CUET 2026 Physics May 24 Shift 2

Question Paper with Solutions

Conducted by National Testing Agency (NTA)

General Instructions

(i) The examination was conducted in Computer-Based Test (CBT) mode.

(ii) Each question carries +5 marks for correct answer and -1 mark for wrong answer.

(iii) The total number of questions are 50.

(iv) Duration of the exam is 1 hour (60 minutes).

1. An electric dipole is placed in an external uniform electric field. The net electric force on the dipole

(A) is always zero
(B) depends on the orientation of the dipole
(C) can never be zero
(D) depends on the dipole moment of the dipole

Correct Answer: (A) is always zero

Solution:

Concept:
An electric dipole consists of two equal and opposite charges, $+q$ and $-q$, separated by a small distance $2a$.
When such a system is placed in an electrostatic field, each charge experiences an electrostatic force given by the product of the charge and the local electric field vector.

Step 1: Understanding the Forces on the Dipole Charges:

In an external electric field $\vec{E}$, the force acting on the positive charge is $\vec{F}_+ = +q\vec{E}$.
Simultaneously, the force acting on the negative charge is $\vec{F}_- = -q\vec{E}$.
The total net force $\vec{F}_{\text{net}}$ acting on the dipole is the vector sum of these individual forces:

$$\vec{F}_{\text{net}} = \vec{F}_+ + \vec{F}_- = q\vec{E} + (-q\vec{E})$$

Step 2: Effect of Field Uniformity:
Because the external electric field is given to be completely uniform, $\vec{E}$ has the exact same magnitude and direction at the locations of both charges.
Therefore, the two forces have equal magnitudes ($F = qE$) and point in diametrically opposite directions along parallel lines of action.
As a result, the vector sum vanishes identically regardless of the orientation angle θ between the dipole moment $\vec{p}$ and the field $\vec{E}$.
Hence, $\vec{F}_{\text{net}} = 0$ under all circumstances in a uniform field.

Step 3: Evaluating the Options:
Option (A) states that the net force is always zero, which correctly represents the translational equilibrium of an electric dipole in a uniform electric field.
Option (B) is incorrect because orientation affects torque ($\vec{\tau} = \vec{p} \times \vec{E}$), not the net translational force.
Option (C) is incorrect because the force is identically zero, not non-zero.
Option (D) is incorrect because the net force does not depend on the dipole moment in a uniform field.

Final Answer:
Therefore, the correct answer is **(A) is always zero**.

Quick Tip: In a uniform electric field, an electric dipole experiences zero net force ($\vec{F}_{\text{net}} = 0$) but may experience a non-zero torque ($\vec{\tau} = \vec{p} \times \vec{E}$).
In a non-uniform electric field, both net force and net torque are generally non-zero.

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2. Identify the correct statements from the following:

A. The charge on a body can have any value greater than the charge on an electron or proton.
B. Gauss's theorem is valid for a closed surface of any shape and for any general charge distribution.
C. The net flux through a closed surface due to a charge lying outside the closed surface is zero.
D. Gauss's theorem is applicable to any field which obeys the inverse square law.
Choose the correct answer from the options given below:

(A) A, B and C only
(B) A, B and D only
(C) A, B, C and D
(D) B, C and D only

Correct Answer: (D) B, C and D only

Solution:

Concept:
Electrostatics is governed by fundamental principles such as the quantization of electric charge and Gauss's law, which relates electric flux to enclosed charges.

Step 1: Evaluating Statement A:
According to the principle of quantization of electric charge, any observable charge q must be an integral multiple of the elementary charge e, i.e., $q = \pm ne$, where $n = 1, 2, 3, \ldots$.
A body cannot have an arbitrary or continuous value of charge (such as $1.5e$ or $2.7e$), even if it is greater than e.
Therefore, Statement A is incorrect.

Step 2: Evaluating Statement B:
Gauss's law states that the total electric flux through any closed Gaussian surface is equal to $\frac{q_{\text{enclosed}}}{\varepsilon_0}$.
This law holds universally for a closed surface of arbitrary shape and size, and for any arbitrary configuration or distribution of charges inside the surface.
Therefore, Statement B is correct.

Step 3: Evaluating Statement C:

If a point charge lies outside a closed surface, every field line entering the surface must also exit the surface.

Consequently, the net inward flux equals the net outward flux, making the total net electric flux through the closed surface identically zero.

Therefore, Statement C is correct.

Step 4: Evaluating Statement D:

Gauss's theorem is mathematically derived from the inverse square dependence of the central field (such as Coulomb's law or Newton's law of gravitation).

Hence, Gauss's law is fundamentally applicable to any vector field that obeys an inverse square law.

Therefore, Statement D is correct.

Final Answer:

Statements B, C, and D are correct, which corresponds to option (D).

Therefore, the correct answer is **(D) B, C and D only**.

Quick Tip: Remember that charge is quantized ($q = ne$) at the microscopic level.

Gauss's law relies fundamentally on the $1/r^2$ nature of Coulomb's force; any deviation from the inverse square law would invalidate Gauss's divergence theorem in its standard form.

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3. Match the LIST-I with LIST-II

LIST-I		LIST-II	
A.	E is independent of r	I.	For a point charge
B.	E is inversely proportional to r	II.	For a short dipole
C.	E is inversely proportional to r^2	III.	For a uniform line charge
D.	E is inversely proportional to r^3	IV.	For a uniformly charged infinite plane sheet

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Concept:

The electric field intensity E due to different types of charge distributions exhibits distinct dependencies on the distance r from the source.

Step 1: Electric Field of an Infinite Plane Sheet:

The electric field due to an infinite, uniformly charged flat sheet with surface charge density σ is:

$$E = \frac{\sigma}{2\varepsilon_0}$$

This magnitude is independent of the perpendicular distance r from the sheet.

Thus, A matches with IV.

Step 2: Electric Field of an Infinite Line Charge:

The electric field at a distance r from an infinite straight wire carrying a uniform linear charge density λ is:

$$E = \frac{\lambda}{2\pi\varepsilon_0 r} \propto \frac{1}{r}$$

This shows an inverse proportionality to the first power of distance r.

Thus, B matches with III.

Step 3: Electric Field of an Isolated Point Charge:

According to Coulomb's law, the electric field created by a point charge q at a distance r is given by:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} \propto \frac{1}{r^2}$$

Hence, the electric field is inversely proportional to r^2.

Thus, C matches with I.

Step 4: Electric Field of a Short Electric Dipole:

For a short electric dipole of dipole moment p, the electric field at an axial point is $E = \frac{2kp}{r^3}$ and at an equatorial point is $E = \frac{kp}{r^3}$.

In general, for a short dipole, $E \propto \frac{1}{r^3}$.

Thus, D matches with II.

Final Answer:

Matching the items gives: A-IV, B-III, C-I, D-II.

Therefore, the correct answer is **(B) A-IV, B-III, C-I, D-II**.

Quick Tip: Summarize field dependencies:

Sheet $\to r^0$ (independent),

Line charge $\to r^{-1}$,

Point charge $\to r^{-2}$,

Dipole $\to r^{-3}$,

Quadrupole $\to r^{-4}$.

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4. A charge q is placed at the center of a line joining two equal positive charges Q. The system of the three charges will be in equilibrium, if q is equal to

(A) $-\frac{Q}{2}$

(B) $-\frac{Q}{4}$

(C) $+\frac{Q}{4}$

(D) $+\frac{Q}{2}$

Correct Answer: (B) $-\frac{Q}{4}$

Solution:

Concept:

For an entire system of charges to be in electrostatic equilibrium, the net electrostatic force acting on every single charge in the configuration must be equal to zero.

Step 1: Equilibrium of the Central Charge:

Let two identical charges $+Q$ be placed at points A and B separated by a total distance $2r$.
The charge q is placed at the midpoint C of the line joining A and B, so the distance from q to each charge is r.
The force exerted on q by the charge at A is directed toward B, and the force exerted by the charge at B is directed toward A.
Because the two charges Q are equal and at identical distances r, their forces on q are equal in magnitude and opposite in direction.
Thus, the central charge q is in equilibrium for any value of q.

Step 2: Condition for Equilibrium of the Outer Charges:

For the entire system to be in equilibrium, the net force on either of the outer charges Q must also be zero.
Consider the charge Q located at point B:
The force on it due to the other charge Q at A (separated by distance $2r$) is repulsive:

$$F_{BA} = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{(2r)^2} = \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{4r^2}$$

The force on it due to the charge q at C (separated by distance r) is:

$$F_{BC} = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$$

Step 3: Solving for the Magnitude and Sign of q:

Setting the net force on the charge at B to zero:

$$F_{BA} + F_{BC} = 0$$

$$\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{4r^2} + \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2} = 0$$

Dividing both sides by $\frac{Q}{4\pi\varepsilon_0 r^2}$:

$$\frac{Q}{4} + q = 0 \implies q = -\frac{Q}{4}$$

Final Answer:

The system of three charges is in equilibrium when $q = -\frac{Q}{4}$.

Therefore, the correct answer is **(B)** $-\frac{Q}{4}$.

Quick Tip: To keep two like charges in equilibrium, the charge placed between them must always be of the opposite sign.

For two identical charges Q with q placed at the midpoint, the equilibrium value is always $q = -Q/4$.

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5. A metal wire is bent in the shape of a circle of 10 cm radius. It is given a charge of 200 μC which spreads on it uniformly. The electric potential at its center is

(A) 3×10^6 V

(B) 6×10^6 V

(C) 9×10^6 V

(D) 18×10^6 V

Correct Answer: (D) 18×10^6 V

Solution:

Concept:

Electric potential is a scalar quantity. The electric potential at any point due to a continuous charge distribution is obtained by integrating the contributions from all infinitesimal charge elements dq.

Step 1: Understanding the Geometry and Given Values:

Radius of the circular ring, $R = 10$ cm $= 0.1$ m.

Total charge distributed uniformly over the wire, $Q = 200\ \mu\text{C} = 200 \times 10^{-6}\ \text{C} = 2 \times 10^{-4}\ \text{C}$.

Permittivity constant, $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{N \cdot m^2/C^2}$.

Step 2: Key Formula for Potential at the Center:

Every infinitesimal charge element dq on the ring lies at the exact same distance R from the center of the circle.

The potential dV at the center due to a small element dq is:

$$dV = \frac{1}{4\pi\varepsilon_0} \frac{dq}{R}$$

Integrating over the entire ring:

$$V = \int dV = \frac{1}{4\pi\varepsilon_0 R} \int dq = \frac{1}{4\pi\varepsilon_0} \frac{Q}{R}$$

Step 3: Numerical Calculation:

Substitute the given values into the formula:

$$V = \frac{(9 \times 10^9) \times (200 \times 10^{-6})}{0.1}$$

$$V = \frac{1.8 \times 10^6}{10^{-1}} = 18 \times 10^6\ \mathrm{V}$$

Final Answer:

The electric potential at the center of the circular wire is 18×10^6 V.

Therefore, the correct answer is **(D)** 18×10^6 **V**.

Quick Tip: Since electric potential is a scalar, you do not need vector resolution. For any uniformly or non-uniformly charged circular wire of total charge Q, the potential at the center is always simply $V = \frac{kQ}{R}$.

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6. Three capacitors of equal capacitance, when connected in series have net capacitance C_1 and when connected in parallel have net capacitance C_2. The ratio of C_1 and C_2 is

(A) $\frac{1}{3}$

(B) 3

(C) $\frac{1}{9}$

(D) 9

Correct Answer: (C) $\frac{1}{9}$

Solution:

Concept:

The equivalent capacitance of combinations of capacitors depends on whether they are connected in series or in parallel configurations.

Step 1: Series Combination of Capacitors:

Let each capacitor have a capacitance equal to C.

When $n = 3$ identical capacitors are connected in series, the reciprocal of the equivalent capacitance equals the sum of reciprocals of individual capacitances:

$$\frac{1}{C_1} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C}$$

Therefore, the equivalent capacitance in series is:

$$C_1 = \frac{C}{3}$$

Step 2: Parallel Combination of Capacitors:

When the same $n = 3$ identical capacitors are connected in parallel, their capacitances simply add up:

$$C_2 = C + C + C = 3C$$

Step 3: Calculating the Ratio $\frac{C_1}{C_2}$:

Now, taking the ratio of the series equivalent capacitance to the parallel equivalent capacitance:

$$\frac{C_1}{C_2} = \frac{\frac{C}{3}}{3C} = \frac{C}{3 \times 3C} = \frac{1}{9}$$

Final Answer:

The ratio of C_1 to C_2 is $\frac{1}{9}$.

Therefore, the correct answer is **(C)** $\frac{1}{9}$.

Quick Tip: For n identical capacitors of capacitance C:

Series: $C_s = C/n$

Parallel: $C_p = nC$

The ratio is always $\frac{C_s}{C_p} = \frac{1}{n^2}$.

Here, $n = 3$, so the ratio is $\frac{1}{3^2} = \frac{1}{9}$.

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7. A 800 pF capacitor is charged by a 100 V battery. After some time, the battery is disconnected. The capacitor is then connected across another 800 pF capacitor. The electrostatic energy stored in the combination will be

(A) 2×10^{-6} J

(B) 3.8×10^{-6} J

(C) 4.2×10^{-6} J

(D) 6×10^{6} J

Correct Answer: (A) 2×10^{-6} J

Solution:

Concept:

When a charged capacitor is disconnected from the charging source, its initial stored charge is conserved.

Connecting it in parallel with an uncharged capacitor results in charge redistribution until both reach a common potential.

Step 1: Identifying Given Data:

Capacitance of the first capacitor, $C_1 = 800$ pF $= 800 \times 10^{-12}$ F.

