Bihar Board Class 12 Physics Half Yearly Examination (Sep - 2025) Question Paper with Solutions

Time Allowed :3 Hours 15 Minutes	Maximum Marks :70	Total Questions :66

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours 15 Minutes duration.
2. The question paper consists of 70 questions.
3. For subjects with a 70-mark theory paper (with practicals): 42 MCQs (35 to be attempted, 1 mark each).
4. Minimum 30% marks in each subject (30 out of 100 for theory, adjusted for practicals where applicable).

1. Which of the following relations is correct?

(A) $\vec{E} = \frac{\vec{F}}{q}$
(B) $\vec{E} = q\vec{F}$
(C) $\vec{E} = \frac{q}{\vec{F}}$
(D) $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{\vec{F}}$

Correct Answer: (A) $\vec{E} = \frac{\vec{F}}{q}$

Solution:

Step 1: Understanding the Concept:
The electric field intensity ($\vec{E}$) at a point in space is a fundamental concept in electrostatics. It is defined as the force ($\vec{F}$) that would be experienced by a unit positive test charge (q) if placed at that point.

Step 2: Key Formula or Approach:
The mathematical definition of the electric field intensity is given by the ratio of the electrostatic force to the magnitude of the test charge.

$$\vec{E} = \frac{\vec{F}}{q}$$

Here, $\vec{E}$ is the electric field vector, $\vec{F}$ is the force vector experienced by the charge, and q is the scalar magnitude of the charge.

Step 3: Detailed Explanation:
Let's analyze the given options:

(A) $\vec{E} = \frac{\vec{F}}{q}$: This aligns perfectly with the definition of electric field intensity. It correctly states that the electric field is the force per unit charge.
(B) $\vec{E} = q\vec{F}$: This incorrectly suggests that the electric field is the product of charge and force. Rearranging the correct formula gives $\vec{F} = q\vec{E}$, not this relation.
(C) $\vec{E} = \frac{q}{\vec{F}}$: This is dimensionally and conceptually incorrect. It represents the reciprocal of force per unit charge.
(D) $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{\vec{F}}$: This option incorrectly combines Coulomb's constant with the force and charge in a way that doesn't define the electric field. The term $\frac{1}{4\pi\epsilon_0}$ is used when calculating the field from a source charge Q at a distance r ($\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{r}$), not in the basic definition involving force.

Step 4: Final Answer:
Based on the definition, the correct relationship is that the electric field is the force experienced by a charge divided by the magnitude of that charge.
Thus, option (A) is the correct representation.

Quick Tip

Remember the fundamental definition: Electric Field = Force / Charge. This is analogous to the definition of a gravitational field (g = F/m). Keeping this analogy in mind can help you recall the formula during an exam.

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2. S.I. unit of electric flux is

(A) ohm-metre
(B) ampere-metre
(C) volt-metre
(D) (volt) x (metre)$^{-1}$

Correct Answer: (C) volt-metre

Solution:

Step 1: Understanding the Concept:
Electric flux (Φ_E) is a measure of the flow of the electric field through a given area. It quantifies the number of electric field lines passing through a surface.

Step 2: Key Formula or Approach:
Electric flux is defined as the product of the component of the electric field perpendicular to the surface and the area of the surface. For a uniform electric field $\vec{E}$ passing through a plane area $\vec{A}$, the flux is given by the dot product:

$$\Phi_E = \vec{E} \cdot \vec{A} = EA\cos\theta$$

Alternatively, electric flux can be defined using the integral form of Gauss's Law, $\Phi_E = \oint \vec{E} \cdot d\vec{A}$. To find the S.I. unit, we can analyze the units of the quantities in the formula.

Step 3: Detailed Explanation:

The S.I. unit of the electric field (E) is Newtons per Coulomb (N/C) or Volts per metre (V/m).
The S.I. unit of area (A) is square metres (m^2).
Using the formula $\Phi_E = E \cdot A$, we can derive the unit for electric flux:
Method 1: Using N/C for Electric Field

$$\text{Unit of } \Phi_E = \left(\frac{N}{C}\right) \times m^2 = \frac{N \cdot m^2}{C}$$

Method 2: Using V/m for Electric Field

$$\text{Unit of } \Phi_E = \left(\frac{V}{m}\right) \times m^2 = V \cdot m$$

Both $N \cdot m^2/C$ and $V \cdot m$ (volt-metre) are correct S.I. units for electric flux.
Let's check the options:
(A) ohm-metre: This is the unit of resistivity.
(B) ampere-metre: This unit is related to magnetic fields (Ampere's law).
(C) volt-metre: This matches our derived unit.
(D) (volt) x (metre)$^{-1}$: This is V/m, which is the unit of the electric field, not electric flux.

Step 4: Final Answer:

The S.I. unit of electric flux is the volt-metre.
Therefore, option (C) is the correct answer.

> **Quick Tip**
>
> Don't confuse the unit of electric field (V/m) with the unit of electric flux ($V \cdot m$). Flux involves an area component (m^2), which cancels out one of the 'per metre' dimensions from the electric field unit, resulting in volt-metre.

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3. Which of the following values of n is not possible in relation Q = ne?

(A) 8
(B) 4
(C) 100
(D) 4.2

Correct Answer: (D) 4.2

Solution:

Step 1: Understanding the Concept:
The relationship $Q = ne$ represents the principle of quantization of electric charge.
This principle states that the total electric charge (Q) on any object is an integral multiple of the elementary charge (e), which is the charge of a single electron or proton.
Here, $e \approx 1.6 \times 10^{-19}$ Coulombs.

Step 2: Key Formula or Approach:
The formula is given as:

$$Q = ne$$

According to the principle of quantization of charge, the number n must be an integer (..., -2, -1, 0, 1, 2, ...).
It represents the number of electrons gained or lost by the body. Since electrons cannot be transferred in fractions, n cannot be a fractional or decimal value.

Step 3: Detailed Explanation:
We need to examine the given options for the value of n and determine which one is not an integer.
(A) 8: This is an integer. A body can lose or gain 8 electrons.
(B) 4: This is an integer. A body can lose or gain 4 electrons.
(C) 100: This is an integer. A body can lose or gain 100 electrons.
(D) 4.2: This is not an integer. A body cannot lose or gain 4.2 electrons, as charge is quantized and electrons are fundamental particles that cannot be split in this context.

Step 4: Final Answer:
Since n must be an integer according to the principle of charge quantization, the value 4.2 is not possible.
Therefore, option (D) is the correct answer.

Quick Tip

The "quantization" of charge means charge comes in discrete packets (quanta), just like money comes in cents or pennies. You can have 4 dollars, but not 4.2 cents. The smallest packet of charge is 'e'. So, any total charge must be a whole number of these packets.

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4. Which of the following is correct for resistivity of a material ?

