate) is:

$$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$$

(or equivalently written as $KAl(SO_4)_2 \cdot 12H_2O$).

Step 3: Detailed Explanation:

Let's count the ions in one formula unit of $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$:

- Number of Potassium ions (K^+) $= 2$

- Number of Sulfate ions (SO_4^{2-}) $= 1$ (from potassium sulfate) $+ 3$ (from aluminum sulfate) $=$ 4 total sulfate ions.

The ratio of K^+ to SO_4^{2-} is:

Ratio $= 2 : 4$

Simplifying the ratio gives $1 : 2$.

(If we use the simplified empirical formula $KAl(SO_4)_2 \cdot 12H_2O$, we directly see 1 K^+ and 2 SO_4^{2-}, giving the same 1:2 ratio).

Step 4: Final Answer:

The ratio of K^+ and SO_4^{2-} ions is 1:2.

Quick Tip: Alums are double salts with the general formula $M_2SO_4 \cdot M'_2(SO_4)_3 \cdot 24H_2O$, where M is a monovalent cation and M' is a trivalent cation. They completely dissociate into their constituent ions in water.

---

69. Consider the following statements about the solutions formed by mixing two liquids.

A. An ideal solution thus formed obeys Raoult's law throughout the composition range.

B. Mixture of chloroform and acetone shows negative deviation from Raoult's law.

C. Mixture of aniline and phenol shows positive deviation from Raoult's law.

(A) A and C only

(B) A and B only

(C) B and C only

(D) A only

Correct Answer: (B) A and B only

Solution:

Step 1: Understanding the Question:

We need to assess the validity of three thermodynamic statements regarding the behavior of ideal and non-ideal liquid-liquid solutions.

Step 3: Detailed Explanation:

Statement A: By definition, an ideal solution rigorously obeys Raoult's law across all concentrations and temperatures. This statement is correct.

Statement B: A mixture of chloroform ($CHCl_3$) and acetone (CH_3COCH_3) features a strong intermolecular hydrogen bond between the polarized hydrogen of chloroform and the carbonyl oxygen of acetone. Because A-B interactions are stronger than A-A and B-B interactions, the escaping tendency of molecules decreases, causing a negative deviation from Raoult's law. This statement is correct.

Statement C: A mixture of aniline and phenol forms very strong intermolecular hydrogen bonds between the amine and hydroxyl groups. Similarly, since the A-B attractive forces are stronger than the pure A-A and B-B forces, it exhibits a **negative** deviation from Raoult's law, not positive. This statement is incorrect.

Step 4: Final Answer:

Statements A and B only are correct.

Quick Tip: Positive deviation occurs when newly formed interactions are *weaker* (e.g., ethanol + acetone). Negative deviation occurs when interactions are *stronger* (e.g., acid + water, or any combination prone to strong H-bonding).

---

70. For a salt XY, which is a strong electrolyte, the plot of Λ_m versus $\sqrt{c}$ has a slope of -90.0 S cm^2 mol$^{-3/2}$ L$^{1/2}$ at 298 K. At 0.01 M concentration of XY, the value of Λ_m is 145.0 S cm^2 mol^{-1}. The limiting molar conductivity of Y^- ion ($\lambda^\circ_{Y^-}$, in S cm^2 mol^{-1}) at 298 K will be
(Given: $\lambda^\circ_{X^+} = 74.0$ S cm^2 mol^{-1})

(A) 76.0

(B) 80.0

(C) 100.0

(D) 90.0

Correct Answer: (B) 80.0

Solution:

Step 1: Understanding the Question:

We need to calculate the limiting molar conductivity of the anion Y^- using the Debye-Hückel-Onsager equation and Kohlrausch's law of independent migration of ions.

Step 2: Key Formula or Approach:

For a strong electrolyte, the variation of molar conductivity with concentration is:

$$\Lambda_m = \Lambda_m^\circ - A\sqrt{c}$$

where Λ_m° is the limiting molar conductivity, and $-A$ is the slope of the plot.

Kohlrausch's law states:

$$\Lambda_m^\circ(XY) = \lambda_{X^+}^\circ + \lambda_{Y^-}^\circ$$

Step 3: Detailed Explanation:

From the given data:

Slope $-A = -90.0 \implies A = 90.0$

Concentration $c = 0.01$ M $\implies \sqrt{c} = \sqrt{0.01} = 0.1$

Molar conductivity $\Lambda_m = 145.0$ S cm^2 mol^{-1}

Plug these values into the Debye-Hückel-Onsager equation to find Λ_m°:

$$145.0 = \Lambda_m^\circ - (90.0 \times 0.1)$$

$$145.0 = \Lambda_m^\circ - 9.0$$

$$\Lambda_m^\circ = 145.0 + 9.0 = 154.0 \text{ S cm}^2 \text{ mol}^{-1}$$

Now, apply Kohlrausch's law to find $\lambda_{Y^-}^\circ$:

$$\Lambda_m^\circ(XY) = \lambda_{X^+}^\circ + \lambda_{Y^-}^\circ$$

$$154.0 = 74.0 + \lambda_{Y^-}^\circ$$

$$\lambda_{Y^-}^\circ = 154.0 - 74.0 = 80.0 \text{ S cm}^2 \text{ mol}^{-1}$$

Step 4: Final Answer:

The limiting molar conductivity of the Y^- ion is 80.0.

Quick Tip: The slope A depends on the type of electrolyte (e.g., 1-1, 2-1) and the solvent properties. Always double-check if you need to subtract or add the $A\sqrt{c}$ term; since conductivity drops as concentration rises, Λ_m° must be strictly greater than Λ_m.

---

71. Arrange the following compounds in the increasing order of polarity

A. $CH_3CH_2OCH_2CH_3$

B. CH_3CH_2OH

C. CH_3COCH_3

D. CH_3COOH

Choose the correct answer from the options given below.

(A) A < C < B < D

(B) A < B < C < D

(C) C < A < D < B

(D) C < A < B < D

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

Solution:

Step 1: Understanding the Question:

We are asked to rank four organic compounds (an ether, an alcohol, a ketone, and a carboxylic acid) based on their relative polarities.

Step 2: Key Formula or Approach:

Solvent polarity is determined by the presence and strength of dipole moments and the ability to engage in hydrogen bonding.

Order of functional group polarity: Alkanes < Ethers < Esters < Ketones/Aldehydes < Alcohols < Carboxylic acids.

Step 3: Detailed Explanation:

- **A (Diethyl ether):** Has a small net dipole moment due to the bent $C-O-C$ bond but cannot donate hydrogen bonds. It is the least polar.

- **C (Acetone):** Has a strong, highly polarized $C=O$ double bond, giving it a high dipole moment, making it more polar than ethers but less polar than H-bonding solvents.
- **B (Ethanol):** Has an $-OH$ group, which provides a strong dipole and allows it to act as both a strong hydrogen bond donor and acceptor, making it highly polar.
- **D (Acetic acid):** Contains both a $C=O$ group and an $-OH$ group. It forms exceptionally strong dimeric hydrogen bonds and has the highest dielectric interaction capacity among the listed compounds. It is the most polar.

The increasing order of polarity is: Ether (A) < Ketone (C) < Alcohol (B) < Acid (D).

Step 4: Final Answer:

The correct sequence is A < C < B < D.

Quick Tip: In chromatography (like TLC), this exact polarity sequence determines the R_f value. Non-polar substances elute faster (high R_f), while carboxylic acids stick strongly to silica gel (low R_f).

---

72. According to crystal field theory, the correct order of ligands with respect to their decreasing order of field strength is

(A) $Cl^- > NH_3 > H_2O > CO$
(B) $CO > NH_3 > H_2O > Cl^-$
(C) $CO > H_2O > NH_3 > Cl^-$
(D) $Cl^- > H_2O > NH_3 > CO$

Correct Answer: (B) $CO > NH_3 > H_2O > Cl^-$

Solution:

Step 1: Understanding the Question:

The question asks for the correct decreasing order of ligand field strength (crystal field splitting energy, Δ_o) according to the spectrochemical series.

Step 2: Key Formula or Approach:

The spectrochemical series arranges ligands in order of increasing crystal field splitting. A simplified order from weak field to strong field is:

Halides (e.g., I^-, Br^-, Cl^-, F^-) < Oxygen donors (e.g., OH^-, H_2O, ox^{2-}) < Nitrogen donors (e.g., NH_3, en) < Carbon donors (e.g., CN^-, CO).

Step 3: Detailed Explanation:

Comparing the given ligands:

- CO (Carbon monoxide) is a strong π-acceptor ligand and sits at the very top of the spectrochemical series.
- NH_3 (Ammonia) is a strong σ-donor nitrogen ligand, forming intermediate to strong fields.
- H_2O (Water) is a typical oxygen donor and acts as a weak field ligand.
- Cl^- (Chloride) is a π-donor halide and exhibits a very weak field.

Arranging them in decreasing order (strongest to weakest):

$CO > NH_3 > H_2O > Cl^-$.

Step 4: Final Answer:

The correct sequence is $CO > NH_3 > H_2O > Cl^-$.

Quick Tip: An easy rule of thumb for ligand strength based on the donor atom: $C > N > O >$ Halogens.

---

73. The amino acid that gives a red-blood colour on treating its sodium fusion extract with sodium nitroprusside is

(A) serine

(B) leucine

(C) threonine

(D) methionine

Correct Answer: (D) methionine

Solution:

Step 1: Understanding the Question:

We need to identify the amino acid that produces a red/violet/blood-red coloration in the sodium nitroprusside test, which is a qualitative laboratory test for a specific element.

Step 2: Key Formula or Approach:

The sodium nitroprusside test ($Na_2[Fe(CN)_5NO]$) is the definitive test for the presence of **Sulphur** in organic compounds. During sodium fusion, the sulfur is converted to sodium sulfide (Na_2S).

Addition of sodium nitroprusside to the extract yields a deep purple or blood-red complex: $[Fe(CN)_5NOS]^{4-}$.

Step 3: Detailed Explanation:

We must identify which of the provided amino acids contains a sulfur atom in its side chain.

- **Serine:** Contains a hydroxyl group ($-OH$).
- **Leucine:** Contains an isobutyl alkyl chain.
- **Threonine:** Contains a secondary hydroxyl group.
- **Methionine:** Contains a thioether group ($-CH_2-CH_2-S-CH_3$).

Since methionine is the only sulfur-containing amino acid among the choices, it will form sodium sulfide in the Lassaigne's extract and give a positive nitroprusside test.

Step 4: Final Answer:

Methionine gives the red-blood colour.

Quick Tip: The only two standard amino acids that contain sulfur are Methionine and Cysteine. If a question mentions a positive test for sulfur (nitroprusside or lead acetate), look for one of these two!

---

74. In an acidic medium, 10 mL of 0.25 M oxalic acid is titrated with $KMnO_4$ solution. If the volume of $KMnO_4$ solution required to reach end point is 10 mL, the strength of the $KMnO_4$ solution is

(A) 0.15 M

(B) 0.10 M

(C) 0.20 M

(D) 0.25 M

Correct Answer: (B) 0.10 M

Solution:

Step 1: Understanding the Question:

A standard redox titration between potassium permanganate ($KMnO_4$) and oxalic acid ($H_2C_2O_4$) in acidic medium. We need to find the molarity of the $KMnO_4$ solution.

Step 2: Key Formula or Approach:

At the equivalence point, the equivalents of the oxidizing agent equal the equivalents of the reducing agent:

$$N_1V_1 = N_2V_2$$

Normality (N) is related to Molarity (M) by the n-factor: $N = M \times \text{n-factor}$.

Step 3: Detailed Explanation:

Determine the n-factors for both reactants in an acidic medium:

1. **Potassium Permanganate ($KMnO_4$):** Mn goes from +7 to +2. The change in oxidation state is 5.

$\text{n-factor}_1 = 5$.

2. **Oxalic Acid ($H_2C_2O_4$):** Carbon goes from +3 to +4 (in CO_2). Since there are 2 carbon atoms per molecule, the total change is $2 \times 1 = 2$.

$\text{n-factor}_2 = 2$.

Apply the equivalence equation:

$$(M_1 \times \text{n-factor}_1) \times V_1 = (M_2 \times \text{n-factor}_2) \times V_2$$

$$(M_1 \times 5) \times 10 \text{ mL} = (0.25 \text{ M} \times 2) \times 10 \text{ mL}$$

Cancel the 10 mL from both sides:

$$5M_1 = 0.50$$

$$M_1 = \frac{0.50}{5} = 0.10 \text{ M}$$

Step 4: Final Answer:

The strength of the $KMnO_4$ solution is 0.10 M.

Quick Tip: Permanganate titration n-factors to memorize: Acidic medium = 5 (Mn^{2+}), Neutral/faintly alkaline = 3 (MnO_2), Strongly alkaline = 1 (MnO_4^{2-}).

---

75. The correct statement is

(A) Aluminium has five valence orbitals.

(B) Boron has a maximum covalency of four.

(C) Beryllium has three valence orbitals.

(D) Magnesium has a maximum covalency of four.

Correct Answer: (B) Boron has a maximum covalency of four.

Solution:

Step 1: Understanding the Question:

Evaluate statements regarding the valence orbitals and maximum covalency (maximum number of covalent bonds) of various s and p-block elements.

Step 3: Detailed Explanation:

Let's verify each option:

(A) Aluminium (Period 3) has valence orbitals 3s, 3p, and 3d. This provides $1(s) + 3(p) + 5(d) = 9$ valence orbitals. Not five. (Incorrect)

(B) Boron (Period 2) has a valence shell electron configuration of $2s^2 2p^1$. Because it belongs to the second period, it lacks vacant d-orbitals. The maximum number of orbitals available for

bonding is four (one 2s and three 2p orbitals). Thus, it can form a maximum of 4 covalent bonds (e.g., BF_4^-). (Correct)

(C) Beryllium (Period 2) has valence orbitals 2s and 2p. Similar to Boron, it has a total of 4 valence orbitals, not three. (Incorrect)

(D) Magnesium (Period 3) has empty 3d orbitals available. Therefore, it can expand its octet and achieve a covalency greater than four (typically up to 6, as seen in complex ions like $[Mg(H_2O)_6]^{2+}$). (Incorrect)

Step 4: Final Answer:

The correct statement is (B).

Quick Tip: Elements of the 2nd period (Li to Ne) are strictly restricted to a maximum covalency of 4 because they do not have accessible d-orbitals to expand their octet.

---

76. Among the following, the compound having conjugated double bonds is

(A) hepta-1,6-diene

(B) hepta-1,3-diene

(C) hepta-1,4-diene

(D) hepta-1,5-diene

Correct Answer: (B) hepta-1,3-diene

Solution:

Step 1: Understanding the Question:

We need to identify the diene where the two carbon-carbon double bonds are conjugated.

Step 2: Key Formula or Approach:

Conjugation occurs when double bonds are separated by exactly one single bond, creating an alternating pattern ($C=C-C=C$). If they are separated by two or more single bonds, they are termed "isolated."

Step 3: Detailed Explanation:

Let's draw the skeleton for each isomer:

- (A) hepta-1,6-diene: $C=C-C-C-C-C=C$ (separated by 3 single bonds; isolated)
- (B) hepta-1,3-diene: $C=C-C=C-C-C-C$ (separated by exactly 1 single bond; **conjugated**)
- (C) hepta-1,4-diene: $C=C-C-C=C-C-C$ (separated by 2 single bonds; isolated)
- (D) hepta-1,5-diene: $C=C-C-C-C=C-C$ (separated by 3 single bonds; isolated)

Step 4: Final Answer:

The compound with conjugated double bonds is hepta-1,3-diene.

Quick Tip: For any diene named *alk-x,y-diene*, it is conjugated if and only if $y = x + 2$.

---

77. $2A \rightarrow B$ is a zero-order reaction, where $k = 1.0$ mol L^{-1} min^{-1}. If the initial concentration of A is 2 M, then the time taken to complete 75% of the reaction will be

(A) 2.0 min

(B) 1.5 min

(C) 0.75 min

(D) 1.0 min

Correct Answer: (B) 1.5 min

Solution:

Step 1: Understanding the Question:

Calculate the time required for a zero-order reaction to reach 75% completion.

Step 2: Key Formula or Approach:

The integrated rate equation for a zero-order reaction (following typical textbook conventions where k directly represents the rate of reactant consumption) is:

$$[A]_t = [A]_0 - kt$$

Where $[A]_0$ is the initial concentration, and $[A]_t$ is the concentration remaining at time t.

Step 3: Detailed Explanation:

Given:

Initial concentration, $[A]_0 = 2$ M

Rate constant, $k = 1.0$ mol L^{-1} min^{-1}

The reaction is 75% complete. This means 75% of A has been consumed.

Amount of A consumed $= 0.75 \times 2$ M $= 1.5$ M

Remaining concentration of A, $[A]_t = 2.0 - 1.5 = 0.5$ M

Substitute into the rate equation:

$$0.5 = 2.0 - 1.0 \times t$$

$$1.0 \times t = 2.0 - 0.5$$

$$t = 1.5 \text{ min}$$

Step 4: Final Answer:

The time taken is 1.5 min.

Quick Tip: For a zero-order reaction, the time for completion is directly proportional to the percentage reacted. If 100% reaction takes time $t_{100} = [A]_0/k$, then 75% completion takes exactly $0.75 \times t_{100}$. Here, $t_{100} = 2/1 = 2$ min. $0.75 \times 2 = 1.5$ min.

---

78. The correct order of solubility of the given salts in water at 298 K is

Salt	K_{sp} at 298 K
$AgBr$	5.0×10^{-13}
$Zn(OH)_2$	1.0×10^{-15}
Hg_2Cl_2	1.3×10^{-18}

(A) $Zn(OH)_2 > AgBr > Hg_2Cl_2$

(B) $Hg_2Cl_2 > Zn(OH)_2 > AgBr$

(C) $AgBr > Zn(OH)_2 > Hg_2Cl_2$

(D) $Hg_2Cl_2 > AgBr > Zn(OH)_2$

Correct Answer: (A) $Zn(OH)_2 > AgBr > Hg_2Cl_2$

Solution:

Step 1: Understanding the Question:

We must calculate and compare the molar solubility (s) for three sparingly soluble salts using their provided K_{sp} values.

Step 2: Key Formula or Approach:

The relationship between K_{sp} and molar solubility (s) depends on the stoichiometry of the salt:

- For a 1:1 salt (AB): $K_{sp} = s^2 \implies s = \sqrt{K_{sp}}$
- For a 1:2 salt (AB_2): $K_{sp} = (s)(2s)^2 = 4s^3 \implies s = \sqrt[3]{K_{sp}/4}$
- For Hg_2Cl_2, the mercury(I) cation is a diatomic ion $[Hg_2]^{2+}$. It dissociates as $Hg_2Cl_2 \rightleftharpoons Hg_2^{2+} + 2Cl^-$, giving 3 ions total. $K_{sp} = (s)(2s)^2 = 4s^3 \implies s = \sqrt[3]{K_{sp}/4}$

Step 3: Detailed Explanation:

1. $AgBr$ (1:1 salt):

$$s = \sqrt{5.0 \times 10^{-13}} = \sqrt{0.5 \times 10^{-12}} \approx 0.707 \times 10^{-6} = 7.1 \times 10^{-7} \text{ M}$$

2. $Zn(OH)_2$ (1:2 salt):

$$4s^3 = 1.0 \times 10^{-15} \implies s^3 = 0.25 \times 10^{-15} = 250 \times 10^{-18}$$

$$s = \sqrt[3]{250} \times 10^{-6} \approx 6.3 \times 10^{-6} \text{ M}$$

3. Hg_2Cl_2 (1:2 salt type behavior):

$$4s^3 = 1.3 \times 10^{-18} \implies s^3 = 0.325 \times 10^{-18}$$

$$s = \sqrt[3]{0.325} \times 10^{-6} \approx 0.69 \times 10^{-6} = 6.9 \times 10^{-7} \text{ M}$$

Comparing the molar solubilities:
$Zn(OH)_2$ $(6.3 \times 10^{-6}) > AgBr$ $(7.1 \times 10^{-7}) > Hg_2Cl_2$ (6.9×10^{-7}).