Initial potential difference across C_1, $V = 100$ V.

Capacitance of the second uncharged capacitor, $C_2 = 800$ pF.

Step 2: Initial Energy and Charge:

The initial charge acquired by the first capacitor is:

$$Q = C_1 V = (800 \times 10^{-12}\ \text{F}) \times 100\ \text{V} = 8 \times 10^{-8}\ \text{C}$$

The initial energy stored in the capacitor is:

$$U_i = \frac{1}{2} C_1 V^2 = \frac{1}{2} \times (800 \times 10^{-12}) \times (100)^2 = 4 \times 10^{-6}\ \text{J}$$

Step 3: Common Potential after Connection:

When connected in parallel to an uncharged capacitor C_2, the total capacitance becomes:

$$C_{\text{total}} = C_1 + C_2 = 800\ \text{pF} + 800\ \text{pF} = 1600\ \text{pF}$$

The common potential V' is:

$$V' = \frac{Q}{C_1 + C_2} = \frac{8 \times 10^{-8}\ \text{C}}{1600 \times 10^{-12}\ \text{F}} = 50\ \text{V}$$

Step 4: Energy Stored in the Combination:

The final electrostatic energy stored in the combination is:

$$U_f = \frac{1}{2} C_{\text{total}} (V')^2 = \frac{1}{2} \times (1600 \times 10^{-12}\ \text{F}) \times (50\ \text{V})^2$$

$$U_f = 800 \times 10^{-12} \times 2500 = 2 \times 10^{-6}\ \text{J}$$

Alternatively, since two identical capacitors share the charge equally, the final energy is half of the initial energy:

$$U_f = \frac{U_i}{2} = \frac{4 \times 10^{-6}\ \text{J}}{2} = 2 \times 10^{-6}\ \text{J}$$

Final Answer:

The electrostatic energy stored in the combination is 2×10^{-6} J.

Therefore, the correct answer is **(A)** 2×10^{-6} **J.**

Quick Tip: When a charged capacitor C is connected in parallel to an identical uncharged capacitor C, exactly half of the initial energy is dissipated as heat/radiation during charge redistribution: $U_f = \frac{1}{2}U_i$.

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8. Match the LIST-I with LIST-II

	LIST-I Quantity		LIST-II Formula
A.	Electromotive force	I.	Drift velocity / Electric field
B.	Electric field	II.	Current / Area
C.	Current density	III.	Electric force / Charge
D.	Charge mobility	IV.	Work / Charge

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Concept:
Electric quantities are defined based on fundamental relations involving force, work, current, area, and carrier velocity.

Step 1: Electromotive Force (emf):
Electromotive force is the work done by a non-electrostatic source in moving a unit positive charge across the terminals of a cell:

$$\text{emf} = \frac{\text{Work}}{\text{Charge}} = \frac{W}{q}$$

Thus, A matches with IV.

Step 2: Electric Field (E):

Electric field intensity at a point is the electrostatic force experienced per unit test charge placed at that location:

$$\vec{E} = \frac{\vec{F}}{q} = \frac{\text{Electric force}}{\text{Charge}}$$

Thus, B matches with III.

Step 3: Current Density (J):

Current density is defined as the electric current flowing per unit cross-sectional area of a conductor taken normal to the direction of current:

$$J = \frac{I}{A} = \frac{\text{Current}}{\text{Area}}$$

Thus, C matches with II.

Step 4: Charge Mobility (μ):

Mobility of a charge carrier is defined as the magnitude of drift velocity acquired per unit applied electric field:

$$\mu = \frac{v_d}{E} = \frac{\text{Drift velocity}}{\text{Electric field}}$$

Thus, D matches with I.

Final Answer:

The correct matching is: A-IV, B-III, C-II, D-I.

Therefore, the correct answer is **(B) A-IV, B-III, C-II, D-I**.

Quick Tip: Remember definitions and SI units to easily identify matches:

Mobility: $\mu = v_d/E$ ($\mathrm{m^2V^{-1}s^{-1}}$),

Current density: $J = I/A$ ($\mathrm{A\ m^{-2}}$),

emf: $\mathcal{E} = W/q$ ($\mathrm{J\ C^{-1} = V}$),

Electric field: $E = F/q$ ($\mathrm{N\ C^{-1}}$).

9. Arrange the following materials in the ascending order of their electrical conductivities.

A. Rubber

B. Iron

C. Carbon

D. Copper

Choose the correct answer from the options given below:

(A) A, B, C, D

(B) D, B, C, A

(C) A, C, B, D

(D) C, A, B, D

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

Solution:

Concept:

Electrical conductivity (σ) is the measure of a material's ability to conduct an electric current. Materials are broadly classified into insulators, semiconductors, and conductors based on their electrical conductivity.

Step 1: Identifying the Nature of Given Materials:

A. **Rubber** is an excellent electrical insulator. It has negligible free electron density and an extremely low conductivity ($\sigma \sim 10^{-13}$ to 10^{-16} $\Omega^{-1}\text{m}^{-1}$).

C. **Carbon** (in the form of graphite or semiconductor) has intermediate conductivity, greater than an insulator like rubber but substantially lower than typical metallic conductors ($\sigma \sim 10^4$ to 10^5 $\Omega^{-1}\text{m}^{-1}$).

B. **Iron** is a good transition metal conductor with conductivity $\sigma \approx 1.0 \times 10^7\ \Omega^{-1}\text{m}^{-1}$.

D. **Copper** is one of the best metallic conductors with a very high conductivity ($\sigma \approx 5.9 \times 10^7\ \Omega^{-1}\text{m}^{-1}$), which is significantly greater than that of iron.

Step 2: Arranging in Ascending Order:

Arranging from lowest conductivity to highest conductivity:

$$\sigma_{\text{Rubber}} < \sigma_{\text{Carbon}} < \sigma_{\text{Iron}} < \sigma_{\text{Copper}}$$

This corresponds to the sequence: A, C, B, D.

Final Answer:

The correct ascending order is A, C, B, D.

Therefore, the correct answer is **(C) A, C, B, D**.

Quick Tip: Remember general conductivity order:
Insulator (Rubber) < Semiconductor/Semimetal (Carbon) < Poor/Transition Metal (Iron) < High Conductor Metal (Copper, Silver).

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10. Identify the correct statements among the following:

A. A current carrying wire is electrically charged.

B. The drift velocity of electrons in a metallic wire will decrease if the temperature of the wire is increased.

C. The emf of a cell depends on the internal resistance of the cell.

D. The internal resistance of dry cells is much higher than the common electrolytic cells.

Choose the correct answer from the options given below:

(A) A, B and D only

(B) A and D only

(C) B and D only

(D) A, C and D only

Correct Answer: (C) B and D only

Solution:

Concept:

Understanding microscopic mechanisms of conduction, electrostatics of conductors, and electrochemistry of practical cells is essential to evaluating these statements.

Step 1: Evaluating Statement A:

In a current-carrying metallic conductor, electrons are in continuous motion, but the total number of conduction electrons at any instant equals the total number of stationary positive metal ions.

Hence, the net electric charge on the wire remains zero.

Therefore, a current-carrying wire is electrically neutral, not charged.

Statement A is incorrect.

Step 2: Evaluating Statement B:

The drift velocity is given by $v_d = \frac{eE\tau}{m}$, where τ is the relaxation time.

As temperature increases, thermal vibrations of lattice ions increase, causing more frequent collisions of electrons.

This reduces the mean relaxation time τ.

Consequently, for a given electric field, the drift velocity v_d decreases with increasing temperature.

Statement B is correct.

Step 3: Evaluating Statement C:

The electromotive force (emf) of a cell depends strictly on the chemical nature of the electrodes and the electrolyte used.

It represents the open-circuit potential difference and does not depend on the cell's internal resistance.

Statement C is incorrect.

Step 4: Evaluating Statement D:

Dry cells use a moist paste rather than a liquid electrolyte, which limits ionic mobility and results in a significantly higher internal resistance compared to liquid electrolytic secondary cells (like lead-acid cells).

Statement D is correct.

Final Answer:

Statements B and D are correct.

Therefore, the correct answer is **(C) B and D only**.

Quick Tip: Common misconception: Current-carrying wire is NOT charged; it produces a magnetic field, not an electrostatic field.

Emf is an intrinsic chemical property and is independent of dimensions or internal resistance of the cell.

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11. At what temperature the resistance of a conductor becomes 20% more than its resistance at 27°C? (The value of the temperature coefficient of resistance of the conductor is 2.0×10^{-4} /K.)

(A) 900 K

(B) 1100 K

(C) 1300 K

(D) 1450 K

Correct Answer: (C) 1300 K

Solution:

Concept:

The electrical resistance of a metallic conductor varies linearly with temperature over moderate temperature ranges according to the formula:

$$R(T) = R_0[1 + \alpha(T - T_0)]$$

where α is the temperature coefficient of resistance, and R_0 is the resistance at reference temperature T_0.

Step 1: Identifying the Given Data:

Initial reference temperature, $T_0 = 27°\text{C} = 27 + 273 = 300$ K.

Let initial resistance at T_0 be R_0.

Final resistance, $R = R_0 + 20\%$ of $R_0 = 1.20R_0$.

Temperature coefficient of resistance, $\alpha = 2.0 \times 10^{-4}\ \text{K}^{-1}$.

Step 2: Formulating the Equation for Temperature Rise:

The change in resistance is:

$$\Delta R = R - R_0 = 0.20R_0$$

From the standard relationship:

$$\Delta R = R_0 \alpha \Delta T$$

where $\Delta T = T - T_0$.

Step 3: Calculating ΔT and the Final Temperature T:

Substitute the values into the equation:

$$0.20R_0 = R_0 \alpha \Delta T$$

$$\Delta T = \frac{0.20}{\alpha} = \frac{0.20}{2.0 \times 10^{-4}\ \text{K}^{-1}} = 1000\ \text{K}$$

Now, compute the final absolute temperature T:

$$T = T_0 + \Delta T = 300\ \text{K} + 1000\ \text{K} = 1300\ \text{K}$$

Final Answer:

The temperature at which resistance becomes 20% more is 1300 K.

Therefore, the correct answer is **(C)** 1300 **K.**

Quick Tip: Always convert temperatures to Kelvin when the answer options are given in Kelvin!

A fractional increase $\frac{\Delta R}{R_0}$ gives $\Delta T = \frac{\Delta R / R_0}{\alpha}$.

Here, $\Delta T = \frac{0.2}{2 \times 10^{-4}} = 1000$ K.

Final temperature $T = 300 + 1000 = 1300$ K.

12. In a Wheatstone bridge arrangement (P, Q, R and S), the resistors P and Q are nearly equal. The bridge is balanced when $R = 500\ \Omega$. On interchanging P and Q, the value of R for balancing is $505\ \Omega$. The value of S will be:

(A) $500\ \Omega$
(B) $502.5\ \Omega$
(C) $505\ \Omega$
(D) $5\ \Omega$

Correct Answer: (B) $502.5\ \Omega$

Solution:

Concept:
In a balanced Wheatstone bridge, the ratio of resistances in adjacent arms is equal.
When ratio arms are interchanged to eliminate systematic errors (known as Carey Foster's method or the method of substitution), the true value of unknown resistance is the geometric mean of the two balance values, which approximates to their arithmetic mean when the values are very close.

Step 1: Setting up the Balance Conditions:
In the standard bridge arrangement:

$$\frac{P}{Q} = \frac{R_1}{S}$$

Given $R_1 = 500\ \Omega$:

$$\frac{P}{Q} = \frac{500}{S} \quad \text{— (1)}$$

When resistors P and Q are interchanged:

$$\frac{Q}{P} = \frac{R_2}{S}$$

Given $R_2 = 505\ \Omega$:

$$\frac{Q}{P} = \frac{505}{S} \quad \text{— (2)}$$

Step 2: Solving for Resistance S:

Multiplying equation (1) and equation (2):

$$\left(\frac{P}{Q}\right) \times \left(\frac{Q}{P}\right) = \left(\frac{500}{S}\right) \times \left(\frac{505}{S}\right)$$

$$1 = \frac{500 \times 505}{S^2} \implies S^2 = 500 \times 505$$

Taking the square root:

$$S = \sqrt{500 \times 505}$$

Since 500 and 505 are very close to each other, the geometric mean is extremely close to the arithmetic mean:

$$S \approx \frac{500 + 505}{2} = 502.5\ \Omega$$

Checking exactly:

$$\sqrt{500 \times 505} = \sqrt{252500} \approx 502.4938\ \Omega \approx 502.5\ \Omega$$

Final Answer:

The value of the resistance S is $502.5\ \Omega$.

Therefore, the correct answer is **(B)** $502.5\ \Omega$.

Quick Tip: When ratio arms P and Q are nearly equal and are interchanged, the unknown resistance is: $S = \sqrt{R_1 R_2} \approx \frac{R_1+R_2}{2}$.

Here, $\frac{500+505}{2} = 502.5\ \Omega$.

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13. A positive charge enters a magnetic field and travels parallel to the magnetic field. The charge experiences

(A) an upward force

(B) a downward force

(C) a force in the direction of magnetic field

(D) no force

Correct Answer: (D) no force

Solution:

Concept:

A charged particle moving through a magnetic field experiences the Lorentz magnetic force, which depends on the charge, velocity vector, and magnetic field vector.

Step 1: Formula for Lorentz Magnetic Force:

The magnetic force $\vec{F}_m$ acting on a particle carrying charge q moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by:

$$\vec{F}_m = q(\vec{v} \times \vec{B})$$

The magnitude of this force is:

$$F_m = qvB\sin\theta$$

where θ is the angle between the velocity vector $\vec{v}$ and the magnetic field vector $\vec{B}$.