(A) $\rho = RLA$
(B) $\rho = \frac{L}{RA}$
(C) $\rho = \frac{RA}{L}$
(D) $\rho = \frac{RL}{A}$

Correct Answer: (C) $\rho = \frac{RA}{L}$

Solution:

Step 1: Understanding the Concept:
Resistivity (ρ) is an intrinsic property of a material that quantifies how strongly it resists the flow of electric current.
The resistance (R) of a conductor depends on its physical dimensions (length and cross-sectional area) and the resistivity of the material it's made from.

Step 2: Key Formula or Approach:
The resistance (R) of a uniform conductor is given by the formula:

$$R = \rho \frac{L}{A}$$

where:
ρ is the electrical resistivity of the material.
L is the length of the conductor.
A is the cross-sectional area of the conductor.
We need to rearrange this formula to solve for resistivity (ρ).

Step 3: Detailed Explanation:
Starting with the resistance formula:

$$R = \rho \frac{L}{A}$$

To isolate ρ, we can multiply both sides by A and divide by L:

$$R \times A = \rho \times L$$
$$\frac{RA}{L} = \rho$$

So, the correct expression for resistivity is $\rho = \frac{RA}{L}$.
Let's compare this with the given options:
(A) $\rho = RLA$: Incorrect.
(B) $\rho = \frac{L}{RA}$: Incorrect. This is the reciprocal of the correct formula.
(C) $\rho = \frac{RA}{L}$: Correct. This matches our derived expression.
(D) $\rho = \frac{RL}{A}$: Incorrect.

Step 4: Final Answer:
By rearranging the formula for resistance, we find that the correct expression for resistivity is $\rho = \frac{RA}{L}$.
Therefore, option (C) is the correct answer.

Quick Tip

Remember the units to verify the formula. Resistance (R) is in Ohms (Ω), Area (A) is in m^2, and Length (L) is in m. The unit of resistivity (ρ) is Ohm-metre ($\Omega \cdot m$). Plugging the units into option (C): $\frac{\Omega \cdot m^2}{m} = \Omega \cdot m$. This dimensional analysis confirms the formula is correct.

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5. When a body is charged, then its mass

(A) decreases
(B) increases
(C) may increase or decrease
(D) remains constant

Correct Answer: (C) may increase or decrease

Solution:

Step 1: Understanding the Concept:
Charging a body involves the transfer of electrons. An electron is a fundamental particle that has a non-zero rest mass ($m_e \approx 9.11 \times 10^{-31}$ kg).
A body becomes charged due to an excess or deficit of electrons.

Step 2: Detailed Explanation:
Case 1: Positive Charging
A body becomes positively charged when it **loses** electrons.
Since each electron has mass, the removal of electrons results in a slight **decrease** in the total mass of the body.

Case 2: Negative Charging
A body becomes negatively charged when it **gains** electrons.
The addition of electrons, each with its own mass, results in a slight **increase** in the total mass of the body.

Step 3: Final Answer:
Since the mass of the body can either increase (if it's negatively charged) or decrease (if it's positively charged), the correct option is that its mass may increase or decrease. Although this change in mass is extremely small and often negligible in practical scenarios, it is physically present.
Therefore, option (C) is the correct answer.

Quick Tip

Think of charging as adding or removing tiny, massive particles (electrons). Adding particles (negative charge) increases mass. Removing particles (positive charge) decreases mass. This simple physical picture helps to arrive at the correct answer quickly.

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6. The quantum of electric charge in esu is

(A) 2.99×10^9
(B) 4.78×10^{-10}
(C) 1.6×10^{-19}
(D) -1.6×10^{-19}

Correct Answer: (B) 4.78×10^{-10}

Solution:

Step 1: Understanding the Concept:
The "quantum of electric charge" refers to the elementary charge (e), which is the magnitude of the charge of a single proton or electron.
The question asks for the value of this elementary charge in the 'esu' (electrostatic unit) system, also known as statcoulombs.

Step 2: Key Formula or Approach:
First, we need the value of the elementary charge in S.I. units (Coulombs).

$$e = 1.602 \times 10^{-19}\,\text{C}$$

Next, we need the conversion factor between Coulombs (C) and esu (or statcoulombs).

$$1\,\text{C} \approx 2.9979 \times 10^9\,\text{esu} \approx 3 \times 10^9\,\text{esu}$$

We can now convert the value of e from Coulombs to esu.

Step 3: Detailed Explanation:
Using the values from Step 2:

$$e(\text{in esu}) = e(\text{in C}) \times \frac{\text{esu}}{\text{C}}$$

$$e = (1.602 \times 10^{-19}\,\text{C}) \times (2.9979 \times 10^9\,\frac{\text{esu}}{\text{C}})$$

$$e \approx 4.803 \times 10^{-10}\,\text{esu}$$

Let's examine the options:
(A) 2.99×10^9: This is the conversion factor itself, not the value of the elementary charge in esu.
(B) 4.78×10^{-10}: This value is very close to our calculated value of 4.803×10^{-10} esu. The

small difference is likely due to rounding of constants used.
(C) 1.6×10^{-19}: This is the value of the elementary charge in Coulombs, not esu.
(D) -1.6×10^{-19}: This is the charge of an electron in Coulombs. The question asks for the quantum (magnitude) of charge.

Step 4: Final Answer:
The value of the elementary charge in esu is approximately 4.8×10^{-10} esu. Option (B) is the closest match.
Therefore, option (B) is the correct answer.

Quick Tip

Memorize the key values: $e \approx 1.6 \times 10^{-19}$ C and the conversion 1 C $\approx 3 \times 10^9$ esu. For the exam, a quick calculation $(1.6 \times 3) \times (10^{-19} \times 10^9) = 4.8 \times 10^{-10}$ will lead you to the right answer.

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7. The electric field at a distance r from the centre of the dipole is proportional to

(A) r
(B) $\frac{1}{r}$
(C) $\frac{1}{r^2}$
(D) $\frac{1}{r^3}$

Correct Answer: (D) $\frac{1}{r^3}$

Solution:

Step 1: Understanding the Concept:
The question is asking about the dependence of the electric field on the distance r from the center of an electric dipole, for distances much larger than the dipole's size.

Step 2: Key Formula or Approach:
Let's consider the electric field (E) due to a short electric dipole at a large distance r ($r \gg$ length of the dipole).
1. **Electric field on the axial line (E_{axial}):**

$$E_{axial} = \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$$

2. **Electric field on the equatorial line ($E_{equatorial}$):**

$$E_{equatorial} = \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}$$

where p is the dipole moment.
In both cases, the magnitude of the electric field E is proportional to $\frac{1}{r^3}$.

For comparison, the electric potential (V) due to a dipole is proportional to $\frac{1}{r^2}$.