Step 4: Final Answer:

The correct order is $Zn(OH)_2 > AgBr > Hg_2Cl_2$.

Quick Tip: Never compare K_{sp} values directly unless the salts have the exact same ion ratio (e.g., both 1:1). A salt with a smaller K_{sp} can be more soluble if it produces more ions upon dissociation!

---

79. The correct decreasing order of oxidation state of the underlined atom in each molecule is

(A) $P_4O_6 > Cl_2O_7 > AlH_3$
(B) $P_4O_{10} > SO_3 > H_2O$
(C) $N_2O_5 > Al_2O_3 > H_2S$
(D) $PbO_2 > N_2O_3 > SO_3$

Correct Answer: (C) $N_2O_5 > Al_2O_3 > H_2S$

Solution:

Step 1: Understanding the Question:

We need to calculate the oxidation state of the first (primary) atom in each given molecule and identify the option where the sequence is strictly decreasing.

Step 2: Key Formula or Approach:

Sum of all oxidation states in a neutral molecule equals zero. Standard states: Oxygen is usually -2, Hydrogen is usually +1 (but -1 with metals).

Step 3: Detailed Explanation:

Let's evaluate the oxidation states for the central atoms in each option:

(A) $P_4O_6 \rightarrow P = +3$; $Cl_2O_7 \rightarrow Cl = +7$; $AlH_3 \rightarrow Al = +3$. Order: $+3, +7, +3$. (Not decreasing)

(B) $P_4O_{10} \rightarrow P = +5$; $SO_3 \rightarrow S = +6$; $H_2O \rightarrow H = +1$. Order: $+5, +6, +1$. (Not decreasing)

(C) $N_2O_5 \rightarrow N = +5$; $Al_2O_3 \rightarrow Al = +3$; $H_2S \rightarrow S = -2$. Order: $+5, +3, -2$. (**Strictly decreasing**)

(D) $PbO_2 \rightarrow Pb = +4$; $N_2O_3 \rightarrow N = +3$; $SO_3 \rightarrow S = +6$. Order: $+4, +3, +6$. (Not decreasing)

Step 4: Final Answer:

The correct option is $N_2O_5 > Al_2O_3 > H_2S$.

Quick Tip: Hydrogen is +1 when bonded to nonmetals (like Sulfur in H_2S) and -1 when bonded to active metals or metalloids acting as metals (like Al in AlH_3).

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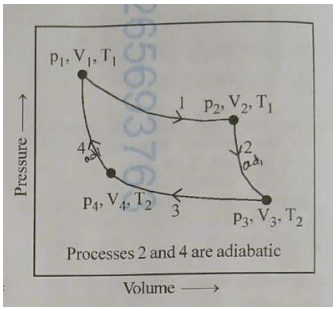
80. Consider the reversible processes for 1.0 mol of an ideal gas as shown in the figure.



w_1, w_2, w_3 and w_4 represent work done (in calories) in the processes 1, 2, 3 and 4, respectively; ΔU_2 and ΔU_4 are changes in the internal energy for the processes 2 and 4, respectively. use $R = 2$ cal K^{-1} mol^{-1}

The correct option is

(A) $w_1 + w_2 + w_3 + w_4 = 0$

(B) $w_1 + w_3 = -2T_1 \ln \frac{V_2}{V_1} - 2T_2 \ln \frac{V_4}{V_3}$

(C) $w_2 + w_4 = \Delta U_2 - \Delta U_4$

(D) $w_1 + w_2 = 2T_1 \ln \frac{V_2}{V_1}$

Correct Answer: (B) $w_1 + w_3 = -2T_1 \ln \frac{V_2}{V_1} - 2T_2 \ln \frac{V_4}{V_3}$

Solution:

Step 1: Understanding the Question:

The graph represents a standard Carnot cycle consisting of two isothermal processes (1 and 3) and two adiabatic processes (2 and 4). We need to identify the correct thermodynamic expression for the work done.

Step 2: Key Formula or Approach:

Using the standard chemistry convention (Work done **on** the system):

- For an isothermal reversible process: $w = -nRT \ln(V_f / V_i)$

- For an adiabatic process: $q = 0$, so by the first law, $w = \Delta U$.

Step 3: Detailed Explanation:

Given $n = 1.0$ mol and $R = 2$ cal K^{-1} mol^{-1}:

- **Process 1 (Isothermal expansion from V_1 to V_2 at T_1):**

$$w_1 = -nRT_1 \ln\left(\frac{V_2}{V_1}\right) = -2T_1 \ln\left(\frac{V_2}{V_1}\right)$$

- **Process 3 (Isothermal compression from V_3 to V_4 at T_2):**

$$w_3 = -nRT_2 \ln\left(\frac{V_4}{V_3}\right) = -2T_2 \ln\left(\frac{V_4}{V_3}\right)$$

Adding w_1 and w_3 together gives:

$$w_1 + w_3 = -2T_1 \ln\left(\frac{V_2}{V_1}\right) - 2T_2 \ln\left(\frac{V_4}{V_3}\right)$$

This matches Option (B) exactly.

Let's briefly check the others:

(A) The net work in a cyclic cycle is the area inside the curve, which is non-zero.

(C) Since $w = \Delta U$ for adiabatic steps, $w_2 + w_4 = \Delta U_2 + \Delta U_4$, not a subtraction.

(D) Does not mathematically conform to any single thermodynamic combination of steps 1 and 2.

Step 4: Final Answer:

The correct equation is $w_1 + w_3 = -2T_1 \ln \frac{V_2}{V_1} - 2T_2 \ln \frac{V_4}{V_3}$.

Quick Tip: Always check the sign convention! In chemistry, expansion work is negative because the system loses energy doing work on the surroundings. In physics, expansion work is often defined as positive.

---

81. Assertion A : For an ideal solution formed by mixing liquids P and Q, $\Delta_{mix}H = 0$ and $\Delta_{mix}V = 0$

Reason R : No interactions occur between P and Q

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

(A) A is not correct but R is correct

(B) Both A and R are correct and R is the correct explanation of A

(C) Both A and R are correct but R is NOT the correct explanation of A

(D) A is correct but R is not correct

Correct Answer: (D) A is correct but R is not correct

Solution:

Step 1: Understanding the Question:

We must evaluate the truth of an Assertion regarding the thermodynamic properties of ideal solutions, and a Reason proposing the molecular cause of this behavior.

Step 2: Detailed Explanation:

Assertion A: For an ideal liquid-liquid solution, there is no enthalpy change upon mixing ($\Delta_{mix}H = 0$) and no change in total volume upon mixing ($\Delta_{mix}V = 0$). This is the fundamental thermodynamic definition of an ideal solution. The Assertion is **correct**.

Reason R: The requirement for an ideal solution is *not* that "no interactions occur." Liquids exist precisely because of strong intermolecular forces. An ideal solution forms when the intermolecular interactions between unlike molecules (P-Q) are exactly identical in strength and nature to the interactions between like molecules (P-P and Q-Q). Because the interactions are identical, there is no net energy change or volume change. The claim that "no interactions occur" is physically absurd for liquid mixtures. The Reason is **incorrect**.

Step 4: Final Answer:

Assertion A is correct but Reason R is not correct.

Quick Tip: An ideal gas implies no intermolecular interactions. An ideal solution implies *perfectly uniform* intermolecular interactions (P-P ≈ Q-Q ≈ P-Q). Do not confuse the two definitions!

---

82. Among the species given below, the spin-only magnetic moment is highest for
(Given : Atomic number of Ti = 22, Mn = 25, Fe = 26 and Co = 27)

(A) $[Ti(H_2O)_6]^{3+}$
(B) $[Mn(CN)_6]^{3-}$
(C) $[Fe(CN)_6]^{3-}$
(D) $[Co(NH_3)_6]^{3+}$

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

Solution:

Step 1: Understanding the Question:

The question asks to identify the coordination complex with the highest spin-only magnetic moment. The magnetic moment depends on the number of unpaired electrons in the central metal ion's d-orbitals.

Step 2: Key Formula or Approach:

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

$$\mu = \sqrt{n(n+2)} \text{ B.M.}$$

where n is the number of unpaired electrons. A higher number of unpaired electrons results in a higher magnetic moment. We need to determine the oxidation state, the d-electron configuration, and the effect of the ligand field (strong vs. weak) for each complex.

Step 3: Detailed Explanation:

Let's analyze each complex: 1. $[Ti(H_2O)_6]^{3+}$: Titanium oxidation state = +3. Electronic configuration of Ti (Z=22) is $[Ar]3d^2 4s^2$. For Ti^{3+}, it is $[Ar]3d^1$. Number of unpaired electrons, $n = 1$.

2. $[Mn(CN)_6]^{3-}$: Manganese oxidation state = +3. Electronic configuration of Mn (Z=25) is $[Ar]3d^5 4s^2$. For Mn^{3+}, it is $[Ar]3d^4$. CN^- is a strong field ligand, so pairing occurs. The t_{2g} level fills first: $t_{2g}^4 e_g^0$. Number of unpaired electrons, $n = 2$.

3. $[Fe(CN)_6]^{3-}$: Iron oxidation state = +3. Electronic configuration of Fe (Z=26) is $[Ar]3d^6 4s^2$. For Fe^{3+}, it is $[Ar]3d^5$. CN^- is a strong field ligand, causing pairing: $t_{2g}^5 e_g^0$. Number of unpaired electrons, $n = 1$.

4. $[Co(NH_3)_6]^{3+}$: Cobalt oxidation state = +3. Electronic configuration of Co (Z=27) is $[Ar]3d^7 4s^2$. For Co^{3+}, it is $[Ar]3d^6$. NH_3 acts as a strong field ligand for Co^{3+}, causing complete pairing: $t_{2g}^6 e_g^0$. Number of unpaired electrons, $n = 0$.

The highest number of unpaired electrons is $n = 2$ for $[Mn(CN)_6]^{3-}$.

Step 3: Final Answer:

The complex with the highest spin-only magnetic moment is $[Mn(CN)_6]^{3-}$.

Quick Tip: Always remember that NH_3 acts as a strong field ligand for Co^{3+} (resulting in a diamagnetic low-spin complex), even though it is generally a moderate field ligand for other +2 transition metals.

---

83. A protein undergoes reversible thermal denaturation from its initial state N to dena-

tured state D according to $N \rightleftharpoons D$. At 60°C, the concentrations of both N and D are equal at equilibrium, and the standard enthalpy change of denaturation is 666 kJ mol^{-1}. The standard entropy change (ΔS° in kJ K^{-1}mol^{-1}) of the protein upon denaturation at 60°C is closest to

(A) 11.1

(B) 2.0

(C) 2000.0

(D) 333.0

Correct Answer: (B) 2.0

Solution:

Step 1: Understanding the Question:

We are given a reversible protein denaturation process at equilibrium. We have the temperature, the standard enthalpy change, and the condition that the concentrations of the reactant and product are equal. We need to find the standard entropy change (ΔS°).

Step 2: Key Formula or Approach:

At equilibrium, the equilibrium constant $K = \frac{[D]}{[N]}$. Since concentrations are equal, $K = 1$. The standard Gibbs free energy change is related to K by:

$$\Delta G^\circ = -RT \ln K$$

Since $K = 1$, $\ln(1) = 0$, which means $\Delta G^\circ = 0$. The fundamental thermodynamic equation is:

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

Setting $\Delta G^\circ = 0$ gives:

$$\Delta S^\circ = \frac{\Delta H^\circ}{T}$$

Step 3: Detailed Explanation:

Given: Temperature, $T = 60^\circ\text{C} = 60 + 273 = 333$ K Standard enthalpy change, $\Delta H^\circ = 666$ kJ mol^{-1}

Substitute these values into the derived equation:

$$\Delta S^\circ = \frac{666 \text{ kJ mol}^{-1}}{333 \text{ K}}$$

$$\Delta S^\circ = 2.0 \text{ kJ K}^{-1}\text{mol}^{-1}$$

Step 4: Final Answer:

The standard entropy change is 2.0 kJ $K^{-1}mol^{-1}$.

Quick Tip: Whenever a reversible process is at equilibrium with equal concentrations of reactants and products, the standard free energy change ΔG° is exactly zero. This allows for direct calculation of ΔS° from ΔH° and T.

---

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

Assertion A : Generally, $3d$ transition metals have high melting points.

Reason R : Involvement of $3d$-electrons in addition to $4s$-electrons in the interatomic metallic bonding.

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

(A) A is not correct but R is correct.

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

(C) Both A and R are correct and R is NOT the correct explanation of A.

(D) A is correct but R is not correct.

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

Solution:

Step 1: Understanding the Question:

The question tests the conceptual understanding of the physical properties of transition metals, specifically their melting points, and the underlying atomic reasons for these properties.

Step 2: Detailed Explanation:

Assertion A: Transition metals are characterized by high melting and boiling points. This is a well-established factual statement. Thus, the Assertion is correct.

Reason R: The high melting points of transition metals are attributed to strong metallic bonding. This strong bonding arises because both the ns electrons (e.g., $4s$) and the unpaired $(n-1)d$ electrons (e.g., $3d$) are available to participate in the delocalized sea of electrons forming the metallic lattice. The greater the number of valence electrons contributed, the stronger the metallic bond, and the higher the melting point. Thus, the Reason is correct and it is the exact scientific explanation for the Assertion.

Step 3: Final Answer:

Both A and R are correct and R is the correct explanation of A.

Quick Tip: The strength of metallic bonding in transition metals roughly scales with the number of unpaired d-electrons. This is why elements near the middle of the d-block (like Cr, Mo, W) have the highest melting points in their respective series.

---

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

Assertion A : The first ionization enthalpy of O is lower than that of N and F.

Reason R : The loss of an electron from O leads to stable half-filled p orbital.

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

(A) A is not correct but R is correct.

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

(C) Both A and R are correct and R is NOT the correct explanation of A.

(D) A is correct but R is not correct.

Correct Answer: (C) Both A and R are correct and R is NOT the correct explanation of A.

Solution:

Step 1: Understanding the Question:

We need to evaluate an assertion about the first ionization enthalpy trend among N, O, and F, and assess if the given reason correctly explains the entire assertion.

Step 2: Detailed Explanation:

Assertion A: The first ionization enthalpy of Oxygen (1314 kJ/mol) is indeed lower than that of Nitrogen (1402 kJ/mol) and Fluorine (1681 kJ/mol). The assertion is physically correct.

Reason R: The electronic configuration of Oxygen is $[He]2s^2 2p^4$. Losing one electron produces the O^+ ion with a $[He]2s^2 2p^3$ configuration. This resulting $2p^3$ state is exactly half-filled, which is unusually stable. Additionally, the paired electrons in the $2p^4$ configuration of oxygen experience inter-electronic repulsion, facilitating easier removal. Thus, the Reason is factually correct.

Evaluating the Link: While Reason R perfectly explains why Oxygen's ionization enthalpy is lower than Nitrogen's (anomalous trend), it does **not** explain why Oxygen's ionization enthalpy is lower than Fluorine's. Oxygen is lower than Fluorine primarily due to Fluorine's higher effective nuclear charge (Z_{eff}) and smaller atomic radius (the normal periodic trend). Because the reason provided only accounts for half of the phenomenon described in the assertion, it is typically considered NOT the complete or correct explanation for the assertion as a whole.

Step 3: Final Answer:

Both A and R are correct but R is NOT the correct explanation of A.

Quick Tip: In assertion-reason questions, if the reason only explains part of the assertion (e.g., explaining O < N but ignoring O < F), it is classified as "NOT the correct explanation". The reason must cover the entire scope of the assertion.

---

86. Consider the following reaction sequences and choose the correct option.
Reaction Scheme:

Center: $Ph - C \equiv C - Me$

Left path: $\xrightarrow{Na/liq.NH_3}$ **L** $\xrightarrow{HBr, \text{benzoyl peroxide}}$ **N**

Right path: $\xrightarrow{H_2, Pd/C \text{ (Lindlar's Catalyst)}}$ **K** $\xrightarrow{HBr}$ **M**

(A) M and N are stereoisomers

(B) K and L are geometrical isomers

(C) K and L are enantiomers

(D) M and N are geometrical isomers

Correct Answer: (B) K and L are geometrical isomers

Solution:

Step 1: Understanding the Question:

An internal alkyne undergoes partial reduction via two different methods to yield two alkenes (K and L). These alkenes subsequently undergo hydrobromination under different conditions to yield alkyl bromides (M and N). We must identify the structural relationship between the products.

Step 2: Detailed Explanation:

Formation of K and L: - **Right Path (to K):** Reduction with H_2 over Lindlar's catalyst (Pd/C poisoned) undergoes syn-addition, yielding the *cis*-alkene. Product **K** is ***cis*-1-phenylprop-1-ene**. - **Left Path (to L):** Birch reduction using Na in liquid NH_3 proceeds via a radical anion mechanism, yielding the more stable *trans*-alkene. Product **L** is ***trans*-1-phenylprop-1-ene**. Since K and L are *cis* and *trans* isomers of the same compound, they are **geometrical isomers**.

Formation of M and N: - **To M:** Addition of HBr to *cis*-1-phenylprop-1-ene follows Markovnikov's rule. The protonation occurs to form the most stable carbocation, which is the resonance-stabilized benzylic carbocation at C1. Bromide ion attacks here. Product **M** is **1-bromo-1-phenylpropane**. - **To N:** Addition of HBr to *trans*-1-phenylprop-1-ene in the presence of benzoyl peroxide proceeds via a free-radical anti-Markovnikov mechanism. The bromine radical adds to the double bond to form the most stable intermediate carbon radical. Addition at C2 leaves the radical at C1 (benzylic, highly stabilized by resonance). Product **N**

is **2-bromo-1-phenylpropane**. Since M and N differ in the position of the bromine atom, they are structural (positional) isomers, not stereoisomers or geometrical isomers.

Comparing the options, statement (B) is factually correct.

Step 3: Final Answer:

K and L are geometrical isomers.

Quick Tip: Lindlar's catalyst = *Syn* addition → *Cis* alkene. Birch reduction (Na/NH_3) = *Anti* addition → *Trans* alkene. This stereochemical divergence is a staple in competitive exams!

---

87. The highest occupied molecular orbital for Ne_2 is

(A) σ^*_{2p}

(B) π_{2p}

(C) σ_{2p}

(D) π^*_{2p}

Correct Answer: (A) σ^*_{2p}

Solution:

Step 1: Understanding the Question:

We need to determine the electronic configuration of the hypothetical Ne_2 molecule using Molecular Orbital (MO) Theory and identify its Highest Occupied Molecular Orbital (HOMO).

Step 2: Key Formula or Approach:

For homonuclear diatomic molecules with more than 14 electrons (like O_2, F_2, Ne_2), the filling order of molecular orbitals is: $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_z} < \pi_{2p_x} = \pi_{2p_y} < \pi^*_{2p_x} = \pi^*_{2p_y} < \sigma^*_{2p_z}$

Step 3: Detailed Explanation:

A single Neon atom has 10 electrons ($1s^2 2s^2 2p^6$). The diatomic molecule Ne_2 would have a total of $10 + 10 = 20$ electrons.