Step 2: Evaluating for Parallel Motion:

The problem states that the positive charge travels parallel to the magnetic field.

Therefore, the angle between $\vec{v}$ and $\vec{B}$ is:

$$\theta = 0^\circ$$

Since $\sin(0^\circ) = 0$:

$$F_m = qvB\sin(0^\circ) = 0$$

Step 3: Conclusion:

Because the cross product of two parallel vectors is zero, the magnetic force exerted on the moving charge is zero.

The charge continues to move undeflected with constant velocity along its original path.

Final Answer:

The charge experiences no force.

Therefore, the correct answer is **(D) no force**.

Quick Tip: Magnetic force is zero when:

1. Charge is at rest ($v = 0$),
2. Charge is neutral ($q = 0$),
3. Motion is parallel ($\theta = 0°$) or antiparallel ($\theta = 180°$) to $\vec{B}$.

---

14. If a ferromagnetic material is inserted in a current carrying solenoid, the magnetic field inside the solenoid

(A) increases

(B) decreases

(C) remains unchanged

(D) becomes zero

Correct Answer: (A) increases

Solution:

Concept:

Ferromagnetic materials possess spontaneous magnetic domains that can align strongly in the direction of an external magnetic field, drastically enhancing the total magnetic flux density.

Step 1: Magnetic Field in an Air-Core Solenoid:

Inside an empty (or air-filled) long solenoid with n turns per unit length carrying current I, the magnetic field is:

$$B_0 = \mu_0 n I$$

where μ_0 is the permeability of free space.

Step 2: Effect of Inserting a Ferromagnetic Core:

When a ferromagnetic material (such as soft iron) is inserted inside the core, the applied field aligns the magnetic domains of the material.

The material acquires a very large magnetization $\vec{M}$.

The resultant total magnetic field B inside the core becomes:

$$B = \mu_0(H + M) = \mu_r B_0$$

where μ_r is the relative permeability of the material.

Step 3: Evaluating the Magnitude:

For ferromagnetic materials, the relative magnetic permeability is extremely large ($\mu_r \gg 1$, typically in the range of 10^3 to 10^5).

Consequently, the net magnetic field inside the solenoid increases tremendously compared to the initial field with an air core.

Final Answer:

The magnetic field inside the solenoid increases.

Therefore, the correct answer is **(A) increases**.

Quick Tip: Relative permeability values:

Diamagnetic: $\mu_r \lessapprox 1$ (field slightly decreases),

Paramagnetic: $\mu_r \gtrapprox 1$ (field slightly increases),

Ferromagnetic: $\mu_r \gg 1$ (field increases dramatically).

---

15. An electron of charge 'e' moves in a circular orbit of radius r around a nucleus with a frequency ν. The magnetic moment associated with the orbital motion of the electron is

(A) $\pi \nu e r^2$

(B) $\frac{\pi \nu r^2}{e}$

(C) $\frac{\pi \nu e}{r}$

(D) $\frac{\pi e r^2}{\nu}$

Correct Answer: (A) $\pi \nu e r^2$

Solution:

Concept:

A revolving charge constitutes an electric current loop. A current-carrying loop possesses a magnetic dipole moment proportional to the current and the enclosed area.

Step 1: Equivalent Electric Current:

The revolving electron of charge e orbits with a frequency ν (revolutions per second).

The time period of one revolution is $T = \frac{1}{\nu}$.

The effective electric current I associated with this circular motion is the charge passing through any section of the orbit per unit time:

$$I = \frac{e}{T} = e\nu$$

Step 2: Area of the Circular Orbit:

The electron revolves in a circular orbit of radius r.

The cross-sectional area A bounded by this current loop is:

$$A = \pi r^2$$

Step 3: Calculating Magnetic Dipole Moment:

The orbital magnetic dipole moment M of a planar current loop is given by:

$$M = I \cdot A$$

Substituting the expressions for I and A:

$$M = (e\nu) \cdot (\pi r^2) = \pi \nu e r^2$$

Final Answer:

The magnetic moment associated with the orbital motion is πver^2.

Therefore, the correct answer is **(A)** πver^2.

Quick Tip: Use dimensional analysis to verify:

Current $\times$ Area $= \mathrm{A} \cdot \mathrm{m}^2$.

Here, $ve = \mathrm{C/s} = \mathrm{A}$, and $\pi r^2 = \mathrm{m}^2$, giving πver^2.

---

16. Identify the correct statements among the following.

A. The torque acting on a planar current loop in a magnetic field changes when its shape is changed without changing its area.

B. Two parallel wires carrying currents in opposite directions attract each other.

C. An ideal ammeter has zero resistance and an ideal voltmeter has infinite resistance.

D. A galvanometer can be converted into a voltmeter by connecting a high resistance in series.

Choose the correct answer from the options given below:

(A) A, B and C only

(B) B, C and D only

(C) C and D only

(D) A and C only

Correct Answer: (C) C and D only

Solution:

Concept:

This question tests core principles of magnetic forces on current loops, interaction between parallel current-carrying wires, and the design of electrical measuring instruments.

Step 1: Evaluating Statement A:

The torque on a planar current loop in a uniform magnetic field is given by $\vec{\tau} = \vec{M} \times \vec{B} = I(\vec{A} \times \vec{B})$.

The magnetic moment $\vec{M} = I\vec{A}$ depends only on the current I and the area $\vec{A}$ of the loop, completely independent of the geometrical shape of the loop.
Therefore, changing the shape while keeping the area constant does not change the torque.
Statement A is incorrect.

Step 2: Evaluating Statement B:
Using the right-hand rule and Ampere's force law, parallel conductors carrying currents in the same direction attract each other, whereas parallel conductors carrying currents in opposite directions repel each other.
Statement B claims that anti-parallel currents attract, which is false.
Statement B is incorrect.

Step 3: Evaluating Statement C:
An ammeter is connected in series; to prevent disturbing the original circuit current, its resistance should ideally be zero.
A voltmeter is connected in parallel; to draw negligible current from the branch, its resistance should ideally be infinite.
Statement C is correct.

Step 4: Evaluating Statement D:
A moving coil galvanometer can measure large potential differences by placing a large resistance R in series with its coil, so that $V = I_g(G+R)$.
This converts the galvanometer into a voltmeter.
Statement D is correct.

Final Answer:
Statements C and D are correct.
Therefore, the correct answer is **(C) C and D only**.

Quick Tip: Remember:

Like currents attract; opposite currents repel.

Galvanometer to Ammeter: Low resistance (shunt) in PARALLEL.

Galvanometer to Voltmeter: High resistance in SERIES.

---

17. A 0.5 m long solenoid has 500 turns and has a flux density of 2.52×10^{-3} T at its center. The current in the solenoid is (Given, $\mu_0 = 4\pi \times 10^{-7}$ H/m):

(A) 1.2 A

(B) 2.0 A

(C) 2.8 A

(D) 3.4 A

Correct Answer: (B) 2.0 A

Solution:

Concept:

The magnetic flux density B at the center of a long, tightly wound current-carrying solenoid depends on the turn density and the electric current flowing through it.

Step 1: Identifying Given Parameters:

Length of the solenoid, $L = 0.5$ m.

Total number of turns, $N = 500$.

Number of turns per unit length, $n = \frac{N}{L} = \frac{500}{0.5} = 1000$ turns/m.

Magnetic field (flux density), $B = 2.52 \times 10^{-3}$ T.

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ H/m $\approx 4 \times 3.1416 \times 10^{-7} \approx 1.257 \times 10^{-6}$ T $\cdot$ m/A.

Step 2: Formula for Magnetic Field of a Solenoid:

The magnetic flux density inside a solenoid is:

$$B = \mu_0 n I = \mu_0 \left(\frac{N}{L}\right) I$$

Step 3: Calculating Current I:

Rearranging the formula to solve for I:

$$I = \frac{B}{\mu_0 n}$$

Substitute the values into the equation:

$$I = \frac{2.52 \times 10^{-3}}{(4\pi \times 10^{-7}) \times 1000} = \frac{2.52 \times 10^{-3}}{4\pi \times 10^{-4}}$$

$$I = \frac{2.52 \times 10}{4\pi} = \frac{25.2}{4 \times 3.1416} = \frac{25.2}{12.566} \approx 2.005 \text{ A} \approx 2.0 \text{ A}$$

Final Answer:

The current flowing in the solenoid is approximately 2.0 A.

Therefore, the correct answer is **(B)** 2.0 **A.**

Quick Tip: Notice that $\mu_0 \approx 1.26 \times 10^{-6}$.

The given $B = 2.52 \times 10^{-3}$ is exactly twice 1.26×10^{-3}!

So, $I = \frac{2.52 \times 10^{-3}}{1.26 \times 10^{-6} \times 10^{3}} = \frac{2.52}{1.26} = 2.0$ A.

---

18. A bar magnet of dipole moment 3 Am^2 rests with its centre on a frictionless point. A force F is applied at right angles to the axis of the magnet, 10 cm from the point. It is observed that an external magnetic field of 0.25 T is required to hold the magnet in equilibrium at an angle of 30° with the field. The value of F is:

(A) 2.75 N

(B) 2.93 N

(C) 3.75 N

(D) 4.08 N

Correct Answer: (C) 3.75 N

Solution:

Concept:

For rotational equilibrium of a rigid body about a pivot, the net torque acting about the pivot point must be equal to zero.

Here, the deflecting mechanical torque due to force F is balanced by the restoring magnetic torque due to the external magnetic field.

Step 1: Identifying Given Data:

Magnetic dipole moment, $M = 3\ \text{A} \cdot \text{m}^2$.

Distance from pivot (center) to the line of action of force, $d = 10\ \text{cm} = 0.1\ \text{m}$.

Force F is applied perpendicular to the axis of the magnet.

Magnetic field magnitude, $B = 0.25\ \text{T}$.

Angle between magnetic dipole moment and magnetic field, $\theta = 30^\circ$.

Step 2: Torque Due to the Magnetic Field:

The magnitude of the torque exerted by the magnetic field on the magnetic dipole is:

$$\tau_{\text{mag}} = MB\sin\theta$$

Substitute the values:

$$\tau_{\text{mag}} = 3 \times 0.25 \times \sin(30^\circ) = 0.75 \times \frac{1}{2} = 0.375\ \text{N} \cdot \text{m}$$

Step 3: Torque Due to the Applied Force:

Since force F is applied at right angles to the axis at a distance d from the center:

$$\tau_{\text{mech}} = F \times d = F \times 0.1$$

Step 4: Applying Equilibrium Condition:

For rotational equilibrium, the mechanical torque must balance the magnetic torque:

$$\tau_{\text{mech}} = \tau_{\text{mag}}$$

$$F \times 0.1 = 0.375$$

$$F = \frac{0.375}{0.1} = 3.75\ \text{N}$$

Final Answer:

The value of the force F is 3.75 N.

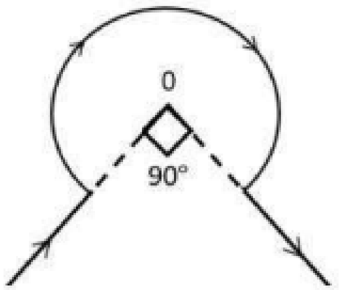
Therefore, the correct answer is **(C)** 3.75 **N.**

Quick Tip: At equilibrium: $\sum \tau = 0 \implies F \cdot d = MB \sin\theta$.

Always ensure distances are converted to SI units (cm $\rightarrow$ m) to avoid decimal errors.

---

19. A wire shown in figure carries a current of 10 **A. The magnitude of the magnetic field at the centre O is: (Given: radius of the bent coil is** 3 **cm.)**



(A) 1×10^{-4} T

(B) 1.57×10^{-3} T

(C) 1.57×10^{-4} T

(D) 2.41×10^{-5} T

Correct Answer: (C) 1.57×10^{-4} T

Solution:

Concept:

The magnetic field at the center of an arc of a circle carrying current is determined using the Biot-Savart Law.

Straight segments whose lines of action pass directly through the point of observation produce zero magnetic field at that point.

Step 1: Analyzing the Components of the Wire:

The wire consists of two straight segments and a major circular arc.

The straight incoming and outgoing lead wires lie along radial lines pointing directly toward/away from the center O.

Since $d\vec{l} \parallel \hat{r}$, the cross product $d\vec{l} \times \hat{r} = 0$.

Thus, the magnetic field contributed by both straight segments at point O is identically zero:

$$B_{\text{straight}} = 0$$

Step 2: Magnetic Field Due to the Circular Arc:

The angle subtended by the gap is 90° ($\frac{\pi}{2}$ rad).

Therefore, the angle subtended by the circular arc carrying current at the center O is:

$$\theta = 360^\circ - 90^\circ = 270^\circ = \frac{3\pi}{2} \text{ radians}$$

The magnetic field at the center of a circular arc of radius R subtending an angle θ is:

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

Step 3: Substituting the Given Values:

Current, $I = 10$ A.

Radius, $R = 3 \text{ cm} = 0.03 \text{ m} = 3 \times 10^{-2}$ m.

$$B = \frac{(4\pi \times 10^{-7}) \times 10}{4\pi \times (3 \times 10^{-2})} \times \left(\frac{3\pi}{2}\right)$$

Simplify the constants:

$$B = \frac{10^{-6}}{3 \times 10^{-2}} \times \frac{3\pi}{2} = \frac{10^{-4}}{3} \times \frac{3\pi}{2} = \frac{\pi}{2} \times 10^{-4} \text{ T}$$

Using $\pi \approx 3.1416$:

$$B = \frac{3.1416}{2} \times 10^{-4} \text{ T} = 1.5708 \times 10^{-4} \text{ T} \approx 1.57 \times 10^{-4} \text{ T}$$

Final Answer:

The magnitude of the magnetic field at the center O is 1.57×10^{-4} T.