Step 3: Detailed Explanation:
The key takeaway from the formulas is the relationship between the electric field E and the distance r.

$$E \propto \frac{1}{r^3}$$

This inverse cube relationship is a characteristic feature of the electric field of a dipole at far distances. This is different from a single point charge, where the field is proportional to $\frac{1}{r^2}$.
Looking at the options:
(A) r: Incorrect.
(B) $\frac{1}{r}$: Incorrect. This describes the potential due to a long line charge.
(C) $\frac{1}{r^2}$: Incorrect. This describes the electric field of a point charge or the potential of a dipole.
(D) $\frac{1}{r^3}$: Correct. This describes the electric field of a dipole.

Step 4: Final Answer:
The strength of the electric field from a dipole is inversely proportional to the cube of the distance.
Therefore, option (D) is the correct answer.

Quick Tip

Remember the power laws for distance dependence in electrostatics:

- Point Charge: Field $\propto \frac{1}{r^2}$, Potential $\propto \frac{1}{r}$
- Dipole: Field $\propto \frac{1}{r^3}$, Potential $\propto \frac{1}{r^2}$

This pattern can help you quickly answer questions about proportionality.

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8. Potential gradient is equal to

(A) $\frac{dx}{dv}$
(B) $dx \cdot dv$
(C) $\frac{dv}{dx}$
(D) none of these

Correct Answer: (C) $\frac{dv}{dx}$

Solution:

Step 1: Understanding the Concept:
The term "gradient" in physics refers to the rate of change of a quantity with respect to position or distance.

Therefore, "potential gradient" refers to the rate of change of electric potential (V) with respect to distance (x).

Step 2: Key Formula or Approach:
The mathematical expression for the potential gradient in one dimension is the derivative of the potential V with respect to the position x.

$$\text{Potential Gradient} = \frac{dV}{dx}$$

This quantity is directly related to the electric field. The electric field component in the x-direction (E_x) is the negative of the potential gradient.

$$E_x = -\frac{dV}{dx}$$

Step 3: Detailed Explanation:
The question asks for the expression that defines the potential gradient itself, not what it's physically equal to (like the negative electric field).
By definition, the potential gradient is the spatial rate of change of potential.
(A) $\frac{dx}{dv}$: This is the rate of change of distance with respect to potential, which is the reciprocal of the potential gradient.
(B) $dx \cdot dv$: This is the product of infinitesimal changes in distance and potential, which has no direct physical meaning as a gradient.
(C) $\frac{dv}{dx}$: This correctly represents the rate of change of potential (V) with respect to distance (x), which is the definition of potential gradient.
(D) none of these: This is incorrect as option (C) is the correct definition.

Step 4: Final Answer:
The definition of potential gradient is the derivative of potential with respect to distance. Therefore, option (C) is the correct answer.

Quick Tip

The word "gradient" itself means "slope" or "rate of change with distance." So, "Potential Gradient" literally translates to the change in Potential (dV) per change in distance (dx). This linguistic clue directly points to the correct mathematical expression $\frac{dV}{dx}$.

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9. Which one of the following is a vector quantity ?

(A) Electric charge
(B) Electric potential
(C) Intensity of electric field
(D) Surface density of charge

Correct Answer: (C) Intensity of electric field

Solution:

Step 1: Understanding the Concept:
A **scalar** quantity is one that is fully described by its magnitude alone (e.g., mass, temperature).
A **vector** quantity is one that requires both magnitude and direction for a complete description (e.g., force, velocity).
We need to evaluate each option to see if it has a direction associated with it.

Step 2: Detailed Explanation:
(A) **Electric charge**: This is a scalar quantity. It tells you the amount of charge (e.g., +5 C) but has no direction.
(B) **Electric potential**: This is a scalar quantity. It represents the electric potential energy per unit charge at a point in space (e.g., 10 Volts). It has magnitude but no direction.
(C) **Intensity of electric field (or Electric Field Strength)**: This is a vector quantity. At any point in space, it has a magnitude (how strong the field is) and a direction (the direction of the force that a positive test charge would experience).
(D) **Surface density of charge**: This is a scalar quantity. It describes how much charge is present per unit area on a surface (e.g., $2\,C/m^2$). It has magnitude but no intrinsic direction.

Step 3: Final Answer:
Among the given options, only the intensity of the electric field has both magnitude and direction, making it a vector quantity.
Therefore, option (C) is the correct answer.

> Quick Tip
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> A simple test is to ask "in which direction?". For charge, potential, or charge density, this question doesn't make sense. For an electric field, it does—the field points away from positive charges and towards negative charges. This indicates it's a vector.

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10. If any hollow spherical conductor is positively charged, then the potential inside it will be .

(A) zero
(B) positive and uniform
(C) positive and non-uniform
(D) negative and uniform

Correct Answer: (B) positive and uniform

Solution:

Step 1: Understanding the Concept:
For a charged conducting sphere, all the excess charge resides on its outer surface. A key property of a conductor in electrostatic equilibrium is that the electric field inside the conductor is zero.
The electric field (E) and the electric potential (V) are related by $E = -\frac{dV}{dr}$.

Step 2: Detailed Explanation:
1. **Electric Field Inside:** Since there is no charge enclosed within any Gaussian surface drawn inside the hollow conductor, the electric field E inside the conductor is zero.
2. **Potential Inside:** From the relation $E = -\frac{dV}{dr}$, if $E = 0$, then $\frac{dV}{dr} = 0$. This implies that the potential V does not change with distance inside the sphere; it is constant or uniform.
3. **Value of the Potential:** This constant potential inside the sphere must be equal to the potential at the surface of the sphere. The potential at the surface (and anywhere inside) of a sphere of radius R with a positive charge $+Q$ is given by:

$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{R}$$

Since Q is positive, the value of V will be positive.

Step 3: Final Answer:
Combining these points, the potential inside the hollow spherical conductor is constant (uniform) and has the same positive value as the potential on its surface.
Therefore, the potential is **positive and uniform**.
Option (B) is the correct answer.

Quick Tip

Remember this rule for conductors in equilibrium: Electric Field inside is always zero, and Potential inside is always constant (and equal to the surface potential). If the charge on the conductor is positive, the potential will be positive. If the charge is negative, the potential will be negative.

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11. If R is resistance and C is capacitance then the dimensional formula of RC is

(A) M^0L^0T
(B) MLT^{-2}
(C) $M^0L^0T^{-1}$
(D) M^0LT

Correct Answer: (A) M^0L^0T

Solution:

Step 1: Understanding the Concept:
The product RC, where R is resistance and C is capacitance, is known as the time constant of an RC circuit.
The time constant represents the time required for the voltage across the capacitor to reach approximately 63.2% of its final value during charging, or to fall to 36.8% of its initial value during discharging.
Since it represents a time, its dimension must be that of time, [T].