Let's fill the molecular orbitals with these 20 electrons: 1. σ_{1s} takes 2 2. σ^*_{1s} takes 2 3. σ_{2s} takes 2 4. σ^*_{2s} takes 2 5. σ_{2p_z} takes 2 6. π_{2p_x} and π_{2p_y} take 4 (2 each) 7. $\pi^*_{2p_x}$ and $\pi^*_{2p_y}$ take 4 (2 each) 8. $\sigma^*_{2p_z}$ takes 2

Total electrons filled $= 2+2+2+2+2+4+4+2 = 20$. The last electrons are filled into the $\sigma^*_{2p_z}$ orbital. Therefore, this is the Highest Occupied Molecular Orbital (HOMO).

Step 4: Final Answer:

The highest occupied molecular orbital is σ^*_{2p}.

Quick Tip: Since Ne_2 has all bonding and antibonding orbitals completely filled, its bond order is exactly zero ($\frac{10-10}{2} = 0$). This is why noble gases exist as monoatomic species and do not form diatomic molecules.

---

88. Match the species in List I with their geometry in List II

List I	List II
A. PCl_5	**I. Tetrahedral**
B. BrF_5	**II. Square Planar**
C. BF_4^-	**III. Trigonal bipyramidal**
D. $[Ni(CN)_4]^{2-}$	**IV. Square pyramidal**

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

We need to determine the molecular geometry of four chemical species based on VSEPR theory and Valence Bond Theory and match them with the correct shape.

Step 2: Detailed Explanation:

Let's analyze each species: **A.** PCl_5**:** Phosphorus has 5 valence electrons. It forms 5 single bonds with Chlorine and has 0 lone pairs. Steric number $= 5 + 0 = 5$ (sp^3d hybridization). The geometry is **Trigonal bipyramidal**. $(A \rightarrow III)$ **B.** BrF_5**:** Bromine has 7 valence electrons. It forms 5 single bonds with Fluorine, leaving 2 non-bonding electrons (1 lone pair). Steric number $= 5 + 1 = 6$ (sp^3d^2 hybridization). The base geometry is octahedral, but with one lone pair, the molecular shape is **Square pyramidal**. $(B \rightarrow IV)$ **C.** BF_4^-**:** Boron normally has 3 valence electrons, plus 1 for the negative charge $= 4$. It forms 4 single bonds with Fluorine and has 0 lone pairs. Steric number $= 4 + 0 = 4$ (sp^3 hybridization). The geometry is **Tetrahedral**. $(C \rightarrow I)$ **D.** $[Ni(CN)_4]^{2-}$**:** Nickel is in the +2 oxidation state ($3d^8$). CN^- is a strong field ligand, forcing the pairing of d-electrons and vacating one 3d orbital. This leads to dsp^2 hybridization. The geometry of dsp^2 complexes is **Square planar**. $(D \rightarrow II)$

Matching results: A-III, B-IV, C-I, D-II.

Step 3: Final Answer:

The correct option is (3) A-III, B-IV, C-I, D-II.

Quick Tip: For $3d^8$ metal complexes with coordination number 4: Strong field ligands (CN^-, CO) force pairing $\rightarrow dsp^2 \rightarrow$ Square planar. Weak field ligands (Cl^-, H_2O) don't pair $\rightarrow sp^3 \rightarrow$ Tetrahedral.

---

89. Match the vitamins in List I with their sources in List II

List I	List II
A. vitamin A	I. meat
B. vitamin B_{12}	II. sunflower oil
C. vitamin E	III. green leafy vegetables
D. vitamin K	IV. carrots

Choose the correct answer from the options given below.

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

The question asks to match specific vitamins to their major natural dietary sources.

Step 2: Detailed Explanation:

Let's pair each vitamin with its primary dietary source: **A. Vitamin A:** Retinol and its precursors (like beta-carotene) are highly concentrated in orange and yellow vegetables. **Carrots** are famously rich in Vitamin A. $(A \rightarrow IV)$ **B. Vitamin B_{12}:** Cobalamin is naturally found almost exclusively in animal products. **Meat**, fish, and dairy are the primary sources. $(B \rightarrow I)$ **C. Vitamin E:** Tocopherols are fat-soluble antioxidants primarily found in plant oils, nuts, and seeds. **Sunflower oil** is an excellent source. $(C \rightarrow II)$ **D. Vitamin K:** Phylloquinone is heavily concentrated in photosynthetic plant tissues, making **green leafy vegetables** (like spinach and kale) the best source. $(D \rightarrow III)$

Matching results: A-IV, B-I, C-II, D-III.

Step 3: Final Answer:

The correct matching is A-IV, B-I, C-II, D-III.

Quick Tip: Vitamin B_{12} is unique among vitamins because it contains a metal ion (Cobalt) and is practically absent from plant-based foods, which is why vegans often require supplementation.

---

90. For the following reaction sequence, choose the correct option

Reaction scheme: $\textbf{Benzene} \xrightarrow{i.CH_3COCl, AlCl_3 \quad ii.NaOCl} \textbf{P + Q}$

(A) Both P and Q are carbonyl compounds.

(B) If P is the sodium salt of a carboxylic acid, Q is a primary alcohol.

(C) P and Q are aromatic compounds.

(D) If P gives a carboxylic acid on acidification, Q gives a poisonous gas on exposure to air and light.

Correct Answer: (D) If P gives a carboxylic acid on acidification, Q gives a poisonous gas on exposure to air and light.

Solution:

Step 1: Understanding the Question:

We need to determine the intermediate and final products of a two-step organic reaction sequence starting from benzene, and then evaluate four descriptive statements about the final products P and Q.

Step 2: Key Formula or Approach:

1. **Friedel-Crafts Acylation:** Benzene + Acetyl chloride (CH_3COCl) + Lewis acid ($AlCl_3$) yields Acetophenone ($Ph-CO-CH_3$). 2. **Haloform Reaction:** Acetophenone contains a methyl ketone group ($-CO-CH_3$). Treatment with sodium hypochlorite ($NaOCl$) undergoes the haloform reaction to yield the sodium salt of a carboxylic acid ($Ph-COONa$) and a haloform precipitate ($CHCl_3$).

Step 3: Detailed Explanation:

Step 1 product: Acetophenone. Step 2 products (P + Q): Sodium benzoate (C_6H_5COONa) and Chloroform ($CHCl_3$).

Let's evaluate the options based on these products: (A) Neither Sodium benzoate nor Chloroform is considered a standard "carbonyl compound" (ketone/aldehyde) in this context. Chloroform certainly isn't. (False) (B) If P is sodium benzoate, Q is chloroform, which is a haloalkane, not a primary alcohol. (False) (C) Sodium benzoate is aromatic, but chloroform is aliphatic. Both are not aromatic. (False) (D) If P is sodium benzoate ($PhCOONa$), acidification yields benzoic acid ($PhCOOH$). If Q is chloroform ($CHCl_3$), exposure to oxygen and UV light oxidizes it to phosgene gas ($COCl_2$), which is highly poisonous. This perfectly

matches the properties of the products. (True)

Step 4: Final Answer:

The correct statement is (4) If P gives a carboxylic acid on acidification, Q gives a poisonous gas on exposure to air and light.

Quick Tip: Chloroform is stored in dark amber bottles filled to the brim to prevent the formation of deadly phosgene gas ($2CHCl_3 + O_2 \xrightarrow{light} 2COCl_2 + 2HCl$).

---

91. Given below are two statements :

Statement I : The class name Reptilia refers to creeping or crawling mode of locomotion.

Statement II : All organisms belonging to Reptilia have three chambered heart.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

Correct Answer: (D) Statement I is correct but Statement II is incorrect

Solution:

Step 1: Understanding the Question:

The question tests fundamental knowledge about the biological class Reptilia, specifically the origin of its name and the anatomy of the reptilian heart.

Step 2: Detailed Explanation:

Statement I: The class name Reptilia is derived from the Latin word *repere* or *reptum*, which literally translates to "to creep or crawl." This accurately describes their typical mode of locomotion. Thus, Statement I is correct.

Statement II: While the majority of reptiles (like snakes, lizards, and turtles) possess a three-chambered heart (two atria and one partially divided ventricle), this is not true for *all* organisms in the class. Crocodilians (crocodiles, alligators, caimans) are reptiles but possess a fully developed four-chambered heart. The word "All" makes this statement factually incorrect. Thus, Statement II is incorrect.

Step 3: Final Answer:

Statement I is correct but Statement II is incorrect.

Quick Tip: In biology MCQ statements, absolute words like "All," "Always," or "None" are frequently red flags indicating a false statement due to known evolutionary exceptions (like the 4-chambered heart in crocodiles).

---

92. How many turns of Calvin cycle are required for the formation of three molecules of glucose ?

(A) 18

(B) 6

(C) 3

(D) 1

Correct Answer: (A) 18

Solution:

Step 1: Understanding the Question:

We need to determine the number of Calvin cycle turns required to synthesize a specific quantity of glucose molecules.

Step 2: Key Formula or Approach:

The Calvin cycle fixes one molecule of CO_2 per turn. Since a single glucose molecule ($C_6H_{12}O_6$) contains 6 carbon atoms, it requires the fixation of 6 CO_2 molecules. Therefore, 1

molecule of glucose requires 6 turns of the Calvin cycle.

Step 3: Detailed Explanation:

If 1 molecule of glucose = 6 turns, Then 3 molecules of glucose = 3×6 turns = 18 turns.

Step 4: Final Answer:

18 turns are required.

Quick Tip: Every single turn of the Calvin cycle produces one net Carbon atom ready for carbohydrate synthesis. N carbons required = N turns required.

---

93. Photorespiration reaction catalyzed by RuBisCo is shown below :

$RuBP + O_2 \rightarrow$ 3-**Phosphoglycerate** $+ X$

Identify "X" from the given options :

(A) Malate

(B) Phosphoenolpyruvate

(C) 2-Phosphoglycolate

(D) Oxaloacetate

Correct Answer: (C) 2-Phosphoglycolate

Solution:

Step 1: Understanding the Question:

The question requires identifying the second product formed during the oxygenation reaction of RuBP catalyzed by the enzyme RuBisCO in the photorespiration pathway.

Step 2: Key Formula or Approach:

During normal photosynthesis (carboxylation), RuBP (5 carbons) + CO_2 (1 carbon) splits into two molecules of 3-PGA (3 carbons each). During photorespiration (oxygenation), RuBP (5 carbons) + O_2 splits into one molecule of 3-PGA (3 carbons) and one 2-carbon compound to

account for the carbon balance.

Step 3: Detailed Explanation:

In the photorespiratory pathway, when RuBisCO binds to O_2 instead of CO_2, the 5-carbon Ribulose-1,5-bisphosphate (RuBP) is cleaved into: - One molecule of 3-phosphoglycerate (3 carbons) - One molecule of phosphoglycolate (2 carbons), specifically 2-phosphoglycolate. Therefore, the unknown compound "X" is 2-Phosphoglycolate.

Step 4: Final Answer:

X is 2-Phosphoglycolate.

Quick Tip: Photorespiration is also called the C_2 cycle precisely because the first stable product unique to this wasteful pathway is the 2-carbon compound, 2-phosphoglycolate.

---

94. Given below are two statements :

Statement I : In gymnosperms, the male and female gametophytes remain within the sporangia.

Statement II : In gymnosperms, seeds are not covered.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

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

Solution:

Step 1: Understanding the Question:

We need to evaluate two anatomical and reproductive characteristics specific to Gymnosperms.

Step 2: Detailed Explanation:

Statement I: Unlike bryophytes and pteridophytes, in gymnosperms (and angiosperms), the male and female gametophytes do not have an independent, free-living existence. They remain retained within the sporangia (microsporangia and megasporangia) which are located on the sporophyte parent plant. Thus, Statement I is correct.

Statement II: The term "Gymnosperm" literally translates from Greek to "naked seed" (*gymnos* = naked, *sperma* = seed). Their ovules are not enclosed by an ovary wall before or after fertilization. Consequently, the resulting seeds remain exposed (uncovered). Thus, Statement II is also correct.

Step 3: Final Answer:

Both Statement I and Statement II are correct.

Quick Tip: A key evolutionary trend in plants is the progressive reduction of the gametophyte stage. In lower plants, it's independent; in seed plants (gymnosperms and angiosperms), it's highly reduced and strictly dependent on the sporophyte.

---

95. How many molecules of pyruvic acid are produced at the end of glycolysis from 206 molecules of glucose ?

(A) 412

(B) 206

(C) 309

(D) 103

Correct Answer: (A) 412

Solution:

Step 1: Understanding the Question:

We need to find the total yield of pyruvic acid from the glycolysis of a given number of glucose molecules.

Step 2: Key Formula or Approach:

Glycolysis is the metabolic pathway that converts a 6-carbon glucose molecule into two 3-carbon molecules of pyruvic acid (pyruvate).

$$1 \text{ Glucose} \xrightarrow{\text{Glycolysis}} 2 \text{ Pyruvic acid}$$

Step 3: Detailed Explanation:

Since the ratio is 1:2, we simply multiply the starting number of glucose molecules by 2. Total Pyruvic acid $= 206 \times 2 = 412$ molecules.

Step 4: Final Answer:

412 molecules of pyruvic acid are produced.

Quick Tip: Always perform a quick carbon balance check: Glucose has 6 carbons. Pyruvate has 3 carbons. Thus, $6 \div 3 = 2$ pyruvates must be formed per glucose to conserve carbon.

---

96. Match List-I with List-II.

List-I	List-II
A. Fusion of protoplasms between gametes	I. Meiosis
B. Fusion of two nuclei	II. Plasmogamy
C. Generation of haploid spores	III. Karyogamy

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

The question requires matching key stages of the sexual cycle in fungi (and general eukaryotic sexual reproduction) with their scientific terms.

Step 2: Detailed Explanation:

The sexual cycle in fungi typically involves three sequential steps: **A. Plasmogamy:** The first step is the fusion of the cytoplasm (protoplasms) of two motile or non-motile gametes or mating types. $(A \rightarrow II)$ **B. Karyogamy:** Following plasmogamy, the two haploid nuclei within the fused cell combine to form a single diploid nucleus (zygote). "Karyo" means nucleus. $(B \rightarrow III)$ **C. Meiosis:** The diploid zygote undergoes reductional division (meiosis) to generate haploid sexual spores, resetting the chromosomal count. $(C \rightarrow I)$

Matching results: A-II, B-III, C-I.

Step 3: Final Answer:

The correct matching is A-II, B-III, C-I.

Quick Tip: The prefixes are a dead giveaway: *Plasmo-* = plasma/cytoplasm; *Karyo-* = nucleus. Knowing just one root word can often solve the entire matching question!

---

97. Mitochondrial inner membrane encloses_____

(A) aqueous humor

(B) matrix

(C) cytosol

(D) mucus

Correct Answer: (B) matrix

Solution:

Step 1: Understanding the Question:

Identify the specific biological compartment contained within the inner membrane of a mitochondrion.

Step 2: Detailed Explanation:

A mitochondrion has a double-membrane structure: an outer membrane and an inner membrane. - The space between the outer and inner membranes is the intermembrane space. - The inner compartment, fully enclosed by the highly folded inner membrane (cristae), is filled with a dense, homogeneous substance called the **mitochondrial matrix**. This matrix contains the enzymes for the Krebs cycle, mitochondrial DNA, and ribosomes.

Other options: - Aqueous humor is fluid in the eye. - Cytosol is the fluid of the main cell cytoplasm outside organelles. - Mucus is a secretory substance of mucous membranes.

Step 3: Final Answer:

The inner membrane encloses the matrix.

Quick Tip: Remember: Glycolysis happens in the Cytosol. The Krebs cycle happens in the Matrix. The Electron Transport Chain happens on the Inner Membrane.

---

98. Phyllotaxy is the pattern of arrangement of _____ on the stem or branch.

(A) sepals

(B) leaves

(C) flowers

(D) fruits

Correct Answer: (B) leaves

Solution:

Step 1: Understanding the Question:

Define the botanical term "Phyllotaxy".

Step 2: Detailed Explanation:

In botany terminology: - **Phyllotaxy** is defined as the pattern of arrangement of **leaves** on a stem or branch. It is usually of three types: alternate, opposite, and whorled. - The arrangement of flowers on a floral axis is termed **Inflorescence**. - The arrangement of sepals or petals in a floral bud is termed **Aestivation**.

Step 3: Final Answer:

Phyllotaxy is the pattern of arrangement of leaves.

Quick Tip: The Greek root word *phyllo* always refers to leaves. Examples: Chlorophyll (green leaf), Mesophyll (middle leaf), Phyllotaxy (leaf arrangement).

---

99. Mad cow disease is caused by _____

(A) *Mycoplasma* sp.
(B) prions
(C) viroids
(D) *Aspergillus* sp.

Correct Answer: (B) prions

Solution:

Step 1: Understanding the Question:

Identify the infectious agent responsible for Mad Cow Disease (Bovine Spongiform Encephalopathy).

Step 2: Detailed Explanation:

Certain infectious neurological diseases are caused by abnormally folded proteins. These infectious proteinaceous particles are called **prions**. Prions are unique because they lack nucleic acids (DNA/RNA) entirely. The most notable diseases caused by prions are Bovine Spongiform Encephalopathy (BSE), commonly called "Mad cow disease" in cattle, and its human analog, Creutzfeldt-Jakob disease (CJD).

Step 3: Final Answer:

Mad cow disease is caused by prions.

Quick Tip: Differentiate the acellular agents: Viruses = DNA/RNA + Protein coat. Viroids = RNA only (infects plants). Prions = Protein only (causes neurological diseases).

---

100. Cell theory was formulated by _____

(A) Antonie Van Leeuwenhoek

(B) Schleiden and Schwann

(C) Robert Brown

(D) Singer and Nicolson

Correct Answer: (B) Schleiden and Schwann

Solution:

Step 1: Understanding the Question:

Identify the scientists who originally formulated the biological Cell Theory.

Step 2: Detailed Explanation:

Let's review the contributions of the scientists listed: - **Antonie Van Leeuwenhoek:** First saw and described a living cell. - **Robert Brown:** Discovered the nucleus. - **Singer and Nicolson:** Proposed the Fluid Mosaic Model of the cell membrane. - **Matthias Schleiden** (a German botanist, 1838) and **Theodore Schwann** (a British zoologist, 1839) together formulated the

Cell Theory, which states that all plants and animals are composed of cells and products of cells. (Later modified by Rudolf Virchow to include that all cells arise from pre-existing cells).

Step 3: Final Answer:

Cell theory was formulated by Schleiden and Schwann.

Quick Tip: Remember "SS": Schleiden (Plants) and Schwann (Animals) formulated the Cell Theory. Rudolf Virchow added the phrase *Omnis cellula-e cellula* to complete it.

---

101. Which of the following plant growth regulators promotes internode elongation prior to flowering in cabbage ?

(A) Ethephon
(B) Abscisic acid
(C) Gibberellin
(D) Indole butyric acid

Correct Answer: (C) Gibberellin

Solution:

Step 1: Understanding the Question:

Identify the plant hormone responsible for the sudden elongation of internodes just before flowering in rosette plants like cabbage.

Step 2: Detailed Explanation:

Plants with a rosette habit (like cabbage and beet) have extremely shortened internodes, keeping the leaves tightly packed near the ground. Just prior to flowering, these plants undergo a process called **bolting**, which is characterized by a massive and rapid elongation of the internodes to elevate the flowers. This physiological response is strictly promoted by the application or natural surge of **Gibberellins**.

Step 3: Final Answer:

Gibberellin promotes internode elongation.