Therefore, the correct answer is **(C)** 1.57×10^{-4} **T**.

Quick Tip: An arc subtending angle θ produces a field $B = \left(\frac{\theta}{2\pi}\right) B_{\text{full circle}} = \left(\frac{\theta}{2\pi}\right) \frac{\mu_0 I}{2R}$.
For a 270° arc, fraction is $\frac{3}{4}$, so $B = \frac{3}{4} \frac{\mu_0 I}{2R}$.

---

20. The mutual inductance of a pair of coils placed close to each other depends upon

(A) The rate at which currents are changing in the two coils.

(B) Relative position and orientation of the two coils

(C) The materials of the wires of the coils

(D) The current in the two coils

Correct Answer: (B) Relative position and orientation of the two coils

Solution:

Concept:

Mutual inductance (M) is a purely geometric and material constant of a coupled two-coil system that quantifies the magnetic flux linkage of one coil per unit current flowing in the other coil.

Step 1: Definition of Mutual Inductance:

The total magnetic flux Φ_2 linked with a secondary coil due to current I_1 in a primary coil is given by:

$$\Phi_2 = M I_1 \implies M = \frac{\Phi_2}{I_1}$$

Although defined through flux and current, M itself is independent of the current I and the rate of change of current $\frac{dI}{dt}$.

Step 2: Factors Determining Mutual Inductance:

Mutual inductance depends strictly upon:

1. The geometry of the coils (their individual cross-sectional areas, lengths, and shapes).
2. Number of turns in each coil (N_1, N_2).
3. Magnetic permeability of the medium filling the space between or inside the coils (μ).
4. The relative separation distance and spatial orientation of the two coils (coupling coefficient k).

Step 3: Evaluating the Given Options:

Option (A) is incorrect because the rate of change of current determines the induced emf ($\varepsilon = -M\frac{dI}{dt}$), not the value of M.

Option (B) is correct because the relative position and orientation determine the fraction of magnetic flux linked between the coils.

Option (C) is incorrect because the wire material affects resistance, not magnetic induction.

Option (D) is incorrect because M is independent of the instantaneous current.

Final Answer:

The mutual inductance depends upon the relative position and orientation of the two coils. Therefore, the correct answer is **(B) Relative position and orientation of the two coils**.

Quick Tip: Mutual inductance $M = k\sqrt{L_1L_2}$, where k is the coupling coefficient ($0 \leq k \leq 1$). The value of k is maximized when coils are coaxial and wound together, and minimized ($k = 0$) when their axes are perpendicular.

---

21. If the number of turns in a coil is tripled, the value of the magnetic flux linked with the coil:

(A) remains unchanged

(B) becomes $\frac{1}{3}$ times

(C) is tripled

(D) becomes $\frac{2}{3}$ times

Correct Answer: (C) is tripled

Solution:

Concept:

The total magnetic flux linked with a coil composed of multiple turns is the sum of the magnetic flux passing through each individual turn.

Step 1: Formula for Total Magnetic Flux:

If a magnetic field $\vec{B}$ passes through a coil of N turns, each having an effective area A, the flux ϕ linked with a single turn is:

$$\phi = BA\cos\theta$$

The total magnetic flux Φ_{total} linked with all N turns of the coil is:

$$\Phi_{\text{total}} = N\phi = NBA\cos\theta$$

Step 2: Proportionality Analysis:

From the relation above, holding the external magnetic field B, area A, and orientation θ constant:

$$\Phi_{\text{total}} \propto N$$

Step 3: Effect of Tripling the Turns:

When the number of turns is changed to $N' = 3N$:

$$\Phi'_{\text{total}} = N'\phi = (3N)\phi = 3(N\phi) = 3\Phi_{\text{total}}$$

Thus, the total magnetic flux linked with the coil is tripled.

Final Answer:

The value of the magnetic flux linked with the coil is tripled.

Therefore, the correct answer is **(C) is tripled**.

Quick Tip: Total magnetic flux linkage is directly proportional to N ($\Phi \propto N$).

Note: Self-inductance L scales with N^2 ($L \propto N^2$), but flux for a given external field scales with N.

---

22. Identity the correct statement(s) among the following.

A. In a d.c. circuit, a capacitor can conduct but not an inductor.

B. In a d.c. circuit, an inductor can conduct but not a capacitor.

C. In a d.c. circuit, both the inductor and capacitor cannot conduct.

D. An inductor has infinite resistance in a d.c. circuit.

Choose the correct answer from the options given below:

(A) A and C only

(B) B and D only

(C) B only

(D) A, C and D only

Correct Answer: (C) B only

Solution:

Concept:

The response of reactive components (inductors and capacitors) to direct current (d.c.) is governed by their reactances at zero frequency ($f = 0$).

Step 1: Behavior of an Inductor in a D.C. Circuit:

The inductive reactance is given by:

$$X_L = \omega L = 2\pi f L$$

For steady direct current (d.c.), the frequency is $f = 0$.

Therefore:

$$X_L = 0$$

An ideal inductor offers zero reactance (zero resistance) in a steady-state d.c. circuit and behaves simply as a short circuit, conducting current freely.
Hence, statement D is incorrect.

Step 2: Behavior of a Capacitor in a D.C. Circuit:
The capacitive reactance is given by:

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

For direct current, $f = 0$, which gives:

$$X_C \to \infty$$

A capacitor offers infinite reactance to steady direct current once fully charged and acts as an open circuit, blocking d.c. completely.

Step 3: Evaluating the Statements:
Statement A asserts that a capacitor conducts and an inductor does not, which is the opposite of the truth.
Statement B states that an inductor can conduct but not a capacitor, which correctly describes steady-state d.c. behavior.
Statement C is false since an inductor conducts.
Statement D is false since an inductor offers zero resistance to steady d.c., not infinite.

Final Answer:
Only statement B is correct.
Therefore, the correct answer is **(C) B only**.

Quick Tip: For steady DC:
Inductor → short circuit ($X_L = 0$, conducts).
Capacitor → open circuit ($X_C = \infty$, blocks).

23. An a.c. voltage is applied to a pure inductor. The current in the inductor would be

(A) leading the voltage by $\frac{\pi}{2}$
(B) lagging the voltage by $\frac{\pi}{2}$
(C) leading the voltage by $\frac{\pi}{4}$
(D) in phase with the voltage.

Correct Answer: (B) lagging the voltage by $\frac{\pi}{2}$

Solution:

Concept:
In an AC circuit containing only a pure inductor, the self-induced back electromotive force opposes changes in current, creating a phase difference between the alternating voltage and alternating current.

Step 1: Deriving the Phase Relationship:
Let an alternating voltage applied across a pure inductor of inductance L be:

$$v(t) = V_m \sin(\omega t)$$

According to Faraday's law of induction and Kirchhoff's loop rule:

$$v(t) - L\frac{di}{dt} = 0 \implies \frac{di}{dt} = \frac{V_m}{L}\sin(\omega t)$$

Step 2: Integrating to Find the Current:
Integrating both sides with respect to time:

$$i(t) = \int \frac{V_m}{L}\sin(\omega t)\,dt = -\frac{V_m}{\omega L}\cos(\omega t)$$

Using the trigonometric identity $-\cos(\theta) = \sin\left(\theta - \frac{\pi}{2}\right)$:

$$i(t) = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

where $I_m = \frac{V_m}{\omega L}$ is the peak current.

Step 3: Comparing the Phase Angles:

The phase of the applied voltage is $\phi_v = \omega t$.

The phase of the resulting current is $\phi_i = \omega t - \frac{\pi}{2}$.

The phase difference is:

$$\Delta\phi = \phi_v - \phi_i = \frac{\pi}{2}$$

This indicates that the current lags the voltage by a phase angle of $\frac{\pi}{2}$ radians (or 90°).

Final Answer:

The current in the inductor lags the voltage by $\frac{\pi}{2}$.

Therefore, the correct answer is **(B) lagging the voltage by $\frac{\pi}{2}$**.

Quick Tip: Remember the mnemonic **CIVIL**:

In a Capacitor (**C**), Current (**I**) leads Voltage (**V**).

In an Inductor (**L**), Voltage (**V**) leads Current (**I**) by $\pi/2$ (i.e., current lags voltage).

---

24. A pure inductor of 0.25 H is connected to a source of 220 V. If the frequency of the source is 50 Hz, then the rms current in the circuit will be.

(A) 1.6 A

(B) 4.0 A

(C) 2.8 A

(D) 28 A

Correct Answer: (C) 2.8 A

Solution:

Concept:

In a purely inductive AC circuit, the opposition to alternating current is given by the inductive reactance $X_L = 2\pi f L$. The root-mean-square (rms) current is determined by Ohm's law for AC circuits.

Step 1: Identifying Given Data:

Inductance, $L = 0.25$ H.

Rms voltage of the AC source, $V_{\text{rms}} = 220$ V.

Frequency of the AC supply, $f = 50$ Hz.

Step 2: Calculating Inductive Reactance (X_L):

The inductive reactance is:

$$X_L = 2\pi f L$$

Substitute the given values:

$$X_L = 2 \times \pi \times 50 \times 0.25 = 25\pi \ \Omega$$

Using $\pi \approx 3.1416$:

$$X_L = 25 \times 3.1416 = 78.54 \ \Omega$$

Step 3: Calculating Rms Current (I_{rms}):

Using the relation for rms current:

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{X_L} = \frac{220}{25\pi} = \frac{220}{78.54}$$

Performing the division:

$$I_{\text{rms}} \approx 2.801 \text{ A} \approx 2.8 \text{ A}$$

Final Answer:

The rms current in the circuit is 2.8 A.

Therefore, the correct answer is **(C)** 2.8 **A**.

Quick Tip: Notice that $2\pi f = 2 \times \pi \times 50 \approx 314$ rad/s.

$X_L = 314 \times 0.25 = 78.5\ \Omega$.

Then $I_{\text{rms}} = \frac{220}{78.5} = 2.8$ A.

---

25. A coil with an average diameter of 0.02 m is placed with its plane perpendicular to a magnetic field of 6000 T. The induced emf in the coil is 11 V, when the magnetic field is changed to 1000 T in 4 s. The number of turns in the coil is

(A) 16

(B) 18

(C) 24

(D) 28

Correct Answer: (D) 28

Solution:

Concept:

According to Faraday's Law of Electromagnetic Induction, the magnitude of induced electromotive force in a coil is proportional to the number of turns and the time rate of change of magnetic flux through each turn.

Step 1: Identifying Given Data:

Diameter of coil, $D = 0.02$ m $\implies$ Radius $r = \frac{D}{2} = 0.01\text{ m} = 10^{-2}$ m.

Area of each turn, $A = \pi r^2 = \pi \times (10^{-2})^2 = \pi \times 10^{-4}\text{ m}^2$.

Initial magnetic field, $B_1 = 6000$ T.

Final magnetic field, $B_2 = 1000$ T.

Time interval, $\Delta t = 4$ s.

Induced emf, $|\varepsilon| = 11$ V.

Step 2: Formula for Induced EMF:

Since the plane of the coil is perpendicular to the magnetic field, the area vector is parallel to

$\vec{B}$, so $\cos\theta = \cos(0^\circ) = 1$.

The magnitude of induced emf in a coil of N turns is:

$$|\varepsilon| = N\frac{|\Delta\Phi|}{\Delta t} = N\frac{A|\Delta B|}{\Delta t}$$

where $|\Delta B| = |B_2 - B_1| = |1000 - 6000| = 5000$ T.

Step 3: Calculating Number of Turns N:

Substitute the known values into the equation:

$$11 = N \times \frac{(\pi \times 10^{-4}) \times 5000}{4}$$

$$11 = N \times \frac{0.5\pi}{4} = N \times \frac{\pi}{8}$$

Using $\pi \approx \frac{22}{7}$:

$$11 = N \times \frac{22}{7 \times 8} = N \times \frac{22}{56}$$

Solving for N:

$$N = \frac{11 \times 56}{22} = \frac{56}{2} = 28$$

Final Answer:

The number of turns in the coil is 28.

Therefore, the correct answer is **(D)** 28.

Quick Tip: Whenever you see factors like 11 or multiples of 11 alongside circular coils, substitute $\pi = \frac{22}{7}$ instead of 3.14 for clean cancellation:
$11 = N\frac{\pi}{8} = N\frac{22}{56} \implies N = 28$.

---

26. Arrange the following electromagnetic waves in the ascending order of their energies.

A. X-rays

B. UV-rays

C. Infrared rays

D. Microwaves

Choose the correct answer from the options given below:

(A) A, B, C, D

(B) B, C, D, A

(C) D, B, A, C

(D) D, C, B, A

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

Solution:

Concept:

The quantum energy of an electromagnetic wave photon is directly proportional to its frequency and inversely proportional to its wavelength, as defined by the Planck-Einstein relation:

$$E = h\nu = \frac{hc}{\lambda}$$

where h is Planck's constant, ν is the frequency, c is the speed of light in vacuum, and λ is the wavelength.

Step 1: Identifying the Energy Spectrum of Electromagnetic Waves:

The electromagnetic spectrum arranged in order of increasing frequency (and therefore increasing photon energy) is:

Radio waves $<$ Microwaves $<$ Infrared rays $<$ Visible light $<$ Ultraviolet rays $<$ X-rays $<$ Gamma rays.

Step 2: Comparing the Given Waves:

1. **Microwaves (D):** Typically have wavelengths between 1 mm and 1 m, corresponding to photon energies of the order of 10^{-6} eV to 10^{-3} eV.

2. **Infrared rays (C):** Typically have wavelengths between 700 nm and 1 mm, with photon energies ranging from approximately 10^{-3} eV to 1.8 eV.