Step 2: Key Formula or Approach:
We can derive the dimension of RC by analyzing the dimensions of R and C individually.
The dimension of Resistance (R) can be found from Ohm's Law, $V = IR$.

$$[R] = \frac{[V]}{[I]} = \frac{[\text{Work/Charge}]}{[\text{Current}]} = \frac{[ML^2T^{-2}]/[AT]}{[A]} = [ML^2T^{-3}A^{-2}]$$

The dimension of Capacitance (C) is found from the definition $Q = CV$.

$$[C] = \frac{[Q]}{[V]} = \frac{[AT]}{[ML^2T^{-2}/AT]} = \frac{[A^2T^2]}{[ML^2T^{-2}]} = [M^{-1}L^{-2}T^4A^2]$$

Step 3: Detailed Explanation:
Now, let's find the dimension of the product RC:

$$[RC] = [R] \times [C]$$
$$[RC] = [ML^2T^{-3}A^{-2}] \times [M^{-1}L^{-2}T^4A^2]$$

Multiplying the terms, we add the exponents of the base dimensions:

$$[RC] = [M^{1-1}L^{2-2}T^{-3+4}A^{-2+2}]$$
$$[RC] = [M^0L^0T^1A^0] = [T]$$

Step 4: Final Answer:
The dimensional formula of RC is M^0L^0T.
Therefore, option (A) is the correct answer.

> **Quick Tip**
>
> In an exam, you can save time by remembering that the product RC is the 'time constant' of a circuit. The name itself implies that its unit is seconds and its dimension is simply [T], which is M^0L^0T. This avoids the need for a lengthy dimensional analysis.

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12. Two capacitors $C_1 = 2\mu F$ and $C_2 = 4\mu F$ are connected in series and a potential difference of 1200 V is applied across them. The potential difference across the ends of 2μF capacitor will be

(A) 600 V
(B) 900 V

(C) 400 V
(D) 800 V

Correct Answer: (D) 800 V

Solution:

Step 1: Understanding the Concept:
When capacitors are connected in series, the charge stored on each capacitor is the same. The total voltage applied across the combination is divided among the individual capacitors.
The potential difference across a capacitor is inversely proportional to its capacitance ($V = Q/C$). So, the smaller capacitor will have a larger voltage drop across it.

Step 2: Key Formula or Approach:
1. Find the equivalent capacitance (C_{eq}) for a series combination:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

2. Calculate the total charge (Q) stored in the circuit:

$$Q = C_{eq} \times V_{total}$$

3. Calculate the potential difference across the first capacitor (V_1):

$$V_1 = \frac{Q}{C_1}$$

Step 3: Detailed Explanation:
First, calculate the equivalent capacitance:

$$\frac{1}{C_{eq}} = \frac{1}{2\mu F} + \frac{1}{4\mu F} = \frac{2+1}{4\mu F} = \frac{3}{4\mu F}$$

$$C_{eq} = \frac{4}{3}\mu F$$

Next, calculate the total charge stored, which is the same for both capacitors:

$$Q = C_{eq} \times V_{total} = \left(\frac{4}{3}\mu F\right) \times 1200V = 4 \times 400\,\mu C = 1600\,\mu C$$

Finally, calculate the potential difference across the 2μF capacitor (C_1):

$$V_1 = \frac{Q}{C_1} = \frac{1600\,\mu C}{2\,\mu F} = 800\,V$$

Step 4: Final Answer:
The potential difference across the 2μF capacitor is 800 V.
Therefore, option (D) is the correct answer.

Quick Tip

For two capacitors in series, you can use the voltage divider rule for capacitors. The voltage across C_1 is $V_1 = V_{total} \times \frac{C_2}{C_1+C_2}$. Using this: $V_1 = 1200V \times \frac{4}{2+4} = 1200V \times \frac{4}{6} = 1200 \times \frac{2}{3} = 800V$. This shortcut is much faster.

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13. The resistance of an ideal ammeter is

(A) zero
(B) very small
(C) very large
(D) infinite

Correct Answer: (A) zero

Solution:

Step 1: Understanding the Concept:
An ammeter is a device used to measure the electric current flowing through a circuit. To measure the current, it must be connected in series with the component through which the current is being measured.
When the ammeter is placed in the circuit, it should not change the original current that it is intended to measure.

Step 2: Detailed Explanation:
The total resistance of the circuit determines the current flowing through it ($I = V/R_{total}$).
If the ammeter itself has some resistance (R_A), connecting it in series would increase the total resistance of the circuit to $R_{circuit} + R_A$.
This increased total resistance would cause the current to decrease, leading to an inaccurate measurement. The measured current would be lower than the actual current.
To minimize this effect, the resistance of the ammeter should be as small as possible.
For an **ideal** ammeter, which would not affect the circuit at all, the resistance must be exactly zero.

Step 3: Final Answer:
An ideal ammeter has zero internal resistance so that it does not alter the current it is measuring. A practical ammeter has a very small, but non-zero, resistance. Since the question asks for an ideal ammeter, the answer is zero.
Therefore, option (A) is correct.

Quick Tip

Remember the ideal properties of measuring instruments:

- **Ideal Ammeter** (in series): Resistance is **zero**.
- **Ideal Voltmeter** (in parallel): Resistance is **infinite**.

This helps to avoid confusion between the two.

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14. Unit of surface charge density is

(A) newton/metre (Nm^{-1})
(B) coulomb-metre (Cm)
(C) newton / metre^2 (Cm^{-2})
(D) coulomb / volt (CV^{-1})

Correct Answer: (C) newton / metre^2 (Cm^{-2})

Solution:

Step 1: Understanding the Concept:
Surface charge density, usually denoted by the symbol σ (sigma), is defined as the amount of electric charge (Q) per unit area (A) on a surface.

Step 2: Key Formula or Approach:
The formula for surface charge density is:

$$\sigma = \frac{Q}{A}$$

To find the S.I. unit, we substitute the S.I. units for charge and area.

Step 3: Detailed Explanation:
The S.I. unit for electric charge (Q) is the **coulomb (C)**.
The S.I. unit for area (A) is the **square metre (m^2)**.
Therefore, the S.I. unit for surface charge density is:

$$\text{Unit of } \sigma = \frac{\text{Unit of Q}}{\text{Unit of A}} = \frac{C}{m^2} = Cm^{-2}$$

Let's analyze the given options:
(A) newton/metre (Nm^{-1}): This is the unit of surface tension.
(B) coulomb-metre (Cm): This is the unit of electric dipole moment.
(C) newton / metre^2 (Cm^{-2}): This option appears to have a typo. "newton / metre^2" is the unit of pressure (Pascal). However, the unit in the parenthesis, "Cm^{-2}", is the correct unit for surface charge density. In multiple-choice questions with such errors, one should choose the option that contains the correct information. The term Cm^{-2} is correct.

(D) coulomb / volt (CV^{-1}): This is the unit of capacitance, also known as the Farad (F).

Step 4: Final Answer:
Based on the definition, the correct unit for surface charge density is coulomb per square metre (Cm^{-2}). Option (C) contains this correct unit, despite the apparent typo.
Therefore, option (C) is the intended correct answer.

Quick Tip

Always break down physical quantities into their fundamental definitions to find their units. Surface charge density = Charge / Area. This immediately gives you Coulomb / metre^2. Be wary of typos in question papers, but trust your fundamental knowledge.