Quick Tip: Whenever you see the terms "rosette habit," "cabbage," "beet," or "bolting," immediately link the answer to Gibberellins. It is one of their most distinct physiological roles.

---

102. Which pigment has absorption peak at 700 nm in the photosynthetic reaction centre PS I (P700) ?

(A) Carotenoids

(B) Chlorophyll b

(C) Chlorophyll a

(D) Xanthophylls

Correct Answer: (C) Chlorophyll a

Solution:

Step 1: Understanding the Question:

Identify the specific pigment molecule that constitutes the reaction center of Photosystem I (PS I) and absorbs light at 700 nm.

Step 2: Detailed Explanation:

In the thylakoid membranes of chloroplasts, pigments are organized into two light-harvesting complexes called Photosystem I (PS I) and Photosystem II (PS II). Each photosystem has a single "reaction center" molecule where the primary photochemical event (electron ejection) occurs. The reaction center is always formed by a specific molecule of **Chlorophyll a**. - In PS I, the reaction center Chlorophyll a has an absorption peak at 700 nm, hence it is called P700. - In PS II, the reaction center Chlorophyll a has an absorption peak at 680 nm, hence it is called P680. Other pigments (Chlorophyll b, carotenoids, xanthophylls) act as antennae molecules to funnel light energy to the reaction center.

Step 3: Final Answer:

The pigment is Chlorophyll a.

Quick Tip: Only Chlorophyll 'a' can act as the reaction center for both photosystems. All other pigments are strictly accessory pigments.

---

103. Sphenopsida class belongs to

(A) pteridophytes

(B) bryophytes

(C) angiosperms

(D) gymnosperms

Correct Answer: (A) pteridophytes

Solution:

Step 1: Understanding the Question:

Identify the major plant group to which the class Sphenopsida belongs.

Step 2: Detailed Explanation:

According to botanical classification, the group **Pteridophytes** (ferns and horsetails) is further subdivided into four classes: 1. **Psilopsida** (e.g., *Psilotum*) 2. **Lycopsida** (e.g., *Selaginella*, *Lycopodium*) 3. **Sphenopsida** (e.g., *Equisetum* - horsetails) 4. **Pteropsida** (e.g., *Dryopteris*, *Pteris*, *Adiantum*)

Therefore, Sphenopsida is a class of pteridophytes.

Step 3: Final Answer:

Sphenopsida belongs to pteridophytes.

Quick Tip: Memorize the representative member of Sphenopsida: *Equisetum* (Horsetail). It is known for having silica in its stems, making them rough to the touch.

---

104. Which of the following represents the correct sequence of arrangement of bones in the lower limb of humans ?

(A) Femur-tarsal-patella-tibia

(B) Femur-tibia-patella-tarsal

(C) Patella-femur-tibia-tarsal

(D) Femur-patella-tibia-tarsal

Correct Answer: (D) Femur-patella-tibia-tarsal

Solution:

Step 1: Understanding the Question:

Identify the correct proximal-to-distal (top-to-bottom) sequence of bones in the human leg.

Step 2: Detailed Explanation:

The bones of the human lower limb, starting from the hip joint down to the foot, are arranged sequentially as follows: 1. **Femur:** The thigh bone, which is the longest and heaviest bone in the body. 2. **Patella:** The knee cap, a cup-shaped sesamoid bone that covers the knee ventrally. 3. **Tibia and Fibula:** The two bones of the lower leg. The tibia is the larger, weight-bearing shin bone. 4. **Tarsals:** The ankle bones (7 in number). 5. **Metatarsals:** The bones of the sole (5 in number). 6. **Phalanges:** The toe bones (14 in number).

Matching this downward sequence with the given options, the correct progression is Femur → Patella → Tibia → Tarsal.

Step 3: Final Answer:

The correct sequence is Femur-patella-tibia-tarsal.

Quick Tip: To remember the sequence, visualize your own leg from top to bottom: Thigh (Femur) → Knee (Patella) → Shin (Tibia) → Ankle (Tarsal).

---

105. Which of the following plant growth regulators is used as herbicide ?

(A) Gibberellin

(B) 2,4-D

(C) Kinetin

(D) Abscisic acid

Correct Answer: (B) 2,4-D

Solution:

Step 1: Understanding the Question:

Identify which of the listed plant growth regulators (hormones) acts as a weed killer (herbicide).

Step 2: Detailed Explanation:

Synthetic auxins are heavily used in agriculture. **2,4-D** (2,4-dichlorophenoxyacetic acid) is a widely used synthetic auxin. It is specifically used as an herbicide to kill dicotyledonous (broad-leaved) weeds. Interestingly, it selectively kills dicot weeds but does not affect mature monocotyledonous plants, making it incredibly useful for preparing weed-free lawns and cereal crops. The other options (Gibberellin, Kinetin, Abscisic acid) do not have this selective herbicidal property.

Step 3: Final Answer:

The herbicide is 2,4-D.

Quick Tip: Agent Orange, a notorious defoliant used during the Vietnam War, was a 50:50 mixture of 2,4-D and 2,4,5-T (both synthetic auxins).

---

106. Genus represents

(A) a group of closely related families

(B) an individual plant or animal

(C) a population of plants and animals

(D) a group of closely related species

Correct Answer: (D) a group of closely related species

Solution:

Step 1: Understanding the Question:

Define the taxonomic category "Genus".

Step 2: Detailed Explanation:

In the biological taxonomic hierarchy, categories are arranged in a specific sequence: Kingdom → Phylum → Class → Order → Family → Genus → Species. Each category represents an aggregate of the category immediately below it: - A Family is a group of related genera. - A **Genus** comprises a group of related **species** which have more characters in common in comparison to species of other genera. For example, the genus *Panthera* includes closely related species like lion (*P. leo*), tiger (*P. tigris*), and leopard (*P. pardus*).

Step 3: Final Answer:

Genus represents a group of closely related species.

Quick Tip: Remember the hierarchy using a mnemonic like: "King Philip Came Over For Good Soup" (Kingdom, Phylum, Class, Order, Family, Genus, Species). A higher category always groups the "closely related" members of the category directly below it.

---

107. The plastid that stores xanthophyll is known as

(A) amyloplast

(B) chloroplast

(C) chromoplast

(D) aleuroplast

Correct Answer: (C) chromoplast

Solution:

Step 1: Understanding the Question:

Identify the type of plastid responsible for storing colored pigments like xanthophylls.

Step 2: Detailed Explanation:

Plastids are classified based on the type of pigments they contain and their function: 1. **Chloroplasts:** Contain chlorophyll and carotenoids, responsible for trapping light energy for photosynthesis. 2. **Chromoplasts:** Contain fat-soluble carotenoid pigments like carotene, **xanthophylls**, and others. These give the part of the plant a yellow, orange, or red color (found in fruits and flowers). 3. **Leucoplasts:** Colorless plastids that store nutrients: - **Amyloplasts:** Store carbohydrates/starch. - **Elaioplasts:** Store oils and fats. - **Aleuroplasts:** Store proteins.

Step 3: Final Answer:

The plastid that stores xanthophyll is the chromoplast.

Quick Tip: The prefix "chromo-" means color. If the question asks about storing colorful pigments (yellow/orange/red) that aren't for active photosynthesis, chromoplast is always the answer.

---

108. In water, frogs respire using _____

(A) trachea

(B) skin

(C) buccal cavity

(D) lungs

Correct Answer: (B) skin

Solution:

Step 1: Understanding the Question:

Identify the primary respiratory organ utilized by frogs when they are submerged in water.

Step 2: Detailed Explanation:

Frogs exhibit two distinct modes of respiration depending on their environment: - **On land:** They respire primarily using the buccal cavity, skin, and lungs (pulmonary respiration). - **In water:** Frogs cannot use their lungs underwater. Instead, they rely entirely on cutaneous respiration, which means they respire by exchanging dissolved oxygen and carbon dioxide directly through their highly vascularized, moist **skin**.

Step 3: Final Answer:

In water, frogs respire using their skin.

Quick Tip: Cutaneous (skin) respiration is also the exclusive method of breathing for frogs during both summer sleep (aestivation) and winter sleep (hibernation).

---

109. Which of the following is not a characteristic of chordates ?

(A) Presence of post anal part (tail)
(B) Presence of notochord
(C) Central nervous system is dorsal
(D) Absence of gills

Correct Answer: (D) Absence of gills

Solution:

Step 1: Understanding the Question:

Identify the statement that contradicts the fundamental defining features of animals belonging to the phylum Chordata.

Step 2: Detailed Explanation:

The phylum Chordata is defined by four fundamental, hallmark characteristics present at some stage of their development: 1. Presence of a solid, unjointed rod called a **notochord**. 2. A single, hollow, **dorsal nerve cord** (central nervous system). 3. Presence of **pharyngeal gill slits** (gills). 4. Presence of a **post-anal tail**.

Option (D) claims the "Absence of gills." Since the presence of pharyngeal gill slits is a defining mandatory feature of all chordate embryos (and adults in some classes like fishes), declaring their absence makes this statement incorrect.

Step 3: Final Answer:

Absence of gills is not a characteristic of chordates.

Quick Tip: Contrast Chordates with Non-chordates to avoid confusion: Chordates have a dorsal, hollow nerve cord and a ventral heart. Non-chordates have a ventral, solid nerve cord and a dorsal heart (if present).

---

110. Smooth endoplasmic reticulum _____

(A) is a site for the synthesis of carbohydrates

(B) has ribosomes attached to its surface

(C) is the major site for the synthesis of lipids

(D) is actively involved in protein synthesis

Correct Answer: (C) is the major site for the synthesis of lipids

Solution:

Step 1: Understanding the Question:

Identify the primary physiological function of the Smooth Endoplasmic Reticulum (SER).

Step 2: Detailed Explanation:

The Endoplasmic Reticulum (ER) exists in two forms: 1. **Rough Endoplasmic Reticulum (RER):** Has ribosomes attached to its outer surface, giving it a rough appearance. Because of ribosomes, its primary function is **protein synthesis** and secretion. 2. **Smooth Endoplasmic Reticulum (SER):** Devoid of ribosomes. Its primary function is the **synthesis of lipids**. In animal cells, lipid-like steroidal hormones are also synthesized in the SER. It also plays a key role in the detoxification of drugs.

Thus, options claiming ribosome attachment or protein synthesis apply to RER, not SER. Synthesis of carbohydrates is primarily linked to chloroplasts (in plants) or cytosol.

Step 3: Final Answer:

Smooth endoplasmic reticulum is the major site for the synthesis of lipids.

Quick Tip: Associate "Smooth" with "Slippery fats" (lipids) and "Rough" with the "Bumpy machines" (ribosomes) that make proteins.

---

111. Which of the following are characteristics of prokaryotic cells ?

(a) Ribosomes are made of 50S and 30S subunits

(b) They can have plasmids

(c) They contain mesosome

(d) They have peroxisomes

Choose the correct answer from the options given below :

(A) (a), (b) and (c) only

(B) (b) and (c) only

(C) (a) and (c) only

(D) (a), (c) and (d) only

Correct Answer: (A) (a), (b) and (c) only

Solution:

Step 1: Understanding the Question:

Identify which of the four provided statements accurately describe the internal structures of a prokaryotic cell (like bacteria).

Step 2: Detailed Explanation:

Let's analyze each statement: (a) **Ribosomes:** Prokaryotes possess 70S ribosomes, which are composed of two subunits: a larger 50S subunit and a smaller 30S subunit. (True) (b) **Plasmids:** Many bacteria contain small, circular, extrachromosomal DNA molecules known as plasmids, which often carry genes for antibiotic resistance. (True) (c) **Mesosomes:** A specialized membranous structure called the mesosome is formed by the infolding of the plasma membrane into the cell. It functions analogously to mitochondria for respiration in bacteria. (True) (d) **Peroxisomes:** Prokaryotes entirely lack membrane-bound organelles. Peroxisomes are single-membrane-bound organelles found exclusively in eukaryotic cells. (False)

Therefore, only statements (a), (b), and (c) are correct characteristics of prokaryotes.

Step 3: Final Answer:

The correct options are (a), (b) and (c) only.

Quick Tip: The defining feature of a prokaryote is the complete absence of any membrane-bound organelles (no nucleus, no mitochondria, no chloroplasts, no ER, no Golgi, no peroxisomes). If an option includes one of these, it is immediately wrong.

---

112. Match List-I with List-II.

List-I	List-II
A. Cristae	I. Flat membrane sacs in stroma of chloroplast
B. Cisternae	II. Infoldings in mitochondria
C. Thylakoids	III. Cell membrane
D. Phospholipid	IV. Disc shaped sacs in the Golgi apparatus

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

We need to correctly match cellular structures to their definitions or locations.

Step 2: Detailed Explanation:

Let's pair each biological term with its correct description: **A. Cristae:** These are the deep, finger-like infoldings of the inner membrane of **mitochondria** that increase surface area for ATP production. $(A \rightarrow II)$ **B. Cisternae:** These are the stacked, flat, disc-shaped membranous sacs that constitute the **Golgi apparatus** and Endoplasmic Reticulum. $(B \rightarrow IV)$ **C. Thylakoids:** These are the flattened, coin-like membrane sacs located in the stroma of the **chloroplast**, which contain chlorophyll for light reactions. $(C \rightarrow I)$ **D. Phospholipid:** The fundamental structural lipid molecule that forms the lipid bilayer of the **cell membrane**. $(D \rightarrow III)$ Matching results: A-II, B-IV, C-I, D-III.

Step 3: Final Answer:

The correct matching is A-II, B-IV, C-I, D-III.

Quick Tip: Do not confuse **Cristae** (inner folds of Mitochondria) with **Cisternae** (stacked sacs of the Golgi). This is one of the most frequently tested vocabulary mix-ups in cytology!

---

113. Which of the following statements related to pituitary gland are correct ?

(a) It is divided anatomically into adenohypophysis and neurohypophysis

(b) It secretes follicle stimulating hormone

(c) It secretes melanocyte stimulating hormone

(d) It does not secrete prolactin

Choose the correct answer from the options given below :

(A) (b) and (c) only

(B) (a) and (d) only

(C) (a), (b) and (c) only

(D) (c) and (d) only

Correct Answer: (C) (a), (b) and (c) only

Solution:

Step 1: Understanding the Question:

Evaluate four statements regarding the anatomy and endocrine secretions of the human pituitary gland.

Step 2: Detailed Explanation:

Let's verify each statement: (a) The pituitary gland is anatomically divided into an anterior lobe (adenohypophysis) and a posterior lobe (neurohypophysis). (True) (b) The pars distalis region of the adenohypophysis secretes gonadotropins, one of which is Follicle Stimulating Hormone (FSH). (True) (c) The pars intermedia region of the adenohypophysis secretes Melanocyte Stimulating Hormone (MSH). (True) (d) The adenohypophysis secretes Prolactin (PRL), which regulates the growth of mammary glands and milk production. Therefore, saying it "does not secrete prolactin" is false. (False)

Thus, only statements (a), (b), and (c) are correct.

Step 3: Final Answer:

The correct options are (a), (b) and (c) only.

Quick Tip: Remember the six main anterior pituitary hormones using the mnemonic "FLAT PEG": **F**SH, **L**H, **A**CTH, **T**SH, **P**rolactin, **E**ndorphins (ignored in basic biology), **G**H.

---

114. Which of the following statements regarding photorespiration are correct ?

(a) Do not occur in C3 plants

(b) CO_2 is consumed and O_2 is generated

(c) Phosphoglycolate is formed

(d) No synthesis of ATP and NADPH

Choose the correct answer from the options given below :

(A) (a) and (b) only

(B) (a) and (d) only

(C) (c) and (d) only

(D) (b) and (d) only

Correct Answer: (C) (c) and (d) only

Solution:

Step 1: Understanding the Question:

Evaluate statements to identify the true characteristics of photorespiration.

Step 2: Detailed Explanation:

Let's examine each statement: (a) Photorespiration is a major characteristic and a wasteful process occurring primarily in **C3 plants**. C4 plants have evolved mechanisms to avoid it. Thus, stating it "does not occur in C3 plants" is incorrect. (False) (b) Photorespiration occurs when RuBisCO acts as an oxygenase. It **consumes** O_2 and ultimately releases (generates) CO_2. This statement asserts the exact opposite. (False) (c) The first stable products of photorespiration are one molecule of 3-phosphoglycerate and one molecule of the 2-carbon compound, **phosphoglycolate**. (True) (d) Unlike cellular respiration or normal photosynthesis, photorespiration is a highly wasteful process because there is **no synthesis of sugars, ATP, or NADPH**. It actually consumes ATP. (True)

Therefore, only statements (c) and (d) are correct.

Step 3: Final Answer:

The correct options are (c) and (d) only.

Quick Tip: Photorespiration does exactly what its name implies: it respires (consumes O_2, releases CO_2) in the presence of photons (light), completely undoing the goal of photosynthesis without producing any ATP energy!

115. Which of the following statements is incorrect ?

(A) Fibrinogen is produced from fibrin (B) Blood coagulates in response to an injury (C) Blood clot consists of fibrins (D) Fibrin is produced from fibrinogen

Correct Answer: (A) Fibrinogen is produced from fibrin

Solution:

Step 1: Understanding the Question:

Identify the factually wrong statement regarding the blood coagulation (clotting) cascade.

Step 2: Detailed Explanation:

Let's analyze the statements based on the mechanism of blood coagulation: - Upon injury, a cascade of enzymatic reactions is triggered to prevent excessive blood loss. Blood coagulates in response to an injury. (Option B is correct). - A blood clot is essentially a network of threads called **fibrins**, in which dead and damaged formed elements of blood are trapped. (Option C is correct). - Fibrins are formed by the conversion of inactive **fibrinogens** present in the plasma by the enzyme thrombin. Thus, fibrin is produced from fibrinogen. (Option D is correct). - Consequently, stating that "Fibrinogen is produced from fibrin" implies the reverse of the actual biological pathway, making it factually backward and incorrect.

Step 3: Final Answer:

The incorrect statement is that fibrinogen is produced from fibrin.

Quick Tip: In biological naming, the suffix "-ogen" always means "generator of" or an inactive precursor (e.g., Fibrinogen generates Fibrin; Pepsinogen generates Pepsin). Therefore, the "-ogen" form is always the starting material!

116. Arrange the following taxonomic categories in ascending order.

(a) Genus

(b) Class

(c) Order

(d) Phylum

(e) Family

(f) Kingdom

(g) Species

Choose the correct answer from the options given below :

(A) (f), (c), (b), (g), (d), (e), (a)

(B) (g), (a), (e), (c), (b), (d), (f)

(C) (a), (c), (d), (g), (f), (b), (e)

(D) (g), (c), (d), (b), (e), (a), (f)

Correct Answer: (B) (g), (a), (e), (c), (b), (d), (f)

Solution:

Step 1: Understanding the Question:

We need to arrange the standard taxonomic hierarchy in ascending order, meaning from the lowest (most specific) category to the highest (most inclusive) category.

Step 2: Detailed Explanation:

The obligate taxonomic categories from smallest (most specific) to largest (most general) are: 1. **Species** (g) 2. **Genus** (a) 3. **Family** (e) 4. **Order** (c) 5. **Class** (b) 6. **Phylum** (or Division in plants) (d) 7. **Kingdom** (f)

Arranging the assigned letters sequentially yields: (g) → (a) → (e) → (c) → (b) → (d) → (f).

Step 3: Final Answer:

The correct option is (2) (g), (a), (e), (c), (b), (d), (f).

Quick Tip: Mnemonic for descending order: **K**eeps **P**onds **C**lean **O**r **F**rogs **G**et **S**ick (Kingdom, Phylum, Class, Order, Family, Genus, Species). Simply reverse it for ascending order.