3. **UV-rays (B):** Typically have wavelengths between 10 nm and 400 nm, with photon energies

ranging from about 3.1 eV to 124 eV.

4. **X-rays (A):** Have very short wavelengths between 0.01 nm and 10 nm, with high photon energies ranging from 100 eV to 100 keV.

Step 3: Ordering in Ascending Order of Energies:

Arranging from the lowest energy to the highest energy gives:

$$E_{\text{Microwaves}} < E_{\text{Infrared}} < E_{\text{UV-rays}} < E_{\text{X-rays}}$$

This corresponds to the sequence: D, C, B, A.

Final Answer:

The ascending order of energies is D, C, B, A.

Therefore, the correct answer is **(D) D, C, B, A.**

Quick Tip: Remember the order of EM waves in increasing frequency/energy:

Radio → **M**icro → **I**nfrared → **V**isible → **U**V → **X**-ray → **G**amma.

(Mnemonic: **R**aging **M**artians **I**nvaded **V**enus **U**sing **X**-ray **G**uns).

---

27. The conduction current is same as displacement current in a circuit when the source is

(A) a.c. only

(B) d.c. only

(C) either a.c. or d.c.

(D) neither d.c nor a.c.

Correct Answer: (C) either a.c. or d.c.

Solution:

Concept:

According to Maxwell's generalization of Ampere's Law (Ampere-Maxwell Law), the total current across any closed boundary is continuous.

The conduction current I_c flowing through the connecting wires transforms seamlessly into a displacement current I_d across the dielectric gap of a capacitor.

Step 1: Understanding Displacement Current:

Displacement current is defined as:

$$I_d = \varepsilon_0 \frac{d\Phi_E}{dt}$$

where Φ_E is the electric flux through a given surface.

Between the plates of a parallel plate capacitor of area A and charge q:

$$\Phi_E = E \cdot A = \left(\frac{q}{\varepsilon_0 A}\right) A = \frac{q}{\varepsilon_0}$$

Taking the time derivative:

$$I_d = \varepsilon_0 \frac{d}{dt}\left(\frac{q}{\varepsilon_0}\right) = \frac{dq}{dt} = I_c$$

Step 2: Analysis for A.C. and D.C. Sources:

1. **For an A.C. source:** The applied voltage is continuously alternating, so the charge $q(t)$ on the capacitor plates varies continuously in time.

Consequently, at every instant of time, the conduction current in the leads equals the displacement current between the plates: $I_c(t) = I_d(t)$.

2. **For a D.C. source:** During the transient charging or discharging phase of a capacitor, the current flowing through the circuit leads is equal to the displacement current across the plates at all instants.

Once fully charged under steady-state d.c., the conduction current ceases ($I_c = 0$) and simultaneously the displacement current ceases ($I_d = 0$), so they remain equal ($I_c = I_d = 0$).

Step 3: Conclusion:

Because the principle of continuity of current is fundamentally conserved regardless of the waveform of the supply, $I_c = I_d$ holds whether the circuit is connected to an a.c. source or a d.c. source.

Final Answer:

The conduction current is the same as the displacement current when the source is either a.c. or d.c.

Therefore, the correct answer is **(C) either a.c. or d.c.**.

Quick Tip: By Maxwell's equation: $\oint \vec{B} \cdot d\vec{l} = \mu_0(I_c + I_d)$.

The total current is continuous across any cross section of a circuit, establishing $I_c = I_d$ for either AC or DC excitation.

---

28. Identify the correct statements among the following.

A. All electromagnetic waves, irrespective of their frequencies, travel at the same speed through vacuum.

B. A capacitor is fully charged by a d.c. source. When it is fully charged, the displacement current is zero.

C. Ultraviolet radiation can be used for viewing objects through haze and fog.

D. A moving charge in a circular orbit cannot produce electromagnetic waves.

Choose the correct answer from the options given below:

(A) A, B and C only

(B) B and C only

(C) A and B only

(D) C and D only

Correct Answer: (C) A and B only

Solution:

Concept:

Electromagnetic waves propagate through space via oscillating electric and magnetic fields. Their properties, such as propagation speed in vacuum, interaction with matter, scattering behavior, and origin through accelerated charges, follow classical electrodynamics.

Step 1: Evaluating Statement A:

In a vacuum, all electromagnetic waves travel at the exact same fundamental physical speed:

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \approx 3 \times 10^8 \text{ m/s}$$

This speed is completely independent of the frequency, wavelength, or intensity of the wave.
Therefore, Statement A is correct.

Step 2: Evaluating Statement B:

When a capacitor connected to a d.c. source becomes fully charged, the potential difference across its plates becomes constant and equal to the battery emf.
Because the charge q and electric field E are no longer changing with time, $\frac{d\Phi_E}{dt} = 0$.
Hence, the displacement current $I_d = \varepsilon_0 \frac{d\Phi_E}{dt} = 0$.
Therefore, Statement B is correct.

Step 3: Evaluating Statement C:

According to Rayleigh scattering, the intensity of scattered light is inversely proportional to the fourth power of wavelength ($I \propto \frac{1}{\lambda^4}$).
Because ultraviolet radiation has an extremely short wavelength, it suffers intense scattering by haze, smoke, and fog particles.
Instead, **infrared radiation** (which has longer wavelengths and scatters very little) is used for photography and viewing through haze and fog.
Therefore, Statement C is incorrect.

Step 4: Evaluating Statement D:

A charge moving in a circular orbit experiences continuous centripetal acceleration ($a = \frac{v^2}{r}$).
According to classical electromagnetic theory, an accelerated electric charge radiates energy continuously in the form of electromagnetic waves.
Therefore, Statement D is incorrect.

Final Answer:

Statements A and B are the only correct statements.

Therefore, the correct answer is **(C) A and B only**.

Quick Tip: Infrared is used for fog/haze photography because long wavelengths scatter minimally (Scattering $\propto \lambda^{-4}$).

Any accelerated charge emits EM radiation; uniform circular motion involves centripetal acceleration, so it radiates!

---

29. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is

(A) $\frac{2E}{c}$

(B) $\frac{2E}{c^2}$

(C) $\frac{E}{c^2}$

(D) $\frac{E}{c}$

Correct Answer: (A) $\frac{2E}{c}$

Solution:

Concept:

Electromagnetic radiation carries linear momentum alongside energy.

When radiation encounters a surface, momentum transfer occurs according to the law of conservation of linear momentum.

Step 1: Momentum of Incident Photons:

According to de Broglie and Einstein relations, radiation of energy E carries linear momentum given by:

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

Taking the direction of incidence along the positive x-axis, the initial momentum of the radiation is:

$$\vec{p}_i = +\frac{E}{c}\hat{i}$$

Step 2: Momentum of Reflected Radiation:

For a perfectly reflecting surface with normal incidence, the radiation is reflected directly backward along its incident path without any loss of energy.

Therefore, the final momentum of the reflected radiation is:

$$\vec{p}_f = -\frac{E}{c}\hat{i}$$

Step 3: Calculating Momentum Transferred to the Surface:

The change in momentum of the radiation is:

$$\Delta\vec{p}_{\text{radiation}} = \vec{p}_f - \vec{p}_i = -\frac{E}{c}\hat{i} - \left(+\frac{E}{c}\hat{i}\right) = -\frac{2E}{c}\hat{i}$$

By Newton's third law and the conservation of momentum, the momentum transferred to the reflecting surface ($\Delta\vec{p}_{\text{surface}}$) is equal and opposite to the change in momentum of the radiation:

$$\Delta\vec{p}_{\text{surface}} = -\Delta\vec{p}_{\text{radiation}} = +\frac{2E}{c}\hat{i}$$

Thus, the magnitude of the momentum transferred is:

$$\Delta p = \frac{2E}{c}$$

Final Answer:

The momentum transferred to the surface is $\frac{2E}{c}$.

Therefore, the correct answer is **(A)** $\frac{2E}{c}$.

Quick Tip: For normal incidence:

1. Perfectly absorbing surface: $\Delta p = \frac{E}{c}$, Radiation pressure $P = \frac{I}{c}$.
2. Perfectly reflecting surface: $\Delta p = \frac{2E}{c}$, Radiation pressure $P = \frac{2I}{c}$.

30. The intensity of a laser beam is 2.5×10^{14} W/m^2. The amplitude of the magnetic field in the beam is

(Given, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2})

(A) ~ 1.15 T

(B) ~ 1.45 T

(C) ~ 2.0 T

(D) ~ 3.25 T

Correct Answer: (B) ~ 1.45 T

Solution:

Concept:

The intensity I of an electromagnetic wave is the time-averaged power transmitted per unit area normal to the direction of propagation. It can be expressed in terms of the peak amplitude of either the electric field (E_0) or the magnetic field (B_0).

Step 1: Identifying the Given Data:

Intensity of the laser beam, $I = 2.5 \times 10^{14}$ W/m^2.

Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2}.

Speed of light in vacuum, $c = 3 \times 10^8$ m/s.

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A.

Step 2: Formula Relating Intensity and Magnetic Field Amplitude:

The average energy density u_{avg} of an electromagnetic wave is:

$$u_{avg} = \frac{1}{2}\frac{B_0^2}{\mu_0}$$

The intensity is related to the average energy density by $I = u_{avg} \cdot c$:

$$I = \frac{cB_0^2}{2\mu_0}$$

Alternatively, since $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$, this can also be written as:

$$I = \frac{1}{2}\varepsilon_0 c^3 B_0^2$$

Step 3: Calculating the Magnetic Field Amplitude B_0:

Rearranging for B_0^2:

$$B_0^2 = \frac{2\mu_0 I}{c}$$

Substitute the numerical values:

$$B_0^2 = \frac{2 \times (4\pi \times 10^{-7}\ \text{H/m}) \times (2.5 \times 10^{14}\ \text{W/m}^2)}{3 \times 10^8\ \text{m/s}}$$

$$B_0^2 = \frac{5.0 \times 10^{14} \times (4\pi \times 10^{-7})}{3 \times 10^8} = \frac{20\pi \times 10^7}{3 \times 10^8}$$

$$B_0^2 = \frac{2\pi}{3} \approx \frac{2 \times 3.1416}{3} = \frac{6.2832}{3} \approx 2.0944\ \text{T}^2$$

Taking the square root:

$$B_0 = \sqrt{2.0944} \approx 1.447\ \text{T} \approx 1.45\ \text{T}$$

Final Answer:

The amplitude of the magnetic field in the beam is approximately 1.45 T.

Therefore, the correct answer is **(B)** ~ 1.45 **T**.

Quick Tip: A useful shortcut relation for intensity in terms of B_0:
$B_0 = \sqrt{\frac{2\mu_0 I}{c}}$.
Notice that $\frac{2\mu_0 I}{c} = \frac{2\times(1.26\times10^{-6})\times(2.5\times10^{14})}{3\times10^8} = 2.1$, giving $B_0 = \sqrt{2.1} \approx 1.45$ T.

---

31. A real image is formed by a convex lens on the screen. If half of the lens is covered by an opaque object, then

(A) half image is not seen

(B) full image of same intensity is seen

(C) half image of same intensity is seen

(D) full image of decreased intensity is seen

Correct Answer: (D) full image of decreased intensity is seen

Solution:

Concept:
Every single exposed point or section of a converging lens refracts light rays originating from every part of an object to form a complete real image at the focal plane.

Step 1: Role of Different Parts of the Lens:
Light rays diverge from every point of the object in all directions.
Both the upper half and the lower half of the lens receive light rays from the top, middle, and bottom of the object.
Each portion of the lens independently bends these rays to intersect at their corresponding image points on the screen.

Step 2: Effect of Covering Half the Lens:
When one half of the lens is covered with an opaque shield (such as black paper):
1. The uncovered half of the lens continues to refract light from every part of the object to the screen.
2. Therefore, no part of the image is lost, and the complete, full image of the object continues to be formed at the exact same location.

Step 3: Intensity of the Resulting Image:
The brightness (intensity) of an optical image depends on the total light energy collected by the lens aperture per unit time ($I \propto$ exposed area A).
Because half of the lens area is obscured, the amount of light energy passing through the lens is halved.
Consequently, the intensity of the formed image is reduced to half its original brightness.

Final Answer:
A full image of decreased intensity is seen.
Therefore, the correct answer is **(D) full image of decreased intensity is seen**.

Quick Tip: Covering a fraction of a lens never cuts off a portion of the image!
It only reduces the amount of light collected, thereby reducing the brightness/intensity in proportion to the uncovered area.

---

32. Arrange the following substances/media in the increasing order of their refractive indices.
A. Crown glass
B. Water
C. Diamond
D. CO_2
Choose the correct answer from the options given below:

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

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

Solution:

Concept:
The refractive index (n) of an optical medium is the ratio of the speed of light in vacuum to the speed of light in that medium. Optical density is generally lowest in gases, intermediate in liquids, and highest in dense crystalline solids.

Step 1: Identifying Refractive Indices of the Media:
1. **CO_2 gas (D):** Gases have refractive indices very close to unity. For carbon dioxide at standard conditions, $n_{CO_2} \approx 1.00045$.
2. **Water (B):** For liquid water, the refractive index is $n_{\text{water}} \approx 1.333$ (or $\frac{4}{3}$).
3. **Crown glass (A):** Crown glass is an optical glass with a refractive index of $n_{\text{crown}} \approx 1.52$.

4. **Diamond (C):** Diamond has one of the highest known optical refractive indices among transparent solids due to its dense, strongly bonded tetrahedral carbon lattice: $n_{\text{diamond}} \approx 2.42$.