---

15. The power of electric circuit is

(A) $V^2.R$
(B) $V.R$
(C) $V^2.R.t$
(D) $\frac{V^2}{R}$

Correct Answer: (D) $\frac{V^2}{R}$

Solution:

Step 1: Understanding the Concept:
Electric power (P) is the rate at which electrical energy is consumed or dissipated in an electric circuit. The S.I. unit of power is the Watt (W).

Step 2: Key Formula or Approach:
The fundamental formula for electric power is:

$$P = V \times I$$

where V is the potential difference (voltage) and I is the current.
We can use Ohm's Law, $V = IR$, to express power in terms of different variables.

Step 3: Detailed Explanation:
We have the primary formula $P = VI$.
To express power in terms of voltage (V) and resistance (R), we can substitute for current (I) using Ohm's Law. From $V = IR$, we get $I = \frac{V}{R}$.
Substituting this into the power formula:

$$P = V \times \left(\frac{V}{R}\right) = \frac{V^2}{R}$$

This gives one of the standard expressions for power.
Let's check the given options:
(A) $V^2.R$: Incorrect.
(B) $V.R$: Incorrect, this is $V \times V/I = V^2/I$.
(C) $V^2.R.t$: Incorrect. Power multiplied by time (t) is energy, not power.
(D) $\frac{V^2}{R}$: Correct. This matches our derived formula.

Step 4: Final Answer:
The correct expression for the power of an electric circuit among the given options is $\frac{V^2}{R}$.
Therefore, option (D) is the correct answer.

> **Quick Tip**
>
> Memorize the three common forms of the power formula: $P = VI$, $P = I^2R$, and $P = V^2/R$. Knowing all three allows you to quickly solve problems regardless of which two of the three variables (V, I, R) are given.

---

16. Wheatstone bridge is used to measure

(A) current
(B) electro-motive force
(C) charge
(D) resistance

Correct Answer: (D) resistance

Solution:

Step 1: Understanding the Concept:
A Wheatstone bridge is a specific type of electrical circuit used for measurement purposes. It consists of four resistive arms arranged in a diamond-like configuration, a voltage source, and a null detector (usually a galvanometer).

Step 2: Detailed Explanation:
The principle of the Wheatstone bridge is based on the concept of a balanced bridge. When the bridge is balanced, the potential difference between the two central points of the bridge is zero, and no current flows through the galvanometer.
The condition for a balanced bridge is:

$$\frac{R_1}{R_2} = \frac{R_3}{R_x}$$

where R_1, R_2, R_3 are known resistances and R_x is the unknown resistance.
By adjusting one of the known resistances (usually a variable resistor) until the galvanometer shows zero deflection, the bridge becomes balanced. At this point, the value of the unknown

resistance can be calculated accurately using the formula:

$$R_x = R_3 \times \frac{R_2}{R_1}$$

This method allows for very precise measurement of resistance.

Step 3: Final Answer:
The primary application of a Wheatstone bridge is the accurate determination of an unknown electrical resistance.
Therefore, option (D) is the correct answer.

Quick Tip

Associate keywords with instruments. For Wheatstone Bridge, the keyword is "unknown resistance." For a potentiometer, it's "EMF" or "internal resistance." For an ammeter, it's "current." This mental mapping is very helpful for quick recall during exams.

---

17. The algebraic sum of all currents meeting at a point of any electric circuit is

(A) zero
(B) infinite
(C) positive
(D) negative

Correct Answer: (A) zero

Solution:

Step 1: Understanding the Concept:
This question describes a fundamental law of circuit analysis known as Kirchhoff's Current Law (KCL), or Kirchhoff's Junction Rule.
A junction (or node) is a point in a circuit where three or more conductors meet.

Step 2: Key Formula or Approach:
Kirchhoff's Current Law states that at any junction in an electrical circuit, the sum of currents flowing into that junction is equal to the sum of currents flowing out of that junction.
This law is a direct consequence of the principle of conservation of electric charge. Charge cannot accumulate at a junction, so the rate at which charge enters a junction must equal the rate at which it leaves.
Mathematically, this is expressed as:

$$\sum I_{in} = \sum I_{out}$$

Rearranging this equation, we can state that the algebraic sum of all currents entering and exiting a junction is zero. By convention, currents entering are taken as positive and currents leaving are taken as negative.

$$\sum_{k=1}^{n} I_k = 0$$

Step 3: Final Answer:
According to Kirchhoff's Current Law, the algebraic sum of all currents meeting at a point (junction) in an electric circuit is always zero.
Therefore, option (A) is the correct answer.

> Quick Tip
>
> Remember Kirchhoff's two laws:
>
> - **Current Law (Junction Rule):** Sum of currents at a junction is zero (Conservation of Charge).
> - **Voltage Law (Loop Rule):** Sum of potential differences around a closed loop is zero (Conservation of Energy).

---

18. A tangent galvanometer is maximum sensitive when its deflection is

(A) 0
(B) $\pi/2$
(C) $\pi/3$
(D) $\pi/4$

Correct Answer: (D) $\pi/4$

Solution:

Step 1: Understanding the Concept:
A tangent galvanometer is an early measuring instrument used to measure electric current. The working principle is based on the tangent law of magnetism. The current (I) is proportional to the tangent of the deflection angle (θ) of the compass needle.
The sensitivity is often considered in terms of the precision of the measurement, meaning the condition under which a small error in reading the deflection angle leads to the smallest possible error in the calculated current.

Step 2: Key Formula or Approach:
The formula for the current in a tangent galvanometer is:

$$I = K \tan(\theta)$$

where K is the reduction factor of the galvanometer.
To find the condition for maximum sensitivity (i.e., minimum relative error), we analyze the

relative error in current, $\frac{dI}{I}$, with respect to an error in angle, $d\theta$.
Differentiating the equation with respect to θ:

$$dI = K\sec^2(\theta)d\theta$$

Now, we find the relative error:

$$\frac{dI}{I} = \frac{K\sec^2(\theta)d\theta}{K\tan(\theta)} = \frac{\sec^2(\theta)}{\tan(\theta)}d\theta$$

$$\frac{dI}{I} = \frac{1/\cos^2(\theta)}{\sin(\theta)/\cos(\theta)}d\theta = \frac{1}{\sin(\theta)\cos(\theta)}d\theta$$

Using the trigonometric identity $\sin(2\theta) = 2\sin(\theta)\cos(\theta)$, we get:

$$\frac{dI}{I} = \frac{2}{\sin(2\theta)}d\theta$$

Step 3: Detailed Explanation:
For the measurement to be most accurate or "sensitive" in this context, the relative error $\frac{dI}{I}$ for a given small error $d\theta$ should be minimum.
The expression $\frac{2}{\sin(2\theta)}d\theta$ will be minimum when the denominator, $\sin(2\theta)$, is maximum.
The maximum value of $\sin(2\theta)$ is 1.
This occurs when $2\theta = 90°$ or $\frac{\pi}{2}$ radians.
Therefore, $\theta = 45°$ or $\frac{\pi}{4}$ radians.