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117. Select the correct sequence of experiments that led to a gradual understanding of photo-

synthesis in green plants.

(A) Production of glucose → role of air → release of oxygen → absorption spectra of chlorophyll a and b
(B) Absorption spectra of chlorophyll a and b → production of glucose → release of oxygen → role of air
(C) Role of air → release of oxygen → production of glucose → absorption spectra of chlorophyll a and b
(D) Release of oxygen → production of glucose → absorption spectra of chlorophyll a and b → role of air

Correct Answer: (C) Role of air → release of oxygen → production of glucose → absorption spectra of chlorophyll a and b

Solution:

Step 1: Understanding the Question:
The question asks for the chronological historical timeline of discoveries related to the process of photosynthesis.

Step 2: Detailed Explanation:
Following the historical timeline detailed in standard biology curricula: 1. **Role of air (1770):** Joseph Priestley performed bell jar experiments with a mouse and a mint plant, demonstrating that plants restore to the air whatever breathing animals and burning candles remove. 2. **Release of oxygen (1779):** Jan Ingenhousz showed that sunlight is essential for plants to purify the air, and later noted that only the green parts of the plant release bubbles (oxygen). 3. **Production of glucose (1854):** Julius von Sachs provided evidence that green parts in plants produce glucose, which is usually stored as starch. 4. **Absorption/Action spectra (1888):** T.W. Engelmann used a prism to split light into its spectral components and illuminated a green alga (*Cladophora*). He described the first action spectrum of photosynthesis, corresponding to the absorption spectra of chlorophyll a and b.
The correct sequence is: Role of air → Release of oxygen → Production of glucose → Absorption spectra.

Step 3: Final Answer:

The correct sequence is given by option (3).

Quick Tip: Link the scientists chronologically: Priestley (Air) → Ingenhousz (O_2 bubbles) → Sachs (Starch/Glucose) → Engelmann (Prism/Spectrum).

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118. Match List-I with List-II.

List-I	List-II
A. Starch	I. Fights infection
B. Antibody	II. Energy storage
C. Concanavalin A	III. Glucose transport
D. Glut-4	IV. Lectin

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

We need to correctly match biological molecules/proteins from a standard biomolecules table with their primary physiological functions.

Step 2: Detailed Explanation:

Let's pair each molecule with its function: **A. Starch:** A complex carbohydrate (polysaccharide) serving as the primary **energy storage** molecule in plants. ($A \rightarrow II$) **B. Antibody:** Specialized proteins (immunoglobulins) produced by the immune system to identify and neutralize foreign objects. They help **fight infection**. ($B \rightarrow I$) **C. Concanavalin A:** A carbohydrate-binding

protein. Such proteins are classified as **lectins**. ($C \rightarrow IV$) **D. GLUT-4:** An insulin-regulated protein that facilitates **glucose transport** into cells, particularly in fat and muscle tissue. ($D \rightarrow III$)

Matching results: A-II, B-I, C-IV, D-III.

Step 3: Final Answer:

The correct option is (3) A-II, B-I, C-IV, D-III.

Quick Tip: GLUT-4 stands for **GLU**cose **T**ransporter type 4. Even if you forget the others, knowing this abbreviation immediately solves part D.

---

119. The number of vertebrae in a human is

(A) 206

(B) 7

(C) 12

(D) 26

Correct Answer: (D) 26

Solution:

Step 1: Understanding the Question:

State the total number of bones that comprise the vertebral column (spine) of an adult human.

Step 2: Detailed Explanation:

The human vertebral column develops from 33 individual vertebrae. However, during growth into adulthood, some of the lower vertebrae fuse together. The adult vertebral column consists of exactly **26** serially arranged units: - 7 Cervical vertebrae (neck) - 12 Thoracic vertebrae (chest) - 5 Lumbar vertebrae (lower back) - 1 Sacral bone (formed by the fusion of 5 sacral vertebrae) - 1 Coccygeal bone (formed by the fusion of 4 coccygeal vertebrae) Total $= 7 + 12 + 5 + 1 + 1 = 26$ bones.

Step 3: Final Answer:

The number of vertebrae in an adult human is 26.

Quick Tip: Do not confuse the 26 vertebrae of the spine with the 206 bones of the entire adult human skeleton!

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120. Endomembrane system includes

(A) Golgi complex, chloroplast, peroxisomes and vacuole
(B) endoplasmic reticulum, Golgi complex, lysosomes and vacuole
(C) endoplasmic reticulum, chloroplast, peroxisomes and vacuole
(D) mitochondria, chloroplast, peroxisomes and vacuole

Correct Answer: (B) endoplasmic reticulum, Golgi complex, lysosomes and vacuole

Solution:

Step 1: Understanding the Question:

Identify the specific group of cellular organelles that collectively constitute the "endomembrane system".

Step 2: Detailed Explanation:

The endomembrane system is a group of organelles inside a eukaryotic cell that work together to modify, package, and transport lipids and proteins. An organelle is considered part of this system if its functions are highly coordinated with the others. The system strictly includes: 1. **Endoplasmic Reticulum (ER)** (synthesizes materials) 2. **Golgi complex** (modifies and packages materials) 3. **Lysosomes** (vesicles containing enzymes packaged by the Golgi) 4. **Vacuoles** (derived from ER and Golgi)

Organelles like mitochondria, chloroplasts, and peroxisomes are **not** part of the endomembrane system because their functions are largely independent and their membranes are not directly continuous with the others.

Step 3: Final Answer:

It includes the endoplasmic reticulum, Golgi complex, lysosomes and vacuole.

Quick Tip: An easy way to rule out wrong answers: Mitochondria and Chloroplasts are semi-autonomous (have their own DNA) and work independently of the packaging-and-shipping network, so they are never part of the endomembrane system.

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121. Length of the stem at time 0 is 20 cm. The arithmetic growth rate is 30 cm per day. What is the length of the stem at the end of the 7^{th} day ?

(A) 460 cm

(B) 50 cm

(C) 170 cm

(D) 230 cm

Correct Answer: (D) 230 cm

Solution:

Step 1: Understanding the Question:

Calculate the final length of a plant stem experiencing constant arithmetic growth over a specific number of days.

Step 2: Key Formula or Approach:

Arithmetic growth implies growth at a constant absolute rate. The mathematical expression for arithmetic growth is a simple linear equation:

$$L_t = L_0 + rt$$

where: L_t = length at time t L_0 = initial length at time $t = 0$ r = growth rate (elongation per unit time) t = time

Step 3: Detailed Explanation:

Given parameters: Initial length, $L_0 = 20$ cm Growth rate, $r = 30$ cm/day Time, $t = 7$ days

Substitute the values into the arithmetic growth equation:

$$L_7 = 20 \text{ cm} + (30 \text{ cm/day} \times 7 \text{ days})$$

$$L_7 = 20 + 210$$

$$L_7 = 230 \text{ cm}$$

Step 4: Final Answer:

The length of the stem is 230 cm.

Quick Tip: Arithmetic growth is linear ($y = mx + c$), characterized by a constant amount of growth per unit time. Geometric growth is exponential ($W_1 = W_0 e^{rt}$), characterized by constant percentage growth.

---

122. Match List-I with List-II.

List-I	List-II
A. Spherical	I. Vibrio
B. Rod	II. Cocci
C. Comma	III. Spirilla
D. Spirillum	IV. Bacilli

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

Match the common morphological shapes of bacteria (List I) with their scientific taxonomic terminology (List II).

Step 2: Detailed Explanation:

Bacteria are grouped into four major categories based on their shape: **A. Spherical:** Bacteria that are round or spherical are called **Coccus** (plural: Cocci). $(A \rightarrow II)$ **B. Rod:** Bacteria that are rod-shaped are called **Bacillus** (plural: Bacilli). $(B \rightarrow IV)$ **C. Comma:** Bacteria shaped like a comma are called **Vibrio**. $(C \rightarrow I)$ **D. Spirillum:** Bacteria that have a spiral or helical shape are naturally called **Spirillum** (plural: Spirilla). $(D \rightarrow III)$

Matching results: A-II, B-IV, C-I, D-III.

Step 3: Final Answer:

The correct option is (1) A-II, B-IV, C-I, D-III.

Quick Tip: Think of common diseases: *Vibrio cholerae* (comma-shaped cholera bacteria), *Lactobacillus* (rod-shaped in milk), *Streptococcus* (chains of spheres causing strep throat).

---

123. The number of action potentials generated by sino-arterial node (SAN) in a healthy human is _____ per minute.

(A) 120 - 140

(B) 28 - 30

(C) 70 - 75

(D) 100 - 110

Correct Answer: (C) 70 - 75

Solution:

Step 1: Understanding the Question:

Identify the natural firing rate of the primary pacemaker of the human heart.

Step 2: Detailed Explanation:

The Sino-atrial Node (SAN) is a specialized patch of nodal tissue located in the right upper corner of the right atrium. It is uniquely auto-excitable, meaning it can generate action potentials without any external stimuli. The SAN generates the maximum number of action potentials compared to other parts of the nodal system, driving the rhythmic contraction of the entire heart. It produces **70 to 75** action potentials per minute in a healthy resting adult, which perfectly corresponds to the normal resting heart rate (average of 72 beats per minute). For this reason, the SAN is called the primary "pacemaker" of the heart.

Step 3: Final Answer:

The number of action potentials generated is 70 - 75 per minute.

Quick Tip: The number of action potentials generated by the SAN is exactly equal to your heart rate. An average resting heart rate is widely known as 72 beats per minute, which falls directly in the 70-75 range.

---

124. Match List-I with List-II.

List-I	List-II
A. Family	I. Sapindales
B. Genus	II. Dicotyledonae
C. Class	III. Anacardiaceae
D. Phylum	IV. Angiospermae
E. Order	V. Mangifera

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

The question requires matching various taxonomic categories with their specific nomenclature based on the biological classification of the mango plant (*Mangifera indica*).

Step 2: Detailed Explanation:

Let us classify the mango plant step-by-step:

A. Family: Mango belongs to the family **Anacardiaceae**. $(A \rightarrow III)$

B. Genus: The genus name of mango is **Mangifera**. $(B \rightarrow V)$

C. Class: Mango is a dicotyledonous plant, so its class is **Dicotyledonae**. $(C \rightarrow II)$

D. Phylum / Division: As a flowering plant, its division is **Angiospermae**. $(D \rightarrow IV)$

E. Order: Mango belongs to the order **Sapindales**. $(E \rightarrow I)$

Combining these, the correct match sequence is A-III, B-V, C-II, D-IV, E-I.

Step 3: Final Answer:

The correct matching is option (A).

Quick Tip: Always memorize the complete classification table of common organisms given in the NCERT text (Mango, Wheat, Housefly, Human) as direct matching questions are frequently derived from it.

---

125. Which of the following is not a part of human central neural system ?

(A) Pericardium

(B) Arachnoid

(C) Dura mater

(D) Pia mater

Correct Answer: (A) Pericardium

Solution:

Step 1: Understanding the Question:

The question asks to identify the structure that is completely unrelated to the human Central Neural System (CNS).

Step 2: Detailed Explanation:

The central neural system, which includes the brain and the spinal cord, is covered and protected by three layers of connective tissue called the cranial meninges. These layers are:

1. **Dura mater:** The tough, fibrous outermost layer.
2. **Arachnoid mater:** The delicate, web-like middle layer.
3. **Pia mater:** The thin, highly vascular innermost layer that adheres closely to the brain.

The **Pericardium**, however, is the double-walled sac containing the heart and the roots of the great vessels. It has no structural or functional relationship with the central neural system.

Step 3: Final Answer:

Pericardium is not a part of the central neural system.

Quick Tip: Remember the layers of the meninges from outside to inside using the mnemonic **DAP**: **D**ura mater, **A**rachnoid, **P**ia mater. Pericardium (*peri* = around, *cardium* = heart) is exclusively for the heart.

---

126. Given below are two statements :

Statement I : Chromosomes are fully condensed at the end of prophase I.

Statement II : Meiosis I resembles mitosis.

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

(A) Statement I is incorrect, but Statement II is true

(B) Both Statement I and Statement II are true

(C) Both Statement I and Statement II are false

(D) Statement I is correct, but Statement II is false

Correct Answer: (D) Statement I is correct, but Statement II is false

Solution:

Step 1: Understanding the Question:

We need to evaluate the validity of two statements relating to the stages of cell division (Meiosis and Mitosis).

Step 2: Detailed Explanation:

Statement I: The final stage of Prophase I is diakinesis. This stage is marked by the terminalisation of chiasmata and the chromosomes becoming fully condensed. The meiotic spindle is assembled to prepare the homologous chromosomes for separation. Therefore, Statement I is factually correct.

Statement II: Meiosis I is a reductional division where homologous chromosomes separate, reducing the chromosome number by half. It does not resemble mitosis. Instead, it is **Meiosis II** (an equational division where sister chromatids separate) that closely resembles a normal mitotic division. Thus, Statement II is incorrect.

Step 3: Final Answer:

Statement I is correct, but Statement II is false.

Quick Tip: Meiosis I = Reductional division (homologous chromosomes separate). Meiosis II = Equational division (sister chromatids separate), which is why it is often described as resembling mitosis.

---

127. Match List-I with List-II.

List-I	List-II
A. Marginal placentation	I. Argemone
B. Axile placentation	II. Tomato
C. Parietal placentation	III. Primrose
D. Free central placentation	IV. Pea

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

The question asks to match different types of placentation (the arrangement of ovules within the ovary) with the plant examples that exhibit them.

Step 2: Detailed Explanation:

Let's match each placentation type with its classic example:

A. Marginal placentation: The placenta forms a ridge along the ventral suture of the ovary, and ovules are borne on this ridge forming two rows. Example: **Pea**. $(A \rightarrow IV)$

B. Axile placentation: The placenta is axial, and the ovules are attached to it in a multilocular ovary. Examples: China rose, **Tomato**, and lemon. $(B \rightarrow II)$

C. Parietal placentation: Ovules develop on the inner wall of the ovary or on the peripheral part. Examples: Mustard and **Argemone**. $(C \rightarrow I)$

D. Free central placentation: Ovules are borne on a central axis, and septa are absent. Examples: Dianthus and **Primrose**. $(D \rightarrow III)$

Matching results: A-IV, B-II, C-I, D-III.

Step 3: Final Answer:

The correct matching is option (A).

Quick Tip: Placentation examples are high-yield questions. Memorize the key pairs: Marginal = Pea; Axile = Tomato, Lemon, China rose; Parietal = Mustard, Argemone; Free central = Dianthus, Primrose; Basal = Sunflower, Marigold.

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128. Symbiotic association between fungi and algae are called

(A) chrysophytes

(B) lichens

(C) sponges

(D) mycorrhiza

Correct Answer: (B) lichens

Solution:

Step 1: Understanding the Question:

Identify the biological term for a specific mutually beneficial (symbiotic) relationship between a fungus and an alga.

Step 2: Detailed Explanation:

Let's analyze the terms:

- **Lichens** are dual organisms formed by the symbiotic association of a fungus (mycobiont) and an alga or cyanobacterium (phycobiont). The algal component provides food via photosynthesis, while the fungal component provides shelter, water, and minerals.
- **Mycorrhiza** refers to a symbiotic association between a fungus and the roots of higher plants (like pines or orchids), not algae.
- **Chrysophytes** is a group of algae that includes diatoms and golden algae.
- **Sponges** are simple, multicellular animals belonging to the phylum Porifera.

Step 3: Final Answer:

The symbiotic association is called lichens.

Quick Tip: Do not confuse Lichens (Algae + Fungi) with Mycorrhiza (Fungi + Roots of higher plants). Lichens are also excellent bioindicators as they do not grow in polluted (specifically SO_2 polluted) areas.

---

129. Which of the following is not a prokaryote ?

(A) Fungi

(B) Bacteria

(C) Blue green algae

(D) Mycoplasma

Correct Answer: (A) Fungi

Solution:

Step 1: Understanding the Question:

Identify the organism from the given options that is a eukaryote rather than a prokaryote.

Step 2: Detailed Explanation:

Prokaryotes are single-celled organisms that lack a true membrane-bound nucleus and other membrane-bound organelles. They all belong to the Kingdom Monera.

- **Bacteria**, **Blue-green algae** (cyanobacteria), and **Mycoplasma** are all members of Kingdom Monera and are therefore prokaryotes.
- **Fungi**, however, belong to the Kingdom Fungi. They possess a well-defined nucleus and membrane-bound organelles, making them **eukaryotes**.

Step 3: Final Answer:

Fungi are not prokaryotes.

Quick Tip: Blue-green algae is a misnomer; they are actually cyanobacteria (prokaryotes) and not true algae (which are eukaryotic). Fungi form their own entirely separate eukaryotic kingdom.

130. Arrange the following elements in descending order of their contribution to percentage weight of the human body.

(a) Oxygen (b) Carbon

(c) Hydrogen (d) Nitrogen

Choose the correct answer from the options given below :

(A) (b), (a), (c), (d)

(B) (a), (b), (c), (d)

(C) (c), (a), (b), (d)

(D) (b), (c), (d), (a)

Correct Answer: (B) (a), (b), (c), (d)

Solution:

Step 1: Understanding the Question:

We need to arrange four major chemical elements in the decreasing order of their percentage weight contribution to the human body.

Step 2: Detailed Explanation:

Based on the standard elemental analysis of the human body, the percentage weight of these elements is roughly:

1. **Oxygen (O):** 65%
2. **Carbon (C):** 18.5%
3. **Hydrogen (H):** 9.5%
4. **Nitrogen (N):** 3.3%

Descending order (highest to lowest) is Oxygen > Carbon > Hydrogen > Nitrogen.

This corresponds to the sequence (a), (b), (c), (d).

Step 3: Final Answer:

The correct descending sequence is (a), (b), (c), (d).

Quick Tip: Water makes up about 60-70% of the human body by weight, and since oxygen is much heavier than hydrogen (16:2 mass ratio in H_2O), Oxygen is overwhelmingly the most abundant element by mass in the body!

---

131. Which one of the following statements is incorrect ?

(A) β-cells of pancreas secrete insulin
(B) α-cells of pancreas secrete glucagon
(C) α-cells of pancreas secrete insulin
(D) Glucagon stimulates glycogenolysis

Correct Answer: (C) α-cells of pancreas secrete insulin

Solution:

Step 1: Understanding the Question:
Identify the factually incorrect statement regarding the endocrine functions of the human pancreas.

Step 2: Detailed Explanation:
The endocrine portion of the pancreas consists of Islets of Langerhans, which contain primarily two types of cells:
- α **(alpha) cells:** Secrete the hormone **glucagon**, which increases blood sugar levels by stimulating glycogenolysis (breakdown of glycogen into glucose). Thus, statements (B) and (D) are correct.
- β **(beta) cells:** Secrete the hormone **insulin**, which decreases blood sugar levels by promoting cellular glucose uptake. Thus, statement (A) is correct.

Statement (C) claims that α-cells secrete insulin, which is entirely false.

Step 3: Final Answer:
The statement "α-cells of pancreas secrete insulin" is incorrect.

Quick Tip: Alpha = Glucagon (raises blood glucose). Beta = Insulin (lowers blood glucose). They are antagonistic hormones that regulate sugar homeostasis.

---

132. Which of the following are characteristic features of Solanaceae family ?

(a) Flowers are bisexual and actinomorphic

(b) Calyx have five sepals and are united

(c) Androecium have five stamens and are epipetalous

(d) Ovary is inferior

Choose the correct answer from the options given below :

(A) (b), (c) and (d) only

(B) (a), (b) and (c) only

(C) (d) only

(D) (a) and (b) only

Correct Answer: (B) (a), (b) and (c) only

Solution:

Step 1: Understanding the Question:

Identify the correct morphological and floral characteristics that define the plant family Solanaceae (the potato family).