Step 2: Arranging in Increasing Order:

Arranging from lowest refractive index to highest refractive index:

$$n_{CO_2} < n_{\text{water}} < n_{\text{crown glass}} < n_{\text{diamond}}$$

$$1.00045 < 1.33 < 1.52 < 2.42$$

This corresponds to the sequence: D, B, A, C.

Final Answer:

The increasing order of refractive indices is D, B, A, C.

Therefore, the correct answer is **(C) D, B, A, C**.

Quick Tip: Standard refractive indices to memorize:

Air/Gas ≈ 1.00,

Water $= 1.33$,

Crown Glass ≈ 1.52,

Dense Flint Glass ≈ 1.65,

Diamond $= 2.42$.

---

33. Match the LIST-I with LIST-II (In the context of Young's double slit experiment)

LIST-I		LIST-II	
A.	The width of one slit is slightly increased.	I.	The fringe width increases.
B.	One slit is closed.	II.	Interference pattern becomes less sharp.
C.	The width of the source slit is increased.	III.	Maximum intensity increases
D.	Light of smaller frequency is used.	IV.	Interference pattern disappears

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Concept:
In Young's Double Slit Experiment (YDSE), the interference pattern depends critically on the coherence of the sources, the slit widths, the separation between slits, and the wavelength of the incident light.

Step 1: Effect of Increasing Width of One Slit (A):
The amplitude of the wave from a slit is proportional to the square root of its width ($a \propto \sqrt{w}$).
If one slit width is increased, its wave amplitude increases ($a_1 > a_2$).
The maximum intensity at the central and other maxima is $I_{\max} = (a_1 + a_2)^2$, which is larger than the original value $(2a)^2$.
Thus, the maximum intensity increases.
Therefore, A matches with III.

Step 2: Effect of Closing One Slit (B):
Interference requires two coherent beams superposing on each other.
If one slit is completely closed, interference cannot occur; only the single-slit diffraction pattern of the remaining open slit will appear.
Hence, the interference pattern disappears.
Therefore, B matches with IV.

Step 3: Effect of Increasing Width of the Source Slit (C):
When the primary source slit is broadened, it can be treated as a collection of many independent, mutually incoherent sources.
Each independent part produces its own interference pattern shifted slightly relative to the others, which overlap and blur each other out.
Consequently, the interference fringes lose contrast and become less sharp.

Therefore, C matches with II.

Step 4: Effect of Using Light of Smaller Frequency (D):

Since $\lambda = \frac{c}{\nu}$, a smaller frequency corresponds to a larger wavelength λ.

The fringe width is given by:

$$\beta = \frac{\lambda D}{d}$$

As wavelength λ increases, the fringe width β increases.

Therefore, D matches with I.

Final Answer:

The correct matching is: A-III, B-IV, C-II, D-I.

Therefore, the correct answer is **(C) A-III, B-IV, C-II, D-I**.

Quick Tip: Quick check:

One slit closed $\rightarrow$ No interference (Pattern disappears, IV).

Lower frequency $\rightarrow$ Higher wavelength $\rightarrow$ Fringe width increases (I).

Looking at options, only (C) satisfies B-IV and D-I simultaneously!

---

34. In a Young's double slit experiment, the intensity at the center of the screen is I. If one of the slits is closed, the intensity at the center of the screen now will be:

(A) $\frac{I}{2}$

(B) I

(C) $\frac{I}{4}$

(D) $\frac{I}{3}$

Correct Answer: (C) $\frac{I}{4}$

Solution:

Concept:

In wave interference, the total electric field at any point is the vector sum of the electric fields from both slits.

Because intensity is proportional to the square of the electric field amplitude, coherent superposition produces an intensity that depends non-linearly on individual slit contributions.

Step 1: Intensity with Both Slits Open:

Let each identical slit produce an electric field of amplitude E_0 and individual intensity $I_0 \propto E_0^2$.

At the center of the screen, the path difference between the waves arriving from the two symmetric slits is zero ($\Delta x = 0$), which implies zero phase difference ($\phi = 0$).

The resultant amplitude is:

$$E_{\text{net}} = E_0 + E_0 = 2E_0$$

The intensity at the center with both slits open is:

$$I = k(E_{\text{net}})^2 = k(2E_0)^2 = 4kE_0^2 = 4I_0$$

Step 2: Intensity with One Slit Closed:

When one of the slits is completely closed, light reaches the center of the screen from only the remaining open slit.

The field amplitude at the center is now simply E_0.

The new intensity I' at the center of the screen is:

$$I' = kE_0^2 = I_0$$

Step 3: Finding the Ratio and the New Intensity:

Comparing the new intensity I' to the original intensity I:

$$I' = I_0 = \frac{I}{4}$$

Final Answer:

The intensity at the center becomes $\frac{I}{4}$.

Therefore, the correct answer is **(C)** $\frac{I}{4}$.

Quick Tip: Central maximum intensity with two identical slits is $I_{\max} = 4I_0$.
Closing one slit leaves only one slit active: $I_{\text{single}} = I_0 = \frac{I_{\max}}{4}$.

---

35. A ray of light of frequency 5×10^{14} Hz is passed through a liquid. The wavelength of light measured inside the liquid is found to be 450×10^{-9} m. The refractive index of the liquid is

(A) 1.25
(B) 1.33
(C) 1.45
(D) 1.51

Correct Answer: (B) 1.33

Solution:

Concept:
When light passes from one medium to another, its frequency remains strictly unchanged because frequency is a characteristic of the source.
The speed of light and its wavelength change in accordance with the refractive index of the medium.

Step 1: Identifying Given Data:
Frequency of light, $\nu = 5 \times 10^{14}$ Hz.
Wavelength of light inside the liquid, $\lambda = 450 \times 10^{-9}$ m.
Speed of light in vacuum, $c = 3 \times 10^{8}$ m/s.

Step 2: Calculating the Speed of Light in the Liquid:
The speed of propagation v in the liquid is given by the wave relation:

$$v = \nu \cdot \lambda$$

Substitute the given values:

$$v = (5 \times 10^{14}\ \text{s}^{-1}) \times (450 \times 10^{-9}\ \text{m})$$

$$v = 2250 \times 10^{5}\ \text{m/s} = 2.25 \times 10^{8}\ \text{m/s}$$

Step 3: Calculating Refractive Index of the Liquid:

The absolute refractive index n of the liquid is the ratio of the speed of light in vacuum to the speed of light in the liquid:

$$n = \frac{c}{v}$$

Substitute the values:

$$n = \frac{3 \times 10^{8}\ \text{m/s}}{2.25 \times 10^{8}\ \text{m/s}} = \frac{3}{2.25} = \frac{300}{225} = \frac{4}{3} \approx 1.333 \approx 1.33$$

Final Answer:

The refractive index of the liquid is 1.33.

Therefore, the correct answer is **(B)** 1.33.

Quick Tip: Remember: Frequency ν never changes upon refraction!

Wavelength in medium is $\lambda = \frac{\lambda_0}{n}$.

Here, $\lambda_0 = \frac{c}{\nu} = \frac{3\times10^8}{5\times10^{14}} = 600$ nm.

Then $n = \frac{\lambda_0}{\lambda} = \frac{600}{450} = \frac{4}{3} \approx 1.33$.

---

36. If the two slits in a Young's double slit experiment have their widths in the ratio $4:1$, then the ratio of intensities at maxima and minima in the interference pattern will be

(A) 16 : 3

(B) 16 : 1

(C) 25 : 9

(D) 9 : 1

Correct Answer: (D) 9 : 1

Solution:

Concept:
In an interference experiment, the light intensity emerging from a slit is directly proportional to its slit width (w).
The amplitude of the light wave is therefore proportional to the square root of the slit width.

Step 1: Relating Slit Widths to Wave Amplitudes:
Let the widths of the two slits be w_1 and w_2.
We are given:

$$\frac{w_1}{w_2} = \frac{4}{1}$$

Since the individual slit intensity is directly proportional to slit width:

$$\frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{4}{1}$$

Because wave intensity is proportional to the square of wave amplitude ($I \propto a^2$):

$$\frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{4}{1}} = \frac{2}{1}$$

Thus, $a_1 = 2a_2$.

Step 2: Formula for Maximum and Minimum Intensity:
The maximum intensity in the interference pattern occurs when the waves interfere constructively in phase:

$$I_{\max} = (a_1 + a_2)^2$$

The minimum intensity occurs when the waves interfere destructively out of phase:

$$I_{\min} = (a_1 - a_2)^2$$

Step 3: Calculating the Intensity Ratio:

Taking the ratio of maximum to minimum intensity:

$$\frac{I_{\text{max}}}{I_{\text{min}}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2$$

Substituting $a_1 = 2a_2$:

$$\frac{I_{\text{max}}}{I_{\text{min}}} = \left(\frac{2a_2 + a_2}{2a_2 - a_2}\right)^2 = \left(\frac{3a_2}{1a_2}\right)^2 = \left(\frac{3}{1}\right)^2 = \frac{9}{1}$$

Final Answer:

The ratio of intensities at maxima and minima is $9:1$.

Therefore, the correct answer is **(D)** $9:1$.

Quick Tip: Direct shortcut formula:
$\frac{I_{\text{max}}}{I_{\text{min}}} = \left(\frac{\sqrt{w_1/w_2}+1}{\sqrt{w_1/w_2}-1}\right)^2$.
Here, $\sqrt{4} = 2 \implies \left(\frac{2+1}{2-1}\right)^2 = 3^2 = 9$. Ratio is $9:1$.

---

37. A concave mirror forms a real image of an object kept at a distance of 9 cm from it. If the object is taken away further from the mirror by 6 cm, the image size is reduced to $(1/4)^{\text{th}}$ of its previous size. The focal length of the mirror is:

(A) -5 cm

(B) -7 cm

(C) 15 cm

(D) 18 cm

Correct Answer: (B) -7 cm

Solution:

Concept:

The linear transverse magnification m produced by a spherical mirror relates the image distance, object distance, and focal length:

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

Step 1: Setting up Magnification for the First Position:

Let the focal length of the concave mirror be f (which is negative).

Initially, the object is placed at a distance $u_1 = -9$ cm.

Since a real, inverted image is formed, the magnification is negative:

$$m_1 = \frac{f}{f-(-9)} = \frac{f}{f+9}$$

The magnitude of magnification is:

$$|m_1| = \left|\frac{f}{f+9}\right|$$

Step 2: Setting up Magnification for the Second Position:

The object is moved further away from the mirror by an additional 6 cm.

The new object distance is:

$$u_2 = -(9+6)\text{ cm} = -15\text{ cm}$$

The new magnification is:

$$m_2 = \frac{f}{f-(-15)} = \frac{f}{f+15}$$

Step 3: Solving for the Focal Length f:

We are given that the new image size is reduced to $\frac{1}{4}$ of its initial size:

$$|m_2| = \frac{1}{4}|m_1|$$

Since both images are real and inverted, m_1 and m_2 have the same negative sign:

$$\frac{f}{f+15} = \frac{1}{4}\left(\frac{f}{f+9}\right)$$

Dividing both sides by f (since $f \neq 0$):

$$\frac{1}{f+15} = \frac{1}{4(f+9)}$$

Cross-multiplying:

$$4(f+9) = f+15$$

$$4f+36 = f+15$$

$$3f = 15-36 = -21$$

$$f = -\frac{21}{3} = -7 \text{ cm}$$

Final Answer:

The focal length of the concave mirror is -7 cm.

Therefore, the correct answer is **(B)** -7 **cm**.

Quick Tip: Using $m = \frac{f}{f-u}$ directly avoids finding image distances v_1 and v_2.
For a real image in a concave mirror: $|m| = \frac{|f|}{u-|f|}$.
$\frac{|f|}{15-|f|} = \frac{1}{4}\frac{|f|}{9-|f|} \implies 4(9-|f|) = 15-|f| \implies |f| = 7$ cm, hence $f = -7$ cm.

---

38. Arrange the following photosensitive metals (work function given in brackets) according to their threshold wavelengths in decreasing order of their values.

A. K ($\Phi = 2.3$ eV)

B. Na ($\Phi = 2.75$ eV)

C. Cs ($\Phi = 2.14$ eV)

D. Ca ($\Phi = 3.2$ eV)

Choose the correct answer from the options given below:

(A) A, B, C, D

(B) D, C, B, A

(C) C, A, D, B

(D) C, A, B, D

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

Solution:

Concept:

The work function (Φ) of a photosensitive metal is the minimum energy required to eject a photoelectron from its surface.

The threshold wavelength (λ_0) represents the maximum wavelength of incident radiation capable of causing photoelectric emission.

Step 1: Formula for Threshold Wavelength:

The relationship between work function and threshold wavelength is:

$$\Phi = \frac{hc}{\lambda_0} \implies \lambda_0 = \frac{hc}{\Phi}$$

This clearly demonstrates that threshold wavelength is inversely proportional to work function:

$$\lambda_0 \propto \frac{1}{\Phi}$$

Step 2: Evaluating the Work Functions:

The given values of work function are:

1. For Cs (C): $\Phi = 2.14$ eV
2. For K (A): $\Phi = 2.3$ eV
3. For Na (B): $\Phi = 2.75$ eV
4. For Ca (D): $\Phi = 3.2$ eV

Step 3: Arranging in Decreasing Order of Threshold Wavelength:

Since λ_0 varies inversely with Φ, the metal with the smallest work function will have the largest threshold wavelength:

$$\Phi_{\text{Cs}} < \Phi_{\text{K}} < \Phi_{\text{Na}} < \Phi_{\text{Ca}}$$

Consequently, the threshold wavelengths in descending (decreasing) order are:

$$\lambda_{0,\text{Cs}} > \lambda_{0,\text{K}} > \lambda_{0,\text{Na}} > \lambda_{0,\text{Ca}}$$

This corresponds to the sequence: C, A, B, D.