Step 4: Final Answer:
The tangent galvanometer is most sensitive (provides the most accurate reading) when the deflection is 45°, or $\pi/4$ radians.
Therefore, option (D) is the correct answer.

Quick Tip

For a tangent galvanometer, the condition for maximum sensitivity (most accurate measurement) is a standard result. It's highly recommended to memorize that the optimal deflection angle is 45° or $\pi/4$.

---

19. The relation between the drift velocity (V_d) and applied electric field (E) of a conductor is

(A) $V_d \propto \sqrt{E}$
(B) $V_d \propto E$
(C) $V_d \propto E^2$
(D) $V_d \propto E^{-2}$

Correct Answer: (B) $V_d \propto E$

Solution:

Step 1: Understanding the Concept:
Drift velocity (V_d) is the average velocity attained by charged particles (like electrons) in a material due to an electric field. In a conductor, free electrons move randomly. When an electric field (E) is applied, they experience a force that superimposes a small, directional "drift" on their random motion.

Step 2: Key Formula or Approach:
The force experienced by an electron of charge e in an electric field E is given by:

$$F = eE$$

This force causes an acceleration (a) of the electron, given by Newton's second law:

$$a = \frac{F}{m} = \frac{eE}{m}$$

where m is the mass of the electron.
Between collisions with the ions of the conductor lattice, the electron accelerates. The drift velocity is the average velocity gained between collisions. It is given by the product of acceleration and the average time between collisions, known as the relaxation time (τ).

$$V_d = a\tau$$

Step 3: Detailed Explanation:
Substituting the expression for acceleration into the drift velocity equation:

$$V_d = \left(\frac{eE}{m}\right)\tau$$

For a given conductor at a constant temperature, the elementary charge (e), the mass of the electron (m), and the relaxation time (τ) are all constants.
Therefore, we can write the relationship as:

$$V_d = (\text{constant}) \times E$$

This shows that the drift velocity is directly proportional to the applied electric field.

$$V_d \propto E$$

Step 4: Final Answer:
The drift velocity of electrons in a conductor is directly proportional to the strength of the applied electric field.
Therefore, option (B) is the correct answer.

Quick Tip

This direct proportionality, $V_d \propto E$, is the microscopic basis of Ohm's law. Since current density $J = neV_d$, if $V_d \propto E$, then $J \propto E$, which is a form of Ohm's law ($J = \sigma E$).

20. The dielectric constant of water is

(A) $V_d \propto \sqrt{E}$
(B) $V_d \propto E$
(C) $V_d \propto E^2$
(D) $V_d \propto E^{-2}$

Correct Answer: None of the options are correct.

Solution:

Step 1: Understanding the Concept:
The question asks for the dielectric constant of water. The dielectric constant (κ or ϵ_r) of a material is a dimensionless quantity that indicates the extent to which it can store electrical energy in an electric field. It is the ratio of the permittivity of the material to the permittivity of free space.
This is a fact-based question that requires knowledge of a specific physical constant.

Step 2: Detailed Explanation:
The dielectric constant of pure water at room temperature (around 20-25 °C) is approximately **80**.
For example, at 20 °C, the dielectric constant is about 80.1.
This is a very high value compared to many other substances, which is due to the polar nature of water molecules.

Step 3: Analyzing the Options:
The options provided are:
(A) $V_d \propto \sqrt{E}$
(B) $V_d \propto E$
(C) $V_d \propto E^2$
(D) $V_d \propto E^{-2}$
These options are not numerical values, but rather relationships between drift velocity (V_d) and electric field (E). They are identical to the options for the previous question and are completely unrelated to the question being asked.

Step 4: Final Answer:
There appears to be a significant error in the question paper, as the options provided do not correspond to the question asked. The question asks for a numerical value (the dielectric constant of water), while the options describe a physical relationship.
The correct value for the dielectric constant of water is approximately 80. None of the given options are correct.

Quick Tip

When encountering a flawed question in an exam, it is important to recognize the error. The question asks for a specific constant value, while the options are mathematical relations. In a real exam, such questions are often identified and either removed from scoring or credit is given to all students. It's crucial to know key physical constants like the dielectric constant of water (≈ 80).

---

21. The electric capacity of earth of radius R is

(A) $4\pi\epsilon_0 R$
(B) $\frac{R}{4\pi\epsilon_0}$
(C) $4\pi\epsilon_0 R^2$
(D) $\frac{4\pi\epsilon_0}{R}$

Correct Answer: (A) $4\pi\epsilon_0 R$

Solution:

Step 1: Understanding the Concept:
The electric capacity, or capacitance, of a conductor is its ability to store electric charge. For an isolated spherical conductor, the capacitance depends on its radius and the permittivity of the surrounding medium. The Earth can be approximated as a very large isolated spherical conductor.

Step 2: Key Formula or Approach:
The electric potential (V) at the surface of a spherical conductor with charge Q and radius R is given by:

$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{R}$$

The capacitance (C) is defined as the ratio of the charge on the conductor to its potential:

$$C = \frac{Q}{V}$$

We can substitute the expression for V into the capacitance formula to find the capacitance of the sphere.

Step 3: Detailed Explanation:
Starting with the definition of capacitance:

$$C = \frac{Q}{V}$$

Substitute the potential of a sphere:

$$C = \frac{Q}{\left(\frac{1}{4\pi\epsilon_0}\frac{Q}{R}\right)}$$

The term Q cancels out:

$$C = \frac{1}{\left(\frac{1}{4\pi\epsilon_0 R}\right)} = 4\pi\epsilon_0 R$$

Step 4: Final Answer:
The electric capacity of the Earth, modeled as an isolated sphere of radius R, is given by the formula $C = 4\pi\epsilon_0 R$.
Therefore, option (A) is the correct answer.

> **Quick Tip**
>
> This is a standard formula that is worth memorizing. The capacitance of an isolated sphere is directly proportional to its radius. Since the Earth has a very large radius (approx. 6400 km), its capacitance is very large (approx. 711 μF).

---

22. S.I. unit of electric dipole moment is

(A) cm
(B) cm^2
(C) cm^{-1}
(D) cm^{-2}

Correct Answer: None of the options are correct.

Solution:

Step 1: Understanding the Concept:
The electric dipole moment ($\vec{p}$) is a measure of the separation of positive and negative electric charges within a system; that is, a measure of the system's overall polarity.

Step 2: Key Formula or Approach:
The electric dipole moment is defined as the product of the magnitude of one of the charges (q) and the distance of separation (d) between the charges.

$$p = q \times d$$

To find the S.I. unit, we need to use the S.I. units for charge and distance.

Step 3: Detailed Explanation:
The S.I. unit of charge (q) is the **Coulomb (C)**.