Step 2: Detailed Explanation:

Let's review the diagnostic features of the Solanaceae family:

(a) The flowers are indeed **bisexual** (hermaphrodite) and typically **actinomorphic** (radially symmetrical). (Correct)

(b) The calyx consists of **five sepals** that are fused (**united**/gamosepalous), and often persistent. (Correct)

(c) The androecium consists of **five stamens** that are attached to the petals (**epipetalous**). (Correct)

(d) The gynoecium features a bicarpellary, syncarpous ovary that is **superior**, not inferior. (Incorrect)

Therefore, statements (a), (b), and (c) correctly describe the Solanaceae family.

Step 3: Final Answer:

The correct characteristics are (a), (b), and (c) only.

Quick Tip: The floral formula for Solanaceae is: $\oplus\ K_{(5)}\ C_{(5)}\ A_5\ \underline{G}_{(2)}$. The underline under G signifies a superior ovary!

---

133. Given below are two statements :

Statement I : When any plane passing through the central axis of the body divides the organism into two identical halves, it is called radial symmetry.

Statement II : In phylum Echinodermata, both adults and larvae are radially symmetrical.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

Correct Answer: (D) Statement I is correct but Statement II is incorrect

Solution:

Step 1: Understanding the Question:

We need to evaluate the definitions of animal symmetry and its specific manifestation across the life stages of echinoderms.

Step 2: Detailed Explanation:

Statement I: This is the exact, textbook definition of radial symmetry. Examples include Coelenterates (cnidarians) and Ctenophores, where any vertical plane passing through the

central axis creates mirrored halves. Thus, Statement I is correct.

Statement II: Echinoderms present a unique evolutionary case regarding symmetry. The **adult echinoderms** (like starfish) exhibit secondary **radial** symmetry (specifically pentamerous radial symmetry). However, their **larvae** (like bipinnaria) are exclusively **bilaterally** symmetrical. Therefore, the claim that both life stages are radially symmetrical is factually wrong. Thus, Statement II is incorrect.

Step 3: Final Answer:

Statement I is correct, but Statement II is incorrect.

Quick Tip: Echinodermata is a favorite topic in exams due to this symmetry shift. Always remember: Adult = Radial, Larva = Bilateral!

---

134. The correct sequence of adult cell cycle phases is

(A) S-M-G2-G1

(B) G1-G2-S-M

(C) G1-M-G2-S

(D) G1-S-G2-M

Correct Answer: (D) G1-S-G2-M

Solution:

Step 1: Understanding the Question:

Identify the correct chronological order of the stages in a standard eukaryotic cell cycle.

Step 2: Detailed Explanation:

The cell cycle consists of Interphase and M-phase. Interphase is further divided into three sequential phases to prepare the cell for division:

1. **G1 phase (Gap 1):** The cell grows and carries out normal metabolism.

2. **S phase (Synthesis):** DNA replication occurs.
3. **G2 phase (Gap 2):** The cell prepares for mitosis and synthesizes necessary proteins.
4. **M phase (Mitosis/Meiosis):** The actual cell division occurs, resulting in two daughter cells.

The correct chronological sequence is therefore G1 → S → G2 → M.

Step 3: Final Answer:

The correct sequence is G1-S-G2-M.

Quick Tip: S-phase is sandwiched right in the middle of the two Gap phases. The cell must finish DNA synthesis (S) before it can enter the second gap (G2) for final pre-mitotic checks.

---

135. In frogs, the number of pairs of cranial nerves arising from the brain are

(A) 12
(B) 6
(C) 9
(D) 10

Correct Answer: (D) 10

Solution:

Step 1: Understanding the Question:

Identify the exact number of cranial nerve pairs present in the nervous system of a frog.

Step 2: Detailed Explanation:

The peripheral nervous system of a frog includes cranial nerves that emerge directly from the brain and spinal nerves that emerge from the spinal cord.
Unlike mammals and birds (which possess 12 pairs of cranial nerves), amphibians like frogs possess exactly **10 pairs** of cranial nerves.

Step 3: Final Answer:

Frogs have 10 pairs of cranial nerves.

Quick Tip: Fish and amphibians = 10 pairs of cranial nerves. Reptiles, birds, and mammals (amniotes) = 12 pairs of cranial nerves.

---

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

Assertion A : In recombinant DNA technology, lysozyme is used for disrupting bacterial cells while cellulase is for plant cells.

Reason R : Isolation of genetic material needs disruption of cells.

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

(A) A is not correct but R is correct

(B) Both A and R are correct and R is the correct explanation of A

(C) Both A and R are correct but R is not the correct explanation of A

(D) A is correct but R is not correct

Correct Answer: (B) Both A and R are correct and R is the correct explanation of A

Solution:

Step 1: Understanding the Question:

We need to evaluate an assertion about the specific enzymes used for cell lysis in biotechnology and a reason describing the necessity of cell disruption.

Step 2: Detailed Explanation:

Assertion A: In recombinant DNA technology, the first step is extracting DNA. To extract the DNA, the cell wall must be broken. Bacteria have cell walls made of peptidoglycan, which is degraded by the enzyme **lysozyme**. Plant cells have cell walls made of cellulose, which is

degraded by **cellulase** (and pectinase). Thus, the assertion is factually correct.

Reason R: The fundamental reason why these specific degrading enzymes (lysozyme and cellulase) are utilized is precisely because the **isolation of genetic material requires the disruption and breakdown of the cell envelope**. The Reason is true, and it directly justifies why the actions described in the Assertion are being performed.

Therefore, both statements are correct, and the Reason provides a valid, logical rationale for the actions taken in the Assertion.

Step 3: Final Answer:

Both A and R are correct and R is the correct explanation of A.

Quick Tip: Also remember the enzyme for fungal cell disruption: chitinase (since fungal cell walls are made of chitin).

---

137. The method of directly injecting a sperm into ovum in assisted reproductive technology is called :

(A) Embryo transfer (ET)
(B) Gamete intra fallopian transfer (GIFT)
(C) Zygote intra fallopian transfer (ZIFT)
(D) Intra cytoplasmic sperm injection (ICSI)

Correct Answer: (D) Intra cytoplasmic sperm injection (ICSI)

Solution:

Step 1: Understanding the Question:

Identify the specific Assisted Reproductive Technology (ART) procedure where a single sperm is manually injected directly into the cytoplasm of an egg.

Step 2: Detailed Explanation:

Let's define the provided acronyms:

- **ET (Embryo Transfer):** Involves transferring an already formed embryo into the uterus or fallopian tube.
- **GIFT (Gamete Intra Fallopian Transfer):** Involves transferring collected sperm and unfertilized eggs directly into the fallopian tube to allow natural fertilization.
- **ZIFT (Zygote Intra Fallopian Transfer):** Involves fertilizing eggs *in vitro* and transferring the zygote (up to 8 blastomeres) into the fallopian tube.
- **ICSI (Intra Cytoplasmic Sperm Injection):** A highly specialized *in vitro* fertilization procedure where a single healthy sperm is isolated and injected directly into the center (cytoplasm) of an ovum using a micropipette. This is specifically used to overcome severe male infertility issues.

Step 3: Final Answer:

The procedure is Intra cytoplasmic sperm injection (ICSI).

Quick Tip: The name itself holds the answer: Intra (Inside) Cytoplasmic (Cytoplasm) Sperm Injection. It literally describes the mechanical act of injecting the sperm into the egg cell.

---

138. Adaptive radiation in placental mammals and Australian Marsupials leading to similarity between distant species is an example of _____

(A) genetic drift
(B) divergent evolution
(C) convergent evolution
(D) founder effect

Correct Answer: (C) convergent evolution

Solution:

Step 1: Understanding the Question:

Identify the evolutionary phenomenon where two separate, geographically isolated lineages of mammals undergo adaptive radiation and end up developing strikingly similar phenotypic traits to fill identical ecological niches.

Step 2: Detailed Explanation:

- Adaptive radiation within a single lineage (e.g., Darwin's finches starting from one ancestor and diversifying) is an example of **divergent evolution**.
- However, when more than one adaptive radiation occurs in isolated geographical areas (one lineage of placental mammals in the Americas/Eurasia, and one lineage of marsupial mammals in Australia), and different groups evolve remarkably similar morphologies to adapt to similar habitats (e.g., the placental wolf and the marsupial Tasmanian wolf), this parallel adaptation is a classic example of **convergent evolution**.

Step 3: Final Answer:

The phenomenon is an example of convergent evolution.

Quick Tip: Divergent evolution = 1 ancestor → Many different forms. Convergent evolution = Different ancestors → Similar forms adapted to similar environments.

---

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

Assertion A : In an experiment, Mendel observed that the F1 progeny plants are all tall and none are dwarf.

Reason R : Stem height is a contrasting trait, with tall being dominant and dwarf being recessive.

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

(A) A is not correct but R is correct

(B) Both A and R are correct and R is the correct explanation of A

(C) Both A and R are correct but R is not the correct explanation of A

(D) A is correct but R is not correct

Correct Answer: (B) Both A and R are correct and R is the correct explanation of A

Solution:

Step 1: Understanding the Question:

Evaluate an assertion concerning Mendel's monohybrid cross results and its underlying genetic reason.

Step 2: Detailed Explanation:

Assertion A: When Gregor Mendel crossed pure-breeding tall pea plants (TT) with pure-breeding dwarf pea plants (tt), he found that 100% of the resulting F1 generation plants were tall (Tt). He observed no dwarf plants in the F1 generation. Thus, the Assertion is historically and genetically accurate.

Reason R: The phenomenon observed in the F1 generation is explained by the Law of Dominance. Stem height in peas has two contrasting traits: Tall and Dwarf. The 'tall' allele (T) is dominant over the 'dwarf' allele (t). Therefore, in the heterozygous F1 hybrids (Tt), only the dominant tall trait is expressed, masking the recessive dwarf trait. Thus, the Reason is correct, and it perfectly explains the observation made in the Assertion.

Step 3: Final Answer:

Both A and R are correct and R is the correct explanation of A.

Quick Tip: The complete masking of one trait by another in an F1 hybrid is the fundamental basis for Mendel's Law of Dominance.

---

140. Arrange the following in descending order of number of species in the Amazonian rain forest.

(a) Plants

(b) Birds

(c) Fishes

(d) Invertebrates

(e) Mammals

Choose the correct answer from the options given below :

(A) (b) > (a) > (d) > (c) > (e)

(B) (c) > (b) > (d) > (e) > (a)

(C) (d) > (a) > (c) > (b) > (e)

(D) (e) > (b) > (a) > (c) > (d)

Correct Answer: (C) (d) > (a) > (c) > (b) > (e)

Solution:

Step 1: Understanding the Question:

We must arrange various taxa in decreasing order based on their approximate species diversity found within the Amazonian rainforest.

Step 2: Detailed Explanation:

According to ecological data (and standard NCERT biodiversity statistics), the Amazonian rainforest harbors staggering biodiversity. The approximate species counts are:

1. **Invertebrates (d):** More than 1,25,000 species.
2. **Plants (a):** More than 40,000 species.
3. **Fishes (c):** Around 3,000 species.
4. **Birds (b):** Around 1,300 species.
5. **Mammals (e):** Around 427 species.

Arranging these from highest to lowest yields:

Invertebrates > Plants > Fishes > Birds > Mammals

Therefore, the correct sequence is (d) > (a) > (c) > (b) > (e).

Step 3: Final Answer:

The correct order is (d) > (a) > (c) > (b) > (e).

Quick Tip: In almost any terrestrial ecosystem, invertebrates (specifically insects) constitute the vast majority of species diversity, while large mammals are the least diverse.

141. Sponges exchange O_2 with CO_2 by

(A) gills

(B) simple diffusion over their entire body surfaces

(C) moist cuticle

(D) tracheal tubes

Correct Answer: (B) simple diffusion over their entire body surfaces

Solution:

Step 1: Understanding the Question:

Identify the primary mechanism of respiratory gas exchange utilized by sponges (Phylum Porifera).

Step 2: Detailed Explanation:

Sponges are very simple, multicellular organisms that possess a cellular level of organization. They lack any specialized respiratory, circulatory, or excretory systems.

Because their bodies are highly porous and water flows continuously through their canal systems, nearly all of their cells are in direct contact with the surrounding water.

Consequently, the exchange of gases (absorbing dissolved O_2 and releasing CO_2) occurs exclusively through **simple diffusion** across the cell membranes over their entire body surface.

Other options like gills (fish), moist cuticle (earthworms), and tracheal tubes (insects) are specialized respiratory organs found in higher, more complex animal phyla.

Step 3: Final Answer:

Sponges exchange gases by simple diffusion over their entire body surfaces.

Quick Tip: Lower invertebrates like Sponges, Coelenterates, and Flatworms rely entirely on simple diffusion through their body surface for gas exchange.

142. For a person with blood group 'O', which of the following is not a possible combination of parents' blood group genotypes ?

(A) Father : I^AI^B and Mother : I^Ai

(B) Father : I^Ai and Mother : I^Bi

(C) Father : I^Ai and Mother : I^Ai

(D) Father : I^Bi and Mother : I^Bi

Correct Answer: (A) Father : I^AI^B and Mother : I^Ai

Solution:

Step 1: Understanding the Question:

We need to determine which set of parental genotypes makes it genetically impossible to produce a child with an 'O' blood type.

Step 2: Detailed Explanation:

The ABO blood group system is controlled by the gene 'I'. The 'O' blood group is a recessive phenotype, meaning a person must possess a homozygous recessive genotype (ii).
To have an 'O' blood type child (ii), the child must inherit one recessive 'i' allele from the father and one recessive 'i' allele from the mother. Thus, **both parents must possess at least one 'i' allele**.

Let's evaluate the options:
(A) Father is I^AI^B. He has no 'i' allele to pass on. He can only pass I^A or I^B. Therefore, this couple can never have a child with blood group 'O'.
(B) Both parents are heterozygous (I^Ai and I^Bi). Both can pass the 'i' allele. (Possible)
(C) Both parents are heterozygous (I^Ai). Both can pass the 'i' allele. (Possible)
(D) Both parents are heterozygous (I^Bi). Both can pass the 'i' allele. (Possible)

Step 3: Final Answer:

The impossible combination is Father : I^AI^B and Mother : I^Ai.

Quick Tip: An AB blood group parent (I^AI^B) can NEVER have an O blood group child, and an O blood group parent (ii) can NEVER have an AB blood group child, regardless of the other parent's genotype.

---

143. Given below are two statements :

Statement I : Modern *Homo sapiens* arose in Australia and moved across continents.

Statement II : *Homo sapiens* arose around 75000 to 10000 years ago.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

Correct Answer: (A) Statement I is incorrect but Statement II is correct

Solution:

Step 1: Understanding the Question:

Evaluate statements regarding the geographical origin and the temporal emergence of modern humans.

Step 2: Detailed Explanation:

Statement I: Anthropological and genetic evidence overwhelmingly demonstrates that anatomically modern *Homo sapiens* arose in **Africa**, not Australia. From Africa, they subsequently migrated outward to populate other continents. Thus, Statement I is factually incorrect.

Statement II: According to established evolutionary timelines, *Homo sapiens* arose during the ice age, specifically between 75,000 to 10,000 years ago. This statement aligns with the accepted evolutionary timeline in standard biology texts. Thus, Statement II is correct.

Step 3: Final Answer:

Statement I is incorrect but Statement II is correct.

Quick Tip: Always remember the "Out of Africa" theory. It is the widely accepted model for the origin and dispersion of modern humans.

---

144. Which of the following is used as an effective sedative and painkiller for treating post-surgery patients ?

(A) Anti-retroviral drugs
(B) Interferon
(C) Antibiotics
(D) Morphine

Correct Answer: (D) Morphine

Solution:

Step 1: Understanding the Question:
Identify the pharmacological agent specifically utilized in clinical settings to provide pain relief and sedation following surgical procedures.

Step 2: Detailed Explanation:
Let's review the medical applications of the listed drugs:
- **Anti-retroviral drugs** are used to treat viral infections like HIV.
- **Interferons** are signaling proteins used to stimulate the immune system, particularly against viral infections and certain cancers.
- **Antibiotics** are used to treat bacterial infections.
- **Morphine** is a potent opioid analgesic derived from the latex of the poppy plant (*Papaver somniferum*). It acts directly on the central nervous system to relieve severe pain and induce sleep (sedation). It is highly effective and widely used for managing post-operative pain.

Step 3: Final Answer:

Morphine is used as an effective sedative and painkiller.

Quick Tip: Opioids bind to specific opioid receptors in the CNS and GI tract. Morphine is the classic benchmark against which all other painkillers (analgesics) are measured.

---

145. Which of the following plant produces non-albuminous seeds ?

(A) Pea

(B) Wheat

(C) Maize

(D) Barley

Correct Answer: (A) Pea

Solution:

Step 1: Understanding the Question:

Identify the plant species from the options that produces seeds lacking residual endosperm at maturity (non-albuminous/ex-albuminous seeds).

Step 2: Detailed Explanation:

Seeds are broadly classified based on the presence of endosperm at maturity:

1. **Albuminous (Endospermic) seeds:** The endosperm is retained and serves to nourish the embryo during germination. These are typical of **monocots** like Wheat, Maize, Barley, Rice, and Coconut (and a few dicots like Castor).

2. **Non-albuminous (Ex-albuminous) seeds:** The endosperm is completely consumed by the developing embryo before seed maturation. Food is stored in fleshy cotyledons instead. These are typical of **dicots** like **Pea**, Gram, Bean, and Groundnut.

Therefore, the Pea plant produces non-albuminous seeds.

Step 3: Final Answer:

Pea produces non-albuminous seeds.

Quick Tip: General rule of thumb: Monocots = Albuminous (exception: Orchids). Dicots = Non-albuminous (exception: Castor).

---

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

Assertion A : Abingdon tortoise in Galapagos islands became extinct within a decade after goats were introduced.

Reason R : Goats were more efficient at browsing than Abingdon tortoise.

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

(A) A is not correct but R is correct

(B) Both A and R are correct and R is the correct explanation of A

(C) Both A and R are correct but R is not the correct explanation of A

(D) A is correct but R is not correct

Correct Answer: (B) Both A and R are correct and R is the correct explanation of A

Solution:

Step 1: Understanding the Question:

We need to evaluate an assertion about an ecological extinction event and assess if the given reason represents the correct ecological mechanism behind it.

Step 2: Detailed Explanation:

Assertion A: Historical ecological records show that the Abingdon tortoise population on the Galapagos Islands suffered a dramatic collapse, leading to extinction shortly after goats were introduced to the islands by humans. The Assertion is factually correct.

Reason R: The rapid extinction was a classic case of **competitive exclusion** between two

distinct species sharing the same limited food resource. Goats are highly active, voracious, and efficient browsers capable of rapidly clearing out ground-level vegetation. The slow-moving tortoises simply could not compete with the grazing efficiency of the goats and ultimately starved. The Reason is factually correct and perfectly explains the mechanism of the extinction described in the Assertion.

Step 3: Final Answer:

Both A and R are correct and R is the correct explanation of A.

Quick Tip: This is a standard textbook example of 'Competitive Exclusion' where an introduced alien species outperforms a native species, driving the native species to extinction.

---

147. The covering of ovum at ovulation is

(A) chorion

(B) endometrium

(C) zona radiata

(D) zona pellucida

Correct Answer: (D) zona pellucida

Solution:

Step 1: Understanding the Question:

Identify the primary acellular envelope surrounding the human egg cell (secondary oocyte) at the time it is released from the ovary.