Final Answer:

The decreasing order of threshold wavelengths is C, A, B, D.

Therefore, the correct answer is **(D) C, A, B, D**.

Quick Tip: Decreasing threshold wavelength $\lambda_0 \iff$ Increasing work function Φ.

Simply sort the given numbers in ascending order: $2.14 < 2.3 < 2.75 < 3.2$, which gives the sequence C, A, B, D.

---

39. An electron and a photon each have the same de-Broglie wavelength of 1.0 nm. The ratio of their linear momenta is

(A) 1 : 1

(B) 1 : 2

(C) 2 : 1

(D) 4 : 9

Correct Answer: (A) 1 : 1

Solution:

Concept:

According to the de Broglie hypothesis, matter waves as well as electromagnetic radiation obey the fundamental relationship linking momentum and wavelength.

Step 1: Formula for de Broglie Wavelength:

The de Broglie wavelength λ associated with any entity (whether a massive particle like an electron or a massless particle like a photon) having linear momentum p is:

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

where h is Planck's constant.

Step 2: Expressing Momentum in Terms of Wavelength:

Rearranging the de Broglie equation gives the linear momentum:

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

This shows that linear momentum is purely determined by the wavelength and Planck's constant.

Step 3: Calculating the Ratio of Momenta:

For the electron:

$$p_e = \frac{h}{\lambda_e}$$

For the photon:

$$p_{\text{ph}} = \frac{h}{\lambda_{\text{ph}}}$$

Since both have the exact same wavelength ($\lambda_e = \lambda_{\text{ph}} = 1.0$ nm):

$$\frac{p_e}{p_{\text{ph}}} = \frac{h/\lambda_e}{h/\lambda_{\text{ph}}} = \frac{\lambda_{\text{ph}}}{\lambda_e} = \frac{1.0\text{ nm}}{1.0\text{ nm}} = 1$$

Thus, the ratio of their linear momenta is 1 : 1.

Final Answer:

The ratio of their linear momenta is 1 : 1.

Therefore, the correct answer is **(A)** 1 : 1.

Quick Tip: Linear momentum depends solely on de Broglie wavelength: $p = h/\lambda$.

Same wavelength $\implies$ Identical momentum, regardless of whether the particle is an electron, proton, or photon!

(Note: Their energies, however, will differ: $E_{\text{ph}} = pc$, whereas $E_e \approx p^2/2m$).

---

40. A monochromatic source emitting light of 600 **nm, has a power output of** 66 **W. The number**

of photons emitted by the source per second is (Given, Plank's constant $h = 6.6 \times 10^{-34}$ Js)

(A) 2×10^{18}

(B) 2×10^{19}

(C) 2×10^{20}

(D) 8×10^{22}

Correct Answer: (C) 2×10^{20}

Solution:

Concept:

The total power P emitted by a light source is the total radiant energy emitted per second, which equals the number of photons emitted per second multiplied by the energy of an individual photon.

Step 1: Identifying the Given Data:

Wavelength of emitted light, $\lambda = 600$ nm $= 600 \times 10^{-9}$ m $= 6 \times 10^{-7}$ m.

Power output of the source, $P = 66$ W $= 66$ J/s.

Planck's constant, $h = 6.6 \times 10^{-34}$ J $\cdot$ s.

Speed of light in vacuum, $c = 3 \times 10^{8}$ m/s.

Step 2: Energy of a Single Photon:

The energy of a single photon is given by:

$$E = \frac{hc}{\lambda}$$

Substitute the given values:

$$E = \frac{(6.6 \times 10^{-34}) \times (3 \times 10^{8})}{6 \times 10^{-7}} = \frac{19.8 \times 10^{-26}}{6 \times 10^{-7}} = 3.3 \times 10^{-19} \text{ J}$$

Step 3: Calculating Number of Photons Emitted per Second (n):

If n is the rate of photon emission:

$$P = n \cdot E \implies n = \frac{P}{E}$$

Substitute the values into the formula:

$$n = \frac{66}{3.3 \times 10^{-19}} = \frac{66}{33 \times 10^{-20}} = 2 \times 10^{20} \text{ photons/s}$$

Final Answer:

The number of photons emitted by the source per second is 2×10^{20}.

Therefore, the correct answer is **(C)** 2×10^{20}.

Quick Tip: Quick formula for photon rate:
$n = \frac{P\lambda}{hc} = \frac{66 \times (600 \times 10^{-9})}{(6.6 \times 10^{-34}) \times (3 \times 10^{8})}$.
Cancel $66/6.6 = 10$, and $600/3 = 200$, yielding $10 \times 200 \times 10^{17} = 2 \times 10^{20}$.

---

41. Match the LIST-I with LIST-II (Symbols have their usual meaning)

	LIST-I Spectral series of Hydrogen		LIST-II Wave Number
A.	Lyman series	I.	$\overline{\nu} = R\left[\frac{1}{1^2} - \frac{1}{n_2^2}\right]$
B.	Paschen series	II.	$\overline{\nu} = R\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$
C.	Balmer series	III.	$\overline{\nu} = R\left[\frac{1}{3^2} - \frac{1}{n_2^2}\right]$
D.	Brackett series	IV.	$\overline{\nu} = R\left[\frac{1}{4^2} - \frac{1}{n_2^2}\right]$

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Concept:

The Rydberg formula gives the wave number ($\overline{\nu} = \frac{1}{\lambda}$) of spectral lines emitted during transitions of an electron in a hydrogen atom:

$$\overline{\nu} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

where n_1 is the lower principal quantum number characteristic of the series, and $n_2 > n_1$.

Step 1: Identifying the Series and Respective n_1 Values:

1. **Lyman series (A):** Transitions terminate at the ground state $n_1 = 1$ from upper levels $n_2 = 2, 3, 4, \ldots$.

The wave number formula is $\overline{\nu} = R\left[\frac{1}{1^2} - \frac{1}{n_2^2}\right]$.

Thus, A matches with I.

2. **Balmer series (C):** Transitions terminate at the first excited state $n_1 = 2$ from upper levels $n_2 = 3, 4, 5, \ldots$.

The wave number formula is $\overline{\nu} = R\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$.

Thus, C matches with II.

3. **Paschen series (B):** Transitions terminate at the state $n_1 = 3$ from upper levels $n_2 = 4, 5, 6, \ldots$.

The wave number formula is $\overline{\nu} = R\left[\frac{1}{3^2} - \frac{1}{n_2^2}\right]$.

Thus, B matches with III.

4. **Brackett series (D):** Transitions terminate at the state $n_1 = 4$ from upper levels $n_2 = 5, 6, 7, \ldots$.

The wave number formula is $\overline{\nu} = R\left[\frac{1}{4^2} - \frac{1}{n_2^2}\right]$.

Thus, D matches with IV.

Step 2: Combining the Matches:

We have: A-I, B-III, C-II, D-IV.

Final Answer:

The correct matching sequence is A-I, B-III, C-II, D-IV.

Therefore, the correct answer is **(D) A-I, B-III, C-II, D-IV**.

Quick Tip: Order of lower energy levels for Hydrogen spectral series:

Lyman ($n_1 = 1$),

Balmer ($n_1 = 2$),

Paschen ($n_1 = 3$),

Brackett ($n_1 = 4$),

Pfund ($n_1 = 5$).

---

42. In Bohr's model of hydrogen atom, which of the following is an integral multiple of $\frac{h}{2\pi}$?

(A) Kinetic energy of electron

(B) Radius of an atom

(C) Potential energy of electron

(D) Angular momentum of electron

Correct Answer: (D) Angular momentum of electron

Solution:

Concept:

Niels Bohr proposed quantum postulates to explain the stability of atoms and the discrete nature of atomic hydrogen line spectra.

Step 1: Bohr's Second Postulate:

Bohr's second quantum postulate states that an electron in an atom revolves only in those stable, non-radiating orbits (called stationary orbits) where its orbital angular momentum L is an integral multiple of $\frac{h}{2\pi}$ (or reduced Planck's constant $\hbar$).

Step 2: Mathematical Formulation:

For an electron of mass m moving with speed v in a circular orbit of radius r:

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

where $n = 1, 2, 3, \ldots$ is the principal quantum number.

Step 3: Evaluating the Options:

Option (A) is incorrect because kinetic energy is $K = \frac{13.6}{n^2}$ eV, which scales as $\frac{1}{n^2}$.

Option (B) is incorrect because orbital radius is $r_n = 0.529\,n^2$ Å, which is proportional to n^2.

Option (C) is incorrect because potential energy is $U = -2K \propto \frac{1}{n^2}$.

Option (D) correctly identifies the quantized physical quantity as orbital angular momentum.

Final Answer:

Orbital angular momentum of the electron is an integral multiple of $\frac{h}{2\pi}$.

Therefore, the correct answer is **(D) Angular momentum of electron**.

Quick Tip: Bohr's quantization condition:

Orbital Angular Momentum: $L = n\hbar = n\frac{h}{2\pi}$.

This condition can be directly derived from de Broglie's standing wave condition: $2\pi r = n\lambda$.

---

43. Arrange the following elements in the increasing order of their binding energies per nucleon.

A. ^{4}**He**

B. ^{6}**Li**

C. ^{14}**N**

D. ^{12}**C**

Choose the correct answer from the options given below:

(A) A, B, C, D

(B) A, B, D, C

(C) B, A, C, D

(D) B, A, D, C

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

Solution:

Concept:
The binding energy per nucleon (E_{bn}) is a direct measure of the stability of an atomic nucleus. The binding energy curve versus mass number reveals prominent local maxima for tightly bound α-particle-like nuclei (^{4}He, ^{12}C, ^{16}O) alongside a general increasing trend for light nuclei.

Step 1: Identifying the Values of Binding Energy per Nucleon:
1. **^{6}Li (B):** Lithium-6 has a mass number $A = 6$ and an exceptionally low binding energy per nucleon of approximately:

$$E_{bn}(^6\text{Li}) \approx 5.33 \text{ MeV/nucleon}$$

2. **^{4}He (A):** Helium-4 (alpha particle) is an exceptionally tightly bound magic nucleus with:

$$E_{bn}(^4\text{He}) \approx 7.07 \text{ MeV/nucleon}$$

3. **^{14}N (C):** Nitrogen-14 is an odd-odd nucleus with a binding energy per nucleon of:

$$E_{bn}(^{14}\text{N}) \approx 7.48 \text{ MeV/nucleon}$$

4. **^{12}C (D):** Carbon-12 is composed of three alpha clusters (even-even nucleus), exhibiting a very high stability:

$$E_{bn}(^{12}\text{C}) \approx 7.68 \text{ MeV/nucleon}$$

Step 2: Arranging in Increasing Order:
Comparing these values:

$$E_{bn}(^6\text{Li}) < E_{bn}(^4\text{He}) < E_{bn}(^{14}\text{N}) < E_{bn}(^{12}\text{C})$$

$$5.33 \text{ MeV} < 7.07 \text{ MeV} < 7.48 \text{ MeV} < 7.68 \text{ MeV}$$

This corresponds to the sequence: B, A, C, D.

Final Answer:

The increasing order of binding energy per nucleon is B, A, C, D.

Therefore, the correct answer is **(C) B, A, C, D**.

Quick Tip: Even-even nuclei like ^{4}He, ^{12}C, and ^{16}O have higher binding energy per nucleon than their odd neighbors on the curve.

^{12}C (~ 7.68 MeV) is more tightly bound than ^{14}N (~ 7.48 MeV), while ^{6}Li has the lowest value among the four (~ 5.3 MeV).

---

44. If r_1 and r_2 are the radii of the atomic nuclei of mass number 4 and 32, respectively, then the ratio $\left(\frac{r_1}{r_2}\right)$ is

(A) 1 : 2

(B) 1 : 3

(C) 1 : 4

(D) 1 : 5

Correct Answer: (A) 1 : 2

Solution:

Concept:

The nuclear volume is directly proportional to the total number of nucleons (mass number A). Consequently, the radius R of an atomic nucleus varies as the cube root of its mass number.

Step 1: Formula for Nuclear Radius:

The radius R of a nucleus of mass number A is given empirically by:

$$R = R_0 A^{1/3}$$

where $R_0 \approx 1.2 \times 10^{-15}$ m $= 1.2$ fm is a constant.

Step 2: Applying to Given Nuclei:

We are given two nuclei with mass numbers:

$$A_1 = 4 \quad \text{and} \quad A_2 = 32$$

Their respective radii are:

$$r_1 = R_0(A_1)^{1/3} = R_0(4)^{1/3}$$

$$r_2 = R_0(A_2)^{1/3} = R_0(32)^{1/3}$$

Step 3: Calculating the Ratio $\frac{r_1}{r_2}$:

Taking the ratio of the two radii:

$$\frac{r_1}{r_2} = \frac{R_0(4)^{1/3}}{R_0(32)^{1/3}} = \left(\frac{4}{32}\right)^{1/3}$$

Simplifying the fraction:

$$\frac{4}{32} = \frac{1}{8}$$

Now taking the cube root:

$$\frac{r_1}{r_2} = \left(\frac{1}{8}\right)^{1/3} = \frac{1}{2}$$

Thus, the ratio is 1 : 2.

Final Answer:

The ratio $\left(\frac{r_1}{r_2}\right)$ is 1 : 2.

Therefore, the correct answer is **(A)** 1 : 2.

Quick Tip: Radius scales with cube root of mass number: $\frac{r_1}{r_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$.

Here, $\left(\frac{4}{32}\right)^{1/3} = \left(\frac{1}{8}\right)^{1/3} = \frac{1}{2}$.