The S.I. unit of distance (d) is the **metre (m)**.
Therefore, the S.I. unit of electric dipole moment is **Coulomb-metre (C.m)**.

Step 4: Final Answer:
The options provided seem to use "cm" to mean "centimetre", which is a unit of length, not electric dipole moment. There is a high probability of a typo in the question, where "cm" was intended to be "C.m" (Coulomb-metre). However, even with that assumption, none of the options are simply "C.m". The options are units of length, area, inverse length, and inverse area, respectively. None of these correspond to the S.I. unit of electric dipole moment, which is Coulomb-metre.

Quick Tip

Always derive units from the fundamental definition of a quantity. For dipole moment, remember p = charge × distance, which directly leads to the S.I. unit of Coulomb-metre (C.m). Recognize that options in an exam can sometimes be incorrect due to typos.

---

23. If a charge is moved from low potential region to high potential region, then electric potential energy

(A) decreases
(B) increases
(C) remains the same
(D) either increases or decreases

Correct Answer: (B) increases

Solution:

Step 1: Understanding the Concept:
Electric potential energy (U) is the energy a charge has due to its position in an electric field. The change in potential energy (ΔU) when a charge q is moved through a potential difference ΔV is given by $\Delta U = q\Delta V$.

Step 2: Key Formula or Approach:
The change in electric potential energy is given by:

$$\Delta U = U_{final} - U_{initial} = q(V_{final} - V_{initial})$$

We are given that the charge moves from a low potential region ($V_{initial}$) to a high potential region (V_{final}), which means $V_{final} > V_{initial}$, so the potential difference $\Delta V = V_{final} - V_{initial}$ is positive.

Step 3: Detailed Explanation:
The question refers to "a charge" without specifying its sign. In physics, when the sign is not

specified, it is conventional to assume a positive test charge ($q > 0$).
Case 1: Positive charge ($q > 0$)

$$\Delta U = (+q) \times (\text{positive } \Delta V) > 0$$

A positive change in potential energy means that the potential energy increases. This is because external work must be done against the electric field to move the positive charge to a region of higher potential.
Case 2: Negative charge ($q < 0$)

$$\Delta U = (-q) \times (\text{positive } \Delta V) < 0$$

A negative change in potential energy means that the potential energy decreases.
Since option (D) "either increases or decreases" is available, it might seem correct. However, standard convention in such questions is to assume a positive charge unless stated otherwise. Based on this convention, the energy increases.

Step 4: Final Answer:
Assuming the charge being moved is positive (standard convention), moving it from a low potential region to a high potential region increases its electric potential energy.
Therefore, option (B) is the most appropriate answer.

> **Quick Tip**
>
> Use the gravitational analogy: moving a positive mass from a low height (low gravitational potential) to a high height (high gravitational potential) requires work and increases its potential energy. Similarly, moving a positive charge from low electric potential to high electric potential increases its potential energy.

---

24. If +q charge is placed inside any spherical surface then total flux coming out from whole surface will be

(A) $q \times \epsilon_0$
(B) $\frac{q}{\epsilon_0}$
(C) $\frac{\epsilon_0}{q}$
(D) $\frac{q^2}{\epsilon_0}$

Correct Answer: (B) $\frac{q}{\epsilon_0}$

Solution:

Step 1: Understanding the Concept:
This question is a direct application of Gauss's Law for electrostatics. Gauss's Law relates the total electric flux (Φ_E) through a closed surface to the net electric charge enclosed by that

surface.

Step 2: Key Formula or Approach:
Gauss's Law is mathematically stated as:

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{enclosed}}{\epsilon_0}$$

where:
Φ_E is the total electric flux.
$q_{enclosed}$ is the net charge inside the closed surface.
ϵ_0 is the permittivity of free space.

Step 3: Detailed Explanation:
In this problem, a charge of $+q$ is placed inside a spherical surface. The spherical surface is our closed "Gaussian" surface.
According to Gauss's Law, the total flux coming out from this surface depends only on the charge enclosed within it.
Here, $q_{enclosed} = +q$.
Substituting this into Gauss's Law formula:

$$\Phi_E = \frac{q}{\epsilon_0}$$

The shape of the surface (spherical) or the exact location of the charge inside the surface does not affect the total flux.

Step 4: Final Answer:
The total electric flux coming out from the whole surface is $\frac{q}{\epsilon_0}$.
Therefore, option (B) is the correct answer.

> Quick Tip
>
> Remember that according to Gauss's Law, the total electric flux through a closed surface is independent of the shape or size of the surface and the position of the charge(s) inside it. It only depends on the total charge enclosed.

---

25. At constant potential difference, if the resistance of any electric circuit is halved, then the value of heat produced will be

(A) half
(B) double
(C) four times
(D) same

Correct Answer: (B) double

Solution:

Step 1: Understanding the Concept:
The heat produced in a resistor is described by Joule's law of heating. The rate of heat production is the electric power dissipated. The total heat produced depends on this power and the time duration.

Step 2: Key Formula or Approach:
The electric power (P) dissipated in a resistor can be expressed in three ways: $P = VI$, $P = I^2R$, and $P = \frac{V^2}{R}$.
Since the potential difference (V) is constant, the most convenient formula to use is:

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

The total heat produced (H) in a time t is $H = P \times t$.

$$H = \frac{V^2}{R}t$$

Step 3: Detailed Explanation:
Let the initial resistance be R_1 and the initial heat produced be H_1.

$$H_1 = \frac{V^2}{R_1}t$$

The resistance is then halved, so the new resistance is $R_2 = \frac{R_1}{2}$.
Let the new heat produced be H_2. Since V and t are constant:

$$H_2 = \frac{V^2}{R_2}t = \frac{V^2}{(R_1/2)}t$$

$$H_2 = 2\left(\frac{V^2}{R_1}t\right)$$

Comparing H_2 with H_1, we see that:

$$H_2 = 2H_1$$

So, the heat produced will be double.

Step 4: Final Answer:
Since heat produced is inversely proportional to resistance at constant voltage ($H \propto 1/R$), halving the resistance will double the heat produced.
Therefore, option (B) is the correct answer.

Quick Tip

When solving problems about changes in power or heat, choose the appropriate power formula based on what is held constant.

- If Voltage (V) is constant, use $P = V^2/R$.
- If Current (I) is constant, use $P = I^2R$.

This choice simplifies the calculation significantly.

---

26. The wavefront due to a point source at a finite distance from the source is

(A) cylindrical
(B) spherical
(C) circular
(D) plane

Correct Answer: (B) spherical

Solution:

Step 1: Understanding the Concept:
A wavefront is defined as the locus of all points in a medium that are in the same phase of vibration. The shape of the wavefront depends on the shape of the source of the disturbance.