Step 2: Detailed Explanation:

During ovulation, a mature Graafian follicle ruptures to release the secondary oocyte. At this stage, the oocyte is immediately surrounded by a thick, transparent, non-cellular glycoprotein layer known as the **zona pellucida**, which is synthesized by the oocyte itself. Outside the zona pellucida is a cellular layer formed by follicle cells, known as the corona radiata (not

zona radiata). Chorion and endometrium are structures related to pregnancy and the uterus, not the unfertilized ovum.

Step 3: Final Answer:

The covering of the ovum at ovulation is the zona pellucida.

Quick Tip: The zona pellucida plays a crucial role during fertilization: it binds spermatozoa and initiates the acrosome reaction, and subsequently hardens to prevent polyspermy (entry of multiple sperm).

---

148. Which of the following is used as a clot buster ?

(A) Statins
(B) Streptokinase
(C) Penicillin
(D) Cyclosporin A

Correct Answer: (B) Streptokinase

Solution:

Step 1: Understanding the Question:

Identify the biologically derived substance used medically to dissolve blood clots in patients experiencing heart attacks.

Step 2: Detailed Explanation:

Let's review the medical applications of the options: - **Statins:** Produced by the yeast *Monascus purpureus*; used as blood-cholesterol-lowering agents. - **Streptokinase:** An enzyme produced by the bacterium *Streptococcus*. It is modified by genetic engineering and used as a "clot buster" to dissolve blood clots in the blood vessels of patients suffering from myocardial infarction (heart attack). - **Penicillin:** A classic antibiotic derived from fungi, used to kill bacteria. - **Cyclosporin A:** Produced by the fungus *Trichoderma polysporum*; used as an

immunosuppressive agent in organ transplant patients.

Step 3: Final Answer:

Streptokinase is used as a clot buster.

Quick Tip: Memorize these three high-yield medical products from microbes: Statins (cholesterol), Streptokinase (clot buster), and Cyclosporin A (immunosuppressant).

---

149. Which of the following structure is not a part of the male reproductive system ?

(A) Infundibulum

(B) Rete testis

(C) Epididymis

(D) Vasa efferentia

Correct Answer: (A) Infundibulum

Solution:

Step 1: Understanding the Question:

Identify the anatomical structure that belongs exclusively to the female reproductive system and not the male reproductive system.

Step 2: Detailed Explanation:

The male reproductive accessory ducts include: - **Rete testis:** A network of tubules within the testes. - **Vasa efferentia:** Fine ciliated ductules that exit the rete testis. - **Epididymis:** A highly coiled tube located on the posterior surface of the testis, serving as a site for sperm maturation. - **Vas deferens:** The tube that transports sperm from the epididymis.

The **Infundibulum**, however, is the funnel-shaped terminal portion of the female Fallopian tube (oviduct) that lies close to the ovary and possesses finger-like fimbriae to collect the ovum. It is completely absent in males.

Step 3: Final Answer:

Infundibulum is not a part of the male reproductive system.

Quick Tip: To remember the sequence of male accessory ducts, use the pathway of sperm: Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis → Vas deferens.

---

150. Given below are two statements :

Statement I : Ovulation is caused by LH surge leading to rupture of Graafian follicles.

Statement II : Graafian follicle remaining after ovulation transform into corpus luteum and secretes large amount of estrogen.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

Correct Answer: (D) Statement I is correct but Statement II is incorrect

Solution:

Step 1: Understanding the Question:

Evaluate statements detailing the hormonal control of ovulation and the subsequent development of ovarian structures.

Step 2: Detailed Explanation:

Statement I: Around the 14th day of a normal menstrual cycle, there is a rapid peak in the secretion of Luteinizing Hormone (LH), known as the LH surge. This surge directly induces the rupture of the mature Graafian follicle, thereby releasing the ovum (ovulation). Thus, Statement I is entirely correct.

Statement II: Following ovulation, the ruptured structural remnants of the Graafian follicle reorganize into a temporary endocrine gland called the **corpus luteum**. The corpus luteum functions primarily to secrete large amounts of **progesterone** (not estrogen), which is essential for maintaining the endometrial lining for potential implantation. Because the statement wrongly identifies the primary hormone as estrogen, Statement II is incorrect.

Step 3: Final Answer:

Statement I is correct but Statement II is incorrect.

Quick Tip: Remember the dominant hormones by cycle phase: Follicular phase = Estrogen (secreted by growing follicles). Luteal phase = Progesterone (secreted by Corpus luteum).

---

151. The opening between the right atrium and the right ventricle is guarded by

(A) sino-atrial node
(B) bicuspid valve
(C) tricuspid valve
(D) semilunar valve

Correct Answer: (C) tricuspid valve

Solution:

Step 1: Understanding the Question:

Identify the specific anatomical valve that regulates blood flow between the right upper chamber (atrium) and right lower chamber (ventricle) of the human heart.

Step 2: Detailed Explanation:

The human heart possesses several valves to ensure unidirectional blood flow: 1. **Tricuspid Valve:** Located between the right atrium and the right ventricle. It is formed by three muscular flaps (cusps). 2. **Bicuspid (Mitral) Valve:** Located between the left atrium and the left ventricle. It is formed by two flaps. 3. **Semilunar Valves:** Guard the openings of the right

ventricle into the pulmonary artery and the left ventricle into the aorta.
The sino-atrial (SA) node is a patch of tissue generating electrical impulses (pacemaker), not a valve.

Step 3: Final Answer:
The opening is guarded by the tricuspid valve.

Quick Tip: Mnemonic to avoid confusion: "Try to be Right" → **Tri**cuspid valve is on the **Right** side.

---

152. Which of the following is not evidence for evolution ?

(A) Divergent evolution of anatomical structures such as forelimbs
(B) Convergent evolution of traits like wings of birds and butterflies
(C) Paleontological evidence from fossil records
(D) Embryological support for evolution as proposed by Ernst Heckel

Correct Answer: (D) Embryological support for evolution as proposed by Ernst Heckel

Solution:

Step 1: Understanding the Question:
Identify the theory or concept among the options that is historically rejected and no longer accepted by modern science as valid evidence for evolution.

Step 2: Detailed Explanation:
Let's analyze the options based on evolutionary biology standards: - **Divergent and Convergent evolution** (Options A and B) represent comparative anatomical evidence (homology and analogy) firmly establishing evolutionary relationships. - **Paleontological evidence** (Option C) from fossils is the most direct physical evidence of historical evolutionary change. - **Ernst Haeckel's "Embryological support"** (Option D) originally proposed the "Recapitulation Theory" (ontogeny recapitulates phylogeny), suggesting that embryos pass through the exact adult stages of their evolutionary ancestors. However, this proposal was

strictly **disapproved and rejected** following careful studies performed by Karl Ernst von Baer, who noted that embryos never pass through the *adult* stages of other animals. Therefore, Haeckel's specific framework is not considered valid evidence today.

Step 3: Final Answer:

Embryological support for evolution as proposed by Ernst Haeckel is not considered evidence.

Quick Tip: While general embryological similarities do support evolution, Haeckel's specific "recapitulation theory" was famously debunked. Always pay attention to the names attached to the theories in evolutionary biology questions.

---

153. The inactive form of Bt toxin is converted to the active form in the insect gut

(A) by nucleases

(B) due to alkaline pH

(C) due to acidic pH

(D) by proteases

Correct Answer: (B) due to alkaline pH

Solution:

Step 1: Understanding the Question:

Identify the specific physiological trigger inside the gut of an insect that activates the lethal properties of the Bt toxin.

Step 2: Detailed Explanation:

The bacterium *Bacillus thuringiensis* (Bt) produces insecticidal proteins in an inactive crystal form known as protoxins. When an insect ingests these crystals, they enter the midgut. The **alkaline pH** of the insect's midgut solubilizes the crystals and triggers the conversion of the inactive protoxins into active toxic proteins. These activated toxins then bind to the surface of the midgut epithelial cells, creating pores that cause cell swelling

and lysis, ultimately leading to the death of the insect. This requirement for alkaline pH is why the toxin is harmless to mammals, including humans, as our stomachs possess an acidic pH.

Step 3: Final Answer:

It is converted to the active form due to alkaline pH.

Quick Tip: This mechanism is the core reason genetically modified Bt crops are safe for human consumption. We have an acidic stomach, while target insects have an alkaline midgut!

---

154. Colostrum, secreted by mother during initial days of lactation, is abundant in

(A) IgD

(B) IgG

(C) IgM

(D) IgA

Correct Answer: (D) IgA

Solution:

Step 1: Understanding the Question:

Identify the specific class of antibody (immunoglobulin) that is highly concentrated in the first breast milk (colostrum) provided to a newborn.

Step 2: Detailed Explanation:

Colostrum is the yellowish fluid produced by the mammary glands during the first few days after childbirth. It is uniquely rich in **Immunoglobulin A (IgA)** antibodies. These IgA antibodies provide crucial passive immunity to the infant, specifically coating the mucosal surfaces of the infant's digestive and respiratory tracts to protect against invasive environmental pathogens during the highly vulnerable early days of life.

Step 3: Final Answer:

Colostrum is abundant in IgA.

Quick Tip: Antibody tricks: **IgA** = Secretions (colostrum, saliva, tears). **IgG** = Gestation (only antibody that crosses the placenta). **IgE** = Eosinophils/Allergies. **IgM** = First responder (largest).

---

155. Which of the following in female gametophyte of an angiosperm helps in guiding the pollen tube for fertilizing the eggs ?

(A) Polar nucleus

(B) Antipodals

(C) Synergids

(D) Central cells

Correct Answer: (C) Synergids

Solution:

Step 1: Understanding the Question:

Identify the specific cells within the embryo sac that functionally direct the entry of the pollen tube.

Step 2: Detailed Explanation:

A mature female gametophyte (embryo sac) in angiosperms is a 7-celled, 8-nucleate structure. At the micropylar end, three cells group together to form the egg apparatus: one egg cell and two **synergids**. These synergids possess special cellular thickenings at their micropylar tip known as the **filiform apparatus**. The primary function of the filiform apparatus of the synergids is to release chemical attractants that guide the growing pollen tube precisely into the synergid, facilitating the release of male gametes for fertilization.

Step 3: Final Answer:

Synergids help in guiding the pollen tube.

Quick Tip: Think of the **Synergids** acting like airport ground crew holding light wands (filiform apparatus) guiding an airplane (pollen tube) safely into the terminal.

---

156. Which of the following disease is not sexually transmitted ?

(A) Genital warts

(B) Syphilis

(C) Tuberculosis

(D) Gonorrhoea

Correct Answer: (C) Tuberculosis

Solution:

Step 1: Understanding the Question:

Identify the infectious disease among the options that is not categorized as a Sexually Transmitted Infection (STI).

Step 2: Detailed Explanation:

Let's classify the mode of transmission for each disease: - **Genital warts** are caused by the Human Papillomavirus (HPV) and are highly contagious via sexual contact. - **Syphilis** is a bacterial infection caused by *Treponema pallidum* and is transmitted almost exclusively via sexual contact. - **Gonorrhoea** is a bacterial infection caused by *Neisseria gonorrhoeae* and is transmitted via sexual contact. - **Tuberculosis (TB)** is a bacterial infection caused by *Mycobacterium tuberculosis*. It primarily affects the lungs and is transmitted via **airborne respiratory droplets** (coughs and sneezes), not through sexual contact.

Step 3: Final Answer:

Tuberculosis is not sexually transmitted.

Quick Tip: Common STIs to remember for biology exams: Syphilis, Gonorrhea, Chlamydia, Genital herpes, Genital warts, Trichomoniasis, Hepatitis B, and HIV.

157. Which of the following statements about lac-operon is correct ?

(A) Galactose can act as an inducer of lac operon

(B) Gene i is constitutively expressed

(C) Lactose activates repressor to bind to the operator

(D) Genes i, z, y and a share single common promoter

Correct Answer: (B) Gene i is constitutively expressed

Solution:

Step 1: Understanding the Question:

Evaluate the provided statements regarding the genetic structure and regulation mechanism of the *lac* operon in bacteria.

Step 2: Detailed Explanation:

Let's review the facts regarding the *lac* operon: - **Option A:** The inducer of the *lac* operon is **lactose** (or its isomer allolactose), not galactose. (Incorrect) - **Option C:** The binding of the inducer (lactose) to the repressor protein actually **inactivates** it, changing its shape so it *cannot* bind to the operator, thereby allowing transcription. It does not activate it. (Incorrect) - **Option D:** While the structural genes (z, y, and a) share a single common promoter, the regulatory gene 'i' is independent and possesses its own distinct promoter. (Incorrect) - **Option B:** The regulatory gene 'i' constantly synthesizes the repressor protein at a low background level regardless of environmental conditions. Genes that are continuously expressed without external regulation are called "constitutive genes". Thus, gene i is constitutively expressed. (Correct)

Step 3: Final Answer:

The correct statement is that Gene i is constitutively expressed.

Quick Tip: The letter 'i' in the *lac* operon stands for "inhibitor", not inducer! It codes for the repressor protein which is always present (constitutive expression) to keep the operon firmly turned off until lactose shows up.

158. Match List-I with List-II.

List-I	List-II
A. Transformation	I. Restriction enzyme
B. Cloning site	II. Transfer DNA to host bacteria
C. Selection	III. Replication
D. Ori	IV. Antibiotic

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

The question requires matching terms related to recombinant DNA technology (List-I) with their corresponding biological functions or features (List-II).

Step 2: Detailed Explanation:

Let us match the given terms correctly:

A. **Transformation:** It is a procedure through which a piece of recombinant DNA is introduced into a host bacterium. (A-II)

B. **Cloning site:** In a vector, cloning sites are essentially the recognition sequences for specific restriction enzymes where the foreign DNA is ligated. (B-I)

C. **Selection:** Selectable markers, often antibiotic resistance genes, help in identifying and selecting transformants from non-transformants. (C-IV)

D. **Ori:** Origin of replication is the specific sequence from where replication starts. (D-III)

Therefore, the correct matching sequence is A-II, B-I, C-IV, D-III.

Quick Tip: Remember that vectors require three essential features for cloning: Origin of replication (Ori), a selectable marker (like antibiotic resistance), and cloning sites (for restriction enzymes).

---

159. A population of diploid organisms is at Hardy-Weinberg equilibrium. If the frequency of allele A is 0.1, the frequency of AA is _____.

(A) 0.99

(B) 0.01

(C) 0.02

(D) 0.10

Correct Answer: (B) 0.01

Solution:

Step 1: Understanding the Question:

We need to calculate the frequency of a homozygous dominant genotype in a population that is at Hardy-Weinberg equilibrium, given the frequency of the dominant allele.

Step 2: Key Formula or Approach:

According to the Hardy-Weinberg equation:

$$p^2 + 2pq + q^2 = 1$$

where p is the frequency of the dominant allele (A) and p^2 is the frequency of the homozygous dominant genotype (AA).

Step 3: Detailed Explanation:

Given the frequency of allele A (p) = 0.1.

The frequency of the AA genotype is p^2.

$p^2 = (0.1)^2 = 0.01$.

Quick Tip: Always double-check what the question asks for: allele frequency (p or q) or genotype frequency (p^2, q^2, or $2pq$).

---

160. Sperm motility is due to _____.

(A) muscular movement

(B) flagellar movement

(C) ciliary movement

(D) amoeboid movement

Correct Answer: (B) flagellar movement

Solution:

Step 1: Understanding the Question:

The question asks for the specific type of cellular movement mechanism that allows human spermatozoa to swim.

Step 2: Detailed Explanation:

A mammalian sperm consists of a head, neck, a middle piece, and a tail. The tail is a long flagellum containing a central axoneme (microtubule structure). The vigorous, whip-like lashing movement of the tail facilitates sperm motility essential for it to swim through the female reproductive tract and reach the ovum for fertilization. Therefore, sperm motility is entirely due to flagellar movement.

Quick Tip: Flagellar movement is characteristic of spermatozoa, whereas ciliary movement is seen in the respiratory tract and fallopian tubes, and amoeboid movement is characteristic of macrophages and leukocytes.

---

161. Consider a population of 10 million cells. Given the per-capita birth rate of 0.002 (per unit time) and the per-capita death rate of 0.002 (per unit time), the expected number of cells after 10 generations is _____.

(A) 100 million

(B) 1 million

(C) 5 million

(D) 10 million

Correct Answer: (D) 10 million

Solution:

Step 1: Understanding the Question:

We need to determine the future population size given an initial population size along with the per-capita birth and death rates.

Step 2: Key Formula or Approach:

The intrinsic rate of natural increase (r) determines population growth and is given by:

$$r = b - d$$

where b is the per-capita birth rate and d is the per-capita death rate.

Step 3: Detailed Explanation:

Given values: Birth rate (b) $= 0.002$ Death rate (d) $= 0.002$ Calculating the intrinsic rate of natural increase:

$$r = 0.002 - 0.002 = 0$$

Since $r = 0$, the population is experiencing zero growth (births perfectly balance deaths). Consequently, the population size will remain constant over time. Therefore, after 10 generations, the expected number of cells remains unchanged at 10 million.

Quick Tip: Whenever $b = d$, r is zero, and the population is stable (at a plateau). You don't need complex exponential formulas to solve this!

---

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

as Reason R.

Assertion A : Forelimbs of human and bats are homologous.

Reason R : Forelimbs of humans and bats have similar anatomical structure.

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

(A) A is false but R is true

(B) Both A and R are correct and R is the correct explanation of A

(C) Both A and R are true, but R is not the correct explanation of A

(D) A is true but R is false

Correct Answer: (B) Both A and R are correct and R is the correct explanation of A

Solution:

Step 1: Understanding the Question:

The question asks to evaluate an assertion about the relationship between human and bat forelimbs and a reason explaining the basis of this relationship.

Step 2: Detailed Explanation:

Assertion A states that the forelimbs of humans and bats are homologous. This is correct because homologous organs are those that share a common origin and basic structural plan, even if they have evolved to perform different functions (grasping in humans vs. flying in bats).

Reason R states that they have a similar anatomical structure. This is also correct, as both possess a similar arrangement of bones: humerus, radius, ulna, carpals, metacarpals, and phalanges. This fundamental similarity in their anatomical plan is the exact biological evidence and reason for classifying them as homologous organs (indicating divergent evolution from a common ancestor).

Therefore, both A and R are correct, and R provides the correct explanation for A.

Quick Tip: Homology = Same origin/structure, different function (Divergent evolution). Analogy = Different origin/structure, same function (Convergent evolution).

163. Muscle contraction is initiated by a signal sent by the central nervous system by the release of _____

(A) cyclic adenine monophosphate

(B) acetyl choline

(C) acetyl coenzyme A

(D) cyclic guanine monophosphate

Correct Answer: (B) acetyl choline

Solution:

Step 1: Understanding the Question:

We need to identify the specific neurotransmitter responsible for initiating skeletal muscle contraction at the neuromuscular junction.

Step 2: Detailed Explanation:

Muscle contraction is initiated by a neural signal from the Central Nervous System (CNS) transmitted via a motor neuron. When the neural signal reaches the neuromuscular junction (the junction between a motor neuron and the sarcolemma of the muscle fiber), it causes the synaptic vesicles to release a neurotransmitter called **acetylcholine**. The binding of acetylcholine to receptors on the sarcolemma generates an action potential that ultimately leads to muscle contraction via the release of calcium ions.

Quick Tip: Acetylcholine (ACh) is the primary neurotransmitter of the somatic nervous system stimulating skeletal muscles. Acetyl coenzyme A is an intermediate in cellular respiration, not a neurotransmitter.