45. The maximum wavelength of electromagnetic radiation which can create a hole-electron pair in the semiconductor Ge is: (Given, the band gap of Ge is 0.72 eV)

(A) $\sim 1.1 \times 10^{-5}$ m
(B) $\sim 1.4 \times 10^{-5}$ m
(C) $\sim 1.7 \times 10^{-6}$ m
(D) $\sim 2.6 \times 10^{-6}$ m

Correct Answer: (C) $\sim 1.7 \times 10^{-6}$ m

Solution:

Concept:
For an incident photon to excite an electron across the forbidden energy gap from the valence band to the conduction band (creating an electron-hole pair), its energy must be at least equal to the band gap energy E_g.
The threshold or maximum wavelength corresponds to the minimum photon energy equal to E_g.

Step 1: Identifying the Given Data:
Band gap of Germanium (Ge), $E_g = 0.72$ eV.
Convert the energy into Joules:

$$E_g = 0.72 \times 1.6 \times 10^{-19} \text{ J} = 1.152 \times 10^{-19} \text{ J}$$

Planck's constant, $h \approx 6.63 \times 10^{-34}$ J $\cdot$ s.
Speed of light in vacuum, $c = 3 \times 10^{8}$ m/s.

Step 2: Formula for Maximum Wavelength:
The photon energy is related to wavelength by:

$$E_g = \frac{hc}{\lambda_{\text{max}}} \implies \lambda_{\text{max}} = \frac{hc}{E_g}$$

Step 3: Calculating λ_{max}:
Substitute the values:

$$\lambda_{\max} = \frac{(6.63 \times 10^{-34} \text{ J}\cdot\text{s}) \times (3 \times 10^{8} \text{ m/s})}{1.152 \times 10^{-19} \text{ J}}$$

$$\lambda_{\max} = \frac{1.989 \times 10^{-25}}{1.152 \times 10^{-19}} \approx 1.7265 \times 10^{-6} \text{ m} \approx 1.7 \times 10^{-6} \text{ m}$$

Alternatively, using the approximation $\lambda(\mu\text{m}) \approx \frac{1.24}{E_g(\text{eV})}$:

$$\lambda_{\max} \approx \frac{1.24}{0.72} \ \mu\text{m} \approx 1.72 \ \mu\text{m} = 1.7 \times 10^{-6} \text{ m}$$

Final Answer:

The maximum wavelength of radiation is approximately 1.7×10^{-6} m.

Therefore, the correct answer is **(C)** $\sim 1.7 \times 10^{-6}$ **m.**

Quick Tip: Use the quick formula:
$\lambda_{\max}(\text{Å}) = \frac{12400}{E_g(\text{eV})} \implies \lambda_{\max} = \frac{12400}{0.72} \approx 17222 \text{ Å} \approx 1.7 \times 10^{-6}$ m.

---

46. If the forward bias voltage in a diode is increased, the width of the depletion region

(A) increases

(B) decreases

(C) fluctuates

(D) does not change

Correct Answer: (B) decreases

Solution:

Concept:

The depletion region in a p-n junction is formed by immobile ionized donor and acceptor atoms creating a built-in barrier potential directed from the n-side to the p-side.

Step 1: Effect of Forward Biasing:

In forward bias, the positive terminal of the external battery is connected to the p-type semiconductor and the negative terminal is connected to the n-type semiconductor.
The applied external electric field $\vec{E}_{\text{ext}}$ is directed from the p-side to the n-side, which is directly opposite to the built-in barrier electric field $\vec{E}_{\text{barrier}}$.

Step 2: Reduction in Barrier Height and Depletion Width:
The effective electric field across the junction becomes:

$$E_{\text{net}} = E_{\text{barrier}} - E_{\text{ext}}$$

Similarly, the net barrier potential difference is reduced from V_0 to $(V_0 - V)$, where V is the applied forward voltage.
The applied forward potential repels majority holes from the p-side and majority electrons from the n-side toward the junction, neutralising some of the uncovered ionized charges.

Step 3: Conclusion:
As the forward bias voltage V is increased, the barrier height continues to diminish and more majority carriers enter the depletion layer.
Consequently, the physical thickness (width) of the depletion region decreases.

Final Answer:
The width of the depletion region decreases.
Therefore, the correct answer is **(B) decreases**.

Quick Tip: Depletion width behavior:
Forward bias $\longrightarrow$ Depletion width DECREASES.
Reverse bias $\longrightarrow$ Depletion width INCREASES.

---

47. For a heavily doped n-type semi-conductor, donor level lies

(A) a little below the conduction band
(B) a little above the valance band

(C) a little inside the valence band

(D) at the center of the band gap

Correct Answer: (A) a little below the conduction band

Solution:

Concept:

In an extrinsic semiconductor, doping with impurity atoms introduces discrete allowed energy levels within the forbidden band gap.

Step 1: Impurity Levels in N-type Semiconductors:

An n-type semiconductor is created by doping an intrinsic semiconductor (such as Si or Ge) with pentavalent donor atoms (such as P, As, or Sb).

Four valence electrons of the donor atom form covalent bonds with adjacent host atoms, leaving the fifth valence electron loosely bound to the donor core.

Step 2: Location of the Donor Energy Level:

The energy required to ionize this fifth electron and promote it into the conduction band is very small (about 0.01 eV for Ge and 0.05 eV for Si).

Therefore, the discrete donor energy level E_D lies just slightly below the bottom of the conduction band E_C in the forbidden energy gap.

At room temperature, thermal energy is sufficient to ionize almost all donor atoms, populating the conduction band with electrons.

Step 3: Evaluating the Options:

Option (A) accurately states that the donor level lies a little below the conduction band.

Option (B) refers to the acceptor energy level in a p-type semiconductor, which lies a little above the valence band.

Options (C) and (D) are incorrect.

Final Answer:

The donor level lies a little below the conduction band.

Therefore, the correct answer is **(A) a little below the conduction band**.

Quick Tip: Remember:

Donor level (n-type) $\rightarrow$ Just below the Conduction Band (E_C).

Acceptor level (p-type) $\rightarrow$ Just above the Valence Band (E_V).

---

48. Match List-I with List-II. Assume that the Si intrinsic semiconductor has 5×10^{28} atoms/m^3. (Given: the intrinsic concentration of electrons in the semiconductor is 10^{16} m^{-3}).

LIST-I		LIST-II	
A.	When it is doped with 2 ppm concentration of a pentavalent atom, n_e is	I.	4.0×10^8 m^{-3}
B.	When it is doped with 2 ppm concentration of a pentavalent atom, n_h is	II.	2.5×10^{23} m^{-3}
C.	When it is doped with 5 ppm concentration of a pentavalent atom, n_e is	III.	10^9 m^{-3}
D.	When it is doped with 5 ppm concentration of a pentavalent atom, n_h is	IV.	10^{23} m^{-3}

Choose the correct answer from the options given below:

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

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

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

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

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

Solution:

Concept:

In an extrinsic semiconductor doped with donor impurities, the electron concentration n_e is approximately equal to the donor concentration N_D.

The hole concentration n_h is determined using the Law of Mass Action:

$$n_e \cdot n_h = n_i^2$$

Step 1: Given Constants:

Total atom density of Si, $N = 5 \times 10^{28}$ atoms/m^3.

Intrinsic carrier concentration, $n_i = 10^{16}\ \text{m}^{-3} \implies n_i^2 = (10^{16})^2 = 10^{32}\ \text{m}^{-6}$.

Step 2: Doping with 2 ppm Pentavalent Impurity (Items A and B):

Doping level is 2 ppm = 2 parts per million = 2×10^{-6}.

Donor concentration:

$$N_D = (2 \times 10^{-6}) \times (5 \times 10^{28}) = 10 \times 10^{22} = 10^{23}\ \text{m}^{-3}$$

Since all donors are ionized at room temperature:

$$n_e \approx N_D = 10^{23}\ \text{m}^{-3}$$

Thus, A matches with IV.

Using the law of mass action to find hole concentration n_h:

$$n_h = \frac{n_i^2}{n_e} = \frac{10^{32}}{10^{23}} = 10^9\ \text{m}^{-3}$$

Thus, B matches with III.

Step 3: Doping with 5 ppm Pentavalent Impurity (Items C and D):

Doping level is 5 ppm = 5×10^{-6}.

Donor concentration:

$$N_D = (5 \times 10^{-6}) \times (5 \times 10^{28}) = 25 \times 10^{22} = 2.5 \times 10^{23}\ \text{m}^{-3}$$

Therefore:

$$n_e \approx N_D = 2.5 \times 10^{23}\ \text{m}^{-3}$$

Thus, C matches with II.

Using the law of mass action to find hole concentration n_h:

$$n_h = \frac{n_i^2}{n_e} = \frac{10^{32}}{2.5 \times 10^{23}} = \frac{1}{2.5} \times 10^9 = 0.4 \times 10^9 = 4.0 \times 10^8 \text{ m}^{-3}$$

Thus, D matches with I.

Final Answer:

The correct matching is: A-IV, B-III, C-II, D-I.

Therefore, the correct answer is **(C) A-IV, B-III, C-II, D-I**.

Quick Tip: Apply the mass-action law: $n_e n_h = n_i^2$.

1 ppm $= 10^{-6}$.

For 2 ppm: $n_e = 2 \times 10^{-6} \times 5 \times 10^{28} = 10^{23}$ m^{-3}, giving $n_h = \frac{10^{32}}{10^{23}} = 10^9$ m^{-3}.

This immediately identifies A-IV and B-III!

---

49. If 200 MeV energy is released in the fission of a single nucleus of $^{235}_{92}$U, how many fissions per second must occur to produce a power of 1 kW?

(A) 6.250×10^{15}

(B) 3.125×10^{13}

(C) 4.251×10^{13}

(D) 2.155×10^{14}

Correct Answer: (B) 3.125×10^{13}

Solution:

Concept:

Electric or thermal power P is defined as the total energy delivered per unit time.

In a nuclear fission reactor, total power equals the rate of nuclear fissions multiplied by the energy released per individual fission event.

Step 1: Identifying the Given Data:

Target power output, $P = 1$ kW $= 1000$ W $= 1000$ J/s.

Energy released per fission, $E = 200$ MeV.

Charge of an electron, $e = 1.6 \times 10^{-19}$ C.

Step 2: Converting Energy per Fission into Joules:

Since 1 eV $= 1.6 \times 10^{-19}$ J:

$$E = 200 \times 10^6 \text{ eV} = (200 \times 10^6) \times (1.6 \times 10^{-19} \text{ J})$$

$$E = 320 \times 10^{-13} \text{ J} = 3.2 \times 10^{-11} \text{ J}$$

Step 3: Calculating Number of Fissions per Second:

Let N be the number of fissions occurring per second:

$$P = N \cdot E \implies N = \frac{P}{E}$$

Substitute the values:

$$N = \frac{1000 \text{ J/s}}{3.2 \times 10^{-11} \text{ J}} = \frac{10^3}{3.2 \times 10^{-11}} = \frac{1}{3.2} \times 10^{14}$$

Performing the division:

$$\frac{1}{3.2} = 0.3125$$

Therefore:

$$N = 0.3125 \times 10^{14} = 3.125 \times 10^{13} \text{ fissions/s}$$

Final Answer:

The number of fissions per second required is 3.125×10^{13}.

Therefore, the correct answer is **(B)** 3.125×10^{13}.

Quick Tip: Energy per fission is 3.2×10^{-11} J.

To find fissions per second for 1 W: $\frac{1}{3.2\times10^{-11}} \approx 3.125 \times 10^{10}\ \text{s}^{-1}$.

For 1 kW = 1000 W, multiply by 10^3: $3.125 \times 10^{13}\ \text{s}^{-1}$.

---

50. An alpha particle of energy $\frac{1}{2}mv^2$ bombards a heavy target nucleus of charge Ze. Then, the distance of closest approach for the alpha particle will be proportional to

(A) v^{-1}

(B) v^{-2}

(C) v^{-4}

(D) $(Ze)^{-1}$

Correct Answer: (B) v^{-2}

Solution:

Concept:

In Rutherford's α-particle scattering experiment, a head-on collision brings the incoming α-particle momentarily to rest at the distance of closest approach r_0.

At this turning point, the initial kinetic energy of the α-particle is entirely converted into electrostatic potential energy.

Step 1: Identifying Energies at the Turning Point:

Initial kinetic energy of the α-particle far away from the nucleus:

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

Charge on the alpha particle (He^{2+}): $q_1 = +2e$.

Charge on the target heavy nucleus: $q_2 = +Ze$.

At the distance of closest approach r_0, the electrostatic potential energy is:

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_0} = \frac{1}{4\pi\varepsilon_0}\frac{(2e)(Ze)}{r_0} = \frac{2Ze^2}{4\pi\varepsilon_0 r_0}$$

Step 2: Applying Conservation of Energy:

Equating initial kinetic energy to final potential energy:

$$\frac{1}{2}mv^2 = \frac{2Ze^2}{4\pi\varepsilon_0 r_0}$$

Step 3: Solving for r_0 and Determining Proportionality:

Rearranging for r_0:

$$r_0 = \frac{4Ze^2}{4\pi\varepsilon_0 mv^2}$$

From this expression, holding the mass m and charges Ze, e constant:

$$r_0 \propto \frac{1}{v^2} = v^{-2}$$

Final Answer:

The distance of closest approach is proportional to v^{-2}.

Therefore, the correct answer is **(B)** v^{-2}.

Quick Tip: Conservation of energy: $K \propto \frac{1}{r_0}$.

Since $K = \frac{1}{2}mv^2 \propto v^2$, we have $r_0 \propto \frac{1}{K} \propto \frac{1}{v^2} = v^{-2}$.

Also note: $r_0 \propto Ze$ and $r_0 \propto m^{-1}$.