164. Which of the following hormone is not secreted by human placenta ?

(A) LH

(B) hCG

(C) Estrogen

(D) Progesterone

Correct Answer: (A) LH

Solution:

Step 1: Understanding the Question:

Identify the hormone that is not synthesized and secreted by the human placenta during pregnancy.

Step 2: Detailed Explanation:

The human placenta acts as a temporary endocrine tissue and produces several essential hormones to maintain pregnancy. These include: - Human chorionic gonadotropin (hCG) - Human placental lactogen (hPL) - Estrogens - Progestogens (Progesterone) Luteinizing Hormone (LH), however, is a gonadotropin secreted by the anterior pituitary gland of the brain, not by the placenta. (Interestingly, hCG mimics the action of LH to maintain the corpus luteum during early pregnancy).

Quick Tip: hCG, hPL, and Relaxin are hormones produced in a woman only during pregnancy.

---

165. Which of the following statements is correct about *Plasmodium* ?

(A) Fertilization takes place in mosquito gut

(B) Reproduces sexually in liver cells

(C) Reproduces sexually in RBCs

(D) Gametocytes develop in mosquito gut

Correct Answer: (A) Fertilization takes place in mosquito gut

Solution:

Step 1: Understanding the Question:

We need to select the true statement regarding the life cycle of the malaria parasite, *Plasmodium*.

Step 2: Detailed Explanation:

Let's review the life cycle of *Plasmodium*: - Gametocytes (sexual stages) are formed inside the red blood cells (RBCs) of the human host. Therefore, option (D) is incorrect. - The human acts as the intermediate host where *Plasmodium* reproduces **asexually** (in liver cells and RBCs). Therefore, options (B) and (C) are incorrect. - When a female *Anopheles* mosquito takes a blood meal, it ingests these gametocytes. Inside the mosquito's stomach/gut, the gametes mature and **fertilization** (syngamy) takes place. Thus, option (A) is correct.

Quick Tip: Asexual reproduction = Human (Liver RBCs). Sexual reproduction (Fertilization) = Mosquito (Gut). Gametocyte formation = Human (RBCs).

---

166. Which of the following are primary consumers in a food chain ?

(A) Carnivores
(B) Parasites
(C) Predators
(D) Herbivores

Correct Answer: (D) Herbivores

Solution:

Step 1: Understanding the Question:

Identify the group of organisms that occupy the second trophic level (primary consumers) in a grazing food chain.

Step 2: Detailed Explanation:

In a food chain, the first trophic level consists of producers (plants/autotrophs) that fix solar energy. Organisms that feed directly on these producers are termed primary consumers. Since

they exclusively eat plant material, primary consumers are **herbivores** (e.g., insects, deer, cows). Carnivores eat herbivores, making them secondary or tertiary consumers.

Quick Tip: Producers = Trophic level 1. Primary consumers = Herbivores = Trophic level 2. Secondary consumers = Primary Carnivores = Trophic level 3.

---

167. Which of the following statements about the reabsorption process in Henle's loop are correct?

(a) The descending limb of Henle's loop is permeable to water but almost impermeable to electrolytes.

(b) Urine gets concentrated in Henle's loop.

(c) Reabsorption of Na^+ and water takes place in Henle's loop.

(d) Active or passive transport of electrolytes occurs in the ascending limb of Henle's loop.

Choose the correct answer from the options given below:

(A) (a), (b) and (d) only

(B) (a) and (b) only

(C) (b), (c) and (d) only

(D) (a), (b) and (c) only

Correct Answer: (A) (a), (b) and (d) only

Solution:

Step 1: Understanding the Question:

Evaluate multiple statements regarding the physiological properties and functions of the Loop of Henle during urine formation.

Step 2: Detailed Explanation:

Let's analyze the statements: - **Statement (a):** True. The descending limb is highly permeable to water but practically impermeable to electrolytes. - **Statement (b):** True. Because water leaves the descending limb, the filtrate (urine) becomes increasingly concentrated as it

moves down toward the hairpin turn. The loop plays a crucial role in maintaining medullary osmolarity, which ultimately concentrates urine. - **Statement (d):** True. The ascending limb is impermeable to water but allows the passage of electrolytes (like NaCl) actively or passively into the medullary fluid. - **Statement (c):** While both Na^+ and water are technically reabsorbed somewhere in the loop, they are not reabsorbed together in the same segment. The statement is broad and often considered misleading in multiple-choice formats compared to the specific accuracy of (a), (b), and (d). Based on the best-fit options provided, (a), (b), and (d) represent the most definitive and precise facts outlined in standard texts.

Quick Tip: Descending limb = Water exits (concentrates filtrate). Ascending limb = Electrolytes exit (dilutes filtrate).

---

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

Assertion A : The logistic growth model of populations is considered more realistic than the exponential growth model.

Reason R : Resources are finite.

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

(A) A is not correct but R is correct

(B) Both A and R are correct and R is the correct explanation of A

(C) Both A and R are correct but R is not the correct explanation of A

(D) A is correct but R is not correct

Correct Answer: (B) Both A and R are correct and R is the correct explanation of A

Solution:

Step 1: Understanding the Question:

Assess an assertion regarding population growth models and whether the given reason logically supports it.

Step 2: Detailed Explanation:

Assertion A is correct: In ecology, the logistic growth model (which results in an S-shaped or sigmoid curve) is considered highly realistic for natural populations, whereas the exponential model (J-shaped curve) is theoretical and rarely sustained.

Reason R is correct: The primary reason the exponential model fails in nature is that environmental resources (food, space, light) are limited and finite. As a population grows, competition for these finite resources increases, eventually halting growth as it approaches the carrying capacity (K). Therefore, the fact that resources are finite is the exact reason why the logistic model is more realistic.

Both statements are true, and R correctly explains A.

Quick Tip: Exponential growth occurs only under ideal, unlimited resource conditions. Logistic growth occurs under realistic, limited resource conditions characterized by carrying capacity (K).

---

169. Which of the following is the correct order of arrangement of vertebrate column from the head to toe?

(A) Cervical vertebra, thoracic vertebra, lumbar vertebra, sacrum

(B) Cervical vertebra, thoracic vertebra, sacrum, lumbar vertebra

(C) Sacrum, lumbar vertebra, thoracic vertebra, cervical vertebra

(D) Cervical vertebra, lumbar vertebra, thoracic vertebra, sacrum

Correct Answer: (A) Cervical vertebra, thoracic vertebra, lumbar vertebra, sacrum

Solution:

Step 1: Understanding the Question:

Identify the correct anatomical sequence of the regions of the human vertebral column starting from the superior end (head) to the inferior end (toe).

Step 2: Detailed Explanation:

The human vertebral column consists of 26 serially arranged vertebrae. From the skull downwards, they are arranged in the following order: 1. **Cervical** vertebrae (7 in number) in the neck region. 2. **Thoracic** vertebrae (12 in number) in the chest region. 3. **Lumbar** vertebrae (5 in number) in the lower back. 4. **Sacral** vertebra (1 fused bone consisting of 5 sacral vertebrae) in the pelvic region. 5. **Coccygeal** vertebra (1 fused bone consisting of 4 coccygeal vertebrae, forming the tailbone). Therefore, the sequence is Cervical → Thoracic → Lumbar → Sacrum.

Quick Tip: Remember the formula: $C_7T_{12}L_5S_{(5)}C_{(4)}$. The order is naturally top to bottom!

---

170. Match List-I with List-II.

List-I	List-II
A. Both species are harmed	**I. Predation**
B. One species is harmed and the other is benefited	**II. Mutualism**
C. Both species are benefited	**III. Competition**
D. One is benefited while the other has no effect	**IV. Commensalism**

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

Match the description of population interactions (+, -, 0) to their corresponding ecological terms.

Step 2: Detailed Explanation:

A. **Both species are harmed (-/-):** This describes **Competition**, where both species expend energy fighting over a limited resource. (A-III)

B. **One species is harmed and the other is benefited (+/-):** This describes **Predation** (or Parasitism), where a predator gains nutrition at the fatal expense of the prey. (B-I)

C. **Both species are benefited (+/+):** This describes **Mutualism**, an obligate or facultative mutually beneficial partnership. (C-II)

D. **One is benefited while the other has no effect (+/0):** This describes **Commensalism**. (D-IV)

The correct match is A-III, B-I, C-II, D-IV.

Quick Tip: Amensalism is the opposite of commensalism: one is harmed, the other is unaffected (-/0).

---

171. If the diploid chromosome number of typical angiosperm is 36, what would be the chromosome number in its endosperm ?

(A) 72

(B) 18

(C) 36

(D) 54

Correct Answer: (D) 54

Solution:

Step 1: Understanding the Question:

Calculate the ploidy level and specific chromosome count of the endosperm in an angiosperm, given its somatic (diploid) chromosome number.

Step 2: Key Formula or Approach:

The somatic cells of a plant are diploid ($2n$). The gametes (pollen/egg) are haploid (n). In angiosperms, the endosperm is formed by triple fusion (one haploid male gamete fusing with two haploid polar nuclei), making it triploid ($3n$).

Step 3: Detailed Explanation:

Given diploid number $(2n) = 36$.

Therefore, haploid number $(n) = \frac{36}{2} = 18$.

Chromosome number in the endosperm $(3n) = 3 \times 18 = 54$.

Quick Tip: Gymnosperm endosperm is haploid (n) because it is formed before fertilization, whereas angiosperm endosperm is triploid $(3n)$ as a product of double fertilization.

---

172. Which of the following enzymes synthesizes precursor mRNA ?

(A) DNA polymerase

(B) RNA polymerase I

(C) RNA polymerase II

(D) RNA polymerase III

Correct Answer: (C) RNA polymerase II

Solution:

Step 1: Understanding the Question:

Identify the specific eukaryotic RNA polymerase responsible for transcribing the precursor to messenger RNA.

Step 2: Detailed Explanation:

In eukaryotes, there is a clear division of labor among three RNA polymerases: 1. **RNA polymerase I** transcribes ribosomal RNAs (rRNAs: 28S, 18S, and 5.8S). 2. **RNA polymerase II** transcribes the precursor of mRNA, which is known as heterogeneous nuclear RNA (hnRNA). 3. **RNA polymerase III** transcribes transfer RNA (tRNA), 5S rRNA, and small nuclear RNAs (snRNAs). Since precursor mRNA is hnRNA, it is synthesized by RNA polymerase II.

Quick Tip: Mnemonic for RNA Polymerases I, II, III: **r**, **m**, **t** (rRNA, mRNA, tRNA) in that exact order (1, 2, 3).

---

173. Given below are two statements :

Statement I : Plasmids are autonomously replicating DNA.

Statement II : Plasmids are extrachromosomal DNA.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

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

Solution:

Step 1: Understanding the Question:

Evaluate the core definitions and features of bacterial plasmids used in biotechnology.

Step 2: Detailed Explanation:

Statement I states that plasmids are autonomously replicating DNA. This is correct. Plasmids possess their own origin of replication (Ori), allowing them to replicate independently of the main bacterial chromosome.

Statement II states that plasmids are extrachromosomal DNA. This is also correct. They are small, typically circular, double-stranded DNA molecules found outside the main nucleoid (chromosomal DNA) of the bacteria.

Both statements accurately describe fundamental properties of plasmids.

Quick Tip: Because plasmids replicate autonomously and reside outside the main genome, they make perfect vectors for carrying foreign DNA into a host cell in recombinant DNA technology.

174. How many theca are present in each lobe of a typical bilobed angiosperm anther ?

(A) 12

(B) 2

(C) 6

(D) 8

Correct Answer: (B) 2

Solution:

Step 1: Understanding the Question:

Identify the number of chambers (theca) present within a single lobe of a typical plant anther.

Step 2: Detailed Explanation:

A typical angiosperm anther consists of two lobes (bilobed structure). A longitudinal groove runs lengthwise, separating these two lobes. Inside each lobe, there are two distinct compartments or cavities called theca. Because each lobe has two theca, the typical anther is described as **dithecous**. Therefore, the number of theca per lobe is 2.

Quick Tip: 1 anther = 2 lobes. 1 lobe = 2 theca. Therefore, a typical bilobed anther is dithecous and has 4 microsporangia in total (tetrasporangiate).

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175. Natural selection can lead to

(a) stabilisation

(b) genetic drift

(c) directional change

(d) disruption

Choose the correct answer from the options given below :

(A) (a) and (c) only

(B) (a) only

(C) (a), (c) and (d) only

(D) (a), (b), (c) and (d)

Correct Answer: (C) (a), (c) and (d) only

Solution:

Step 1: Understanding the Question:

Identify the possible evolutionary outcomes that can arise from the operation of natural selection on a population's traits.

Step 2: Detailed Explanation:

Depending on environmental pressures, natural selection acts on phenotypic variations in three primary ways: 1. **Stabilisation (a):** Individuals with average/mean traits are favored, narrowing the distribution curve. 2. **Directional change (c):** Individuals at one extreme of the trait distribution are favored, shifting the curve in one direction. 3. **Disruption (d):** Individuals at both extremes are favored over the mean, leading to a bimodal (two-peaked) curve. **Genetic drift (b)** is an entirely separate mechanism of evolution driven by random chance events (sampling error) in small populations, not by natural selection. Thus, (b) is excluded.

Quick Tip: Genetic drift and Natural Selection are both forces of evolution, but they are entirely independent processes. Drift is random; selection is non-random.

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176. Which of the following statements are correct?

(a) Energy flow from producers to consumers is unidirectional

(b) Energy pyramid can never be inverted

(c) Transfer of energy follows the 10% law

Choose the correct answer from the options given below :

(A) (b) and (c) only

(B) (a), (b) and (c)

(C) (a) and (b) only

(D) (a) and (c) only

Correct Answer: (B) (a), (b) and (c)

Solution:

Step 1: Understanding the Question:

Assess the correctness of fundamental ecological principles relating to energy flow in an ecosystem.

Step 2: Detailed Explanation:

- **Statement (a):** True. Energy flow is strictly unidirectional. Solar energy captured by autotrophs moves through the trophic levels to consumers and is lost as heat. It is never returned to the sun or transferred back from consumers to producers. - **Statement (b):** True. The pyramid of energy is always upright and can never be inverted. This is a direct consequence of the Second Law of Thermodynamics, as energy is progressively lost as heat at each successive trophic step. - **Statement (c):** True. The transfer of energy between trophic levels strictly obeys Lindeman's 10% law, meaning that on average, only about 10% of the energy available at one trophic level is passed onto the next. Since all three statements are biologically correct, option (B) is the right choice.

Quick Tip: While pyramids of numbers and biomass can sometimes be inverted (e.g., insects on a single tree, or phytoplankton in the sea), the energy pyramid is universally upright.

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177. Match List-I with List-II.

List-I	List-II
A. Excess growth hormone	I. Reabsorption of water and electrolytes in kidney
B. Luteinizing hormone	II. Contraction of uterus during child birth
C. Vasopressin	III. Acromegaly
D. Oxytocin	IV. Ovulation

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Step 1: Understanding the Question:

Match human hormones and their pathological disorders with their primary physiological functions.

Step 2: Detailed Explanation:

A. **Excess growth hormone:** Hypersecretion of GH in adults causes abnormal bone growth, particularly in the face and extremities, a condition called **Acromegaly**. (A-III)

B. **Luteinizing hormone (LH):** A mid-cycle surge in LH stimulates the rupture of the Graafian follicle, leading to **Ovulation**. (B-IV)

C. **Vasopressin:** Also known as Antidiuretic Hormone (ADH), it acts on the distal convoluted tubule and collecting duct to stimulate the **reabsorption of water and electrolytes** to prevent diuresis. (C-I)

D. **Oxytocin:** A posterior pituitary hormone that acts heavily on uterine smooth muscles, stimulating vigorous **contraction of the uterus during child birth**. (D-II)

Therefore, the correct sequence is A-III, B-IV, C-I, D-II.

Quick Tip: Excess GH in childhood = Gigantism. Excess GH in adulthood = Acromegaly. Deficiency of GH = Dwarfism.

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178. Which of the following are secondary lymphoid organs?

(a) Bone marrow

(b) Tonsils

(c) Spleen

(d) Thymus

Choose the correct answer from the options given below :

(A) (a) and (d) only

(B) (a) and (b) only

(C) (b) and (c) only

(D) (b) and (d) only

Correct Answer: (C) (b) and (c) only

Solution:

Step 1: Understanding the Question:

Categorize the listed anatomical structures into primary and secondary lymphoid organs.

Step 2: Detailed Explanation:

The human immune system features two types of lymphoid organs: 1. **Primary lymphoid organs:** The sites where lymphocytes are produced, matured, and acquire antigen-specific receptors. These are exclusively the **Bone marrow** and the **Thymus**. (Thus, (a) and (d) are excluded). 2. **Secondary lymphoid organs:** The sites where mature lymphocytes migrate to interact with antigens and proliferate to become effector cells. These include the **Spleen**, **Tonsils**, lymph nodes, and Peyer's patches of the small intestine. (Thus, (b) and (c) are correct).

Quick Tip: Think of Primary lymphoid organs as the "training academies" for white blood cells and Secondary lymphoid organs as the "battlefields" where they fight infections.

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179. During PCR, primers bind to the DNA strands in the _____ step.

(A) ligation

(B) denaturation

(C) extension

(D) annealing

Correct Answer: (D) annealing

Solution:

Step 1: Understanding the Question:

Identify the specific step in the Polymerase Chain Reaction (PCR) cycle where short RNA/DNA primers attach to the target sequence.

Step 2: Detailed Explanation:

A single cycle of PCR involves three steps:

1. **Denaturation:** The double-stranded DNA template is heated (approx. $94^{\circ}C$) to separate it into two single strands.
2. **Annealing:** The temperature is lowered (approx. $50 - 60^{\circ}C$), allowing the short oligonucleotide primers to hydrogen bond (anneal) to the complementary regions at the 3' ends of the single-stranded DNA templates.
3. **Extension:** The temperature is raised again (approx. $72^{\circ}C$), and Taq polymerase synthesizes the new DNA strand by adding dNTPs to the primers.

Therefore, primers bind during the annealing step.

Quick Tip: The order of PCR steps dictates the temperature profile: High (Denature) → Low (Anneal) → Medium (Extend).

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180. Given below are two statements :

Statement I : Down's syndrome is caused by the absence of one of the X-chromosomes.

Statement II : Turner's syndrome is caused by the presence of an additional copy of the chromosomes.

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

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

(B) Both Statement I and Statement II are correct

(C) Both Statement I and Statement II are incorrect

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

Correct Answer: (C) Both Statement I and Statement II are incorrect

Solution:

Step 1: Understanding the Question:

Evaluate the cytogenetic causes of two major chromosomal disorders: Down's syndrome and Turner's syndrome.

Step 2: Detailed Explanation:

Let's review the genetic basis of both disorders:

- **Statement I:** Down's syndrome is an autosomal aneuploidy caused by the presence of an **additional copy of chromosome 21** (Trisomy 21). It has nothing to do with the absence of an X-chromosome. Therefore, Statement I is completely false.
- **Statement II:** Turner's syndrome is a sex-chromosomal disorder affecting females, caused by the **absence of one of the X chromosomes** (karyotype 45, X0). It is a monosomy, not a case of an additional chromosome. Therefore, Statement II is also completely false.

Both statements essentially swap the definitions of the disorders. Thus, both statements are incorrect.

Quick Tip: Trisomy 21 = Down's syndrome (47 chromosomes). XXY = Klinefelter's syndrome (47 chromosomes). X0 = Turner's syndrome (45 chromosomes).