Step 2: Detailed Explanation:
Consider a point source of light in an isotropic medium (a medium where properties are the same in all directions). The light waves travel outwards from the source with the same speed in all directions.
After a certain time t, the waves will have traveled a distance $r = vt$, where v is the speed of light in the medium.
All the points at this distance r from the point source will be in the same phase. The locus of all points at a constant distance from a fixed point in three-dimensional space is a sphere.
Therefore, the wavefront originating from a point source at a finite distance is spherical.

Step 3: Analyzing other options:
(A) Cylindrical wavefronts are produced by a linear source (like a slit).
(C) Circular wavefronts would be the case in a two-dimensional medium, but light propagates in three dimensions.
(D) Plane wavefronts are produced when the source is at an infinite distance (e.g., light from a distant star). A spherical wavefront appears as a plane wavefront over a small area when observed far from the source.

Step 4: Final Answer:
For a point source at a finite distance, the locus of points in the same phase forms a sphere.

Therefore, option (B) is the correct answer.

Quick Tip

Memorize the relationship between source type and wavefront shape:

- **Point source → Spherical wavefront**
- **Line source → Cylindrical wavefront**
- **Source at infinity → Plane wavefront**

---

27. The angle of minimum deviation of a thin prism of refractive index μ and angle of prism A is

(A) $(1-\mu)A$
(B) $(\mu-1)A$
(C) $(\mu+1)A$
(D) $(\mu+1)A^2$

Correct Answer: (B) $(\mu-1)A$

Solution:

Step 1: Understanding the Concept:
When a ray of light passes through a prism, it deviates from its original path. The angle of deviation (δ) depends on the angle of incidence. The minimum deviation (δ_m) occurs when the angle of incidence and emergence are equal. For a "thin" prism (where the prism angle A is very small, typically $< 10°$), the deviation is small and nearly constant for a range of small incidence angles.

Step 2: Key Formula or Approach:
The general prism formula relates the refractive index μ, the prism angle A, and the angle of minimum deviation δ_m:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

For a thin prism, the angles A and δ_m are very small. We can use the small-angle approximation: $\sin\theta \approx \theta$ (where θ is in radians).

Step 3: Detailed Explanation:
Applying the small-angle approximation to the prism formula:

$$\mu \approx \frac{\left(\frac{A+\delta_m}{2}\right)}{\left(\frac{A}{2}\right)}$$

$$\mu \approx \frac{A + \delta_m}{A}$$

Now, we can solve for δ_m:

$$\mu A \approx A + \delta_m$$

$$\delta_m \approx \mu A - A$$

$$\delta_m \approx (\mu - 1)A$$

Since the deviation for a thin prism is almost independent of the angle of incidence, this formula gives the deviation for any small angle of incidence, including the condition of minimum deviation.

Step 4: Final Answer:
The angle of minimum deviation for a thin prism is given by the expression $(\mu - 1)A$. Therefore, option (B) is the correct answer.

Quick Tip

This is a very important formula for thin prisms and is frequently asked in exams. Memorize it directly: $\delta = (\mu - 1)A$. Note that deviation is positive, and for materials like glass, $\mu > 1$, so the term $(\mu - 1)$ will be positive.

---

28. The Boolean expression for NAND gate is

(A) $Y = A + B$
(B) $Y = \overline{A.B}$
(C) $Y = \overline{A + B}$
(D) $Y = A.B$
Note: The options in the image are slightly different from the OCR. (B) is Y = A.B, (C) is Y = $\overline{A + B}$ and (D) is Y = $\overline{A.B}$. I will solve based on the image.

Correct Answer: (D) $Y = \overline{A.B}$

Solution:

Step 1: Understanding the Concept:
A logic gate is a basic building block of a digital circuit. The NAND gate is a universal gate, meaning any other logic function can be implemented using only NAND gates. The name "NAND" is a combination of "NOT" and "AND".

Step 2: Detailed Explanation:
The operation of a NAND gate is equivalent to performing an AND operation on the inputs and then inverting the result with a NOT operation.
1. **AND operation:** The Boolean expression for an AND gate with inputs A and B is

$Y_{AND} = A \cdot B$. The output is 1 only if both A and B are 1.
2. **NOT operation (Inversion):** The NOT operation inverts the input. In Boolean algebra, inversion is represented by an overbar (vinculum).
Combining these, the output of the NAND gate is the inversion of the AND operation:

$$Y_{NAND} = \text{NOT}(A \text{ AND } B) = \overline{A \cdot B}$$

Step 3: Analyzing the Options (based on the image):
(A) $Y = A + B$: This is the expression for an OR gate.
(B) $Y = A \cdot B$: This is the expression for an AND gate.
(C) $Y = \overline{A + B}$: This is the expression for a NOR gate.
(D) $Y = \overline{A \cdot B}$: This is the correct expression for a NAND gate.

Step 4: Final Answer:
The Boolean expression that represents the logic of a NAND gate is $Y = \overline{A \cdot B}$.
Therefore, option (D) is the correct answer.

Quick Tip

Break down the names of the gates to remember their functions:

- **NAND** = NOT + AND $\rightarrow \overline{A \cdot B}$
- **NOR** = NOT + OR $\rightarrow \overline{A + B}$
- **XOR** = Exclusive OR $\rightarrow A \oplus B$

---

29. Light owes its colour due to its

(A) amplitude
(B) velocity
(C) frequency
(D) phase

Correct Answer: (C) frequency

Solution:

Step 1: Understanding the Concept:
The color of visible light is the physiological perception of electromagnetic radiation within a certain range of wavelengths. Different colors correspond to different energies of photons.

Step 2: Detailed Explanation:
The energy of a photon of light is given by the Planck-Einstein relation, $E = hf$, where h is Planck's constant and f is the frequency of the light. Since the color we perceive is directly related to the energy of the light, it is fundamentally determined by the frequency.

When light travels from one medium to another (e.g., from air to water), its speed (v) and wavelength (λ) change according to $v = f\lambda$, but its **frequency (f) remains constant**. Because the color of a beam of light does not change when it enters a different medium, we can conclude that color is a property associated with frequency, which is an intrinsic property of the source and does not change with the medium.

Step 3: Analyzing other options:
(A) **Amplitude:** The amplitude of a light wave is related to its intensity or brightness, not its color.
(B) **Velocity:** The velocity of light changes as it moves from one medium to another, but the color does not change.
(D) **Phase:** The phase relates to the position of a point in time on a waveform cycle and is not directly related to color perception.

Step 4: Final Answer:
The color of light is fundamentally determined by its frequency.
Therefore, option (C) is the correct answer.

> **Quick Tip**
>
> A key fact to remember is that frequency is a characteristic of the source of the wave and does not change when the wave passes from one medium to another. Since color doesn't change, it must be linked to frequency.

---

30. Equivalent focal length of two lenses in contact having powers -15 D and +5 D will be

(A) -10 cm
(B) -20 cm
(C) +20 cm
(D) +10 cm

Correct Answer: (A) -10 cm

Solution:

Step 1: Understanding the Concept:
When two or more thin lenses are placed in contact, the combination acts as a single lens. The power of this equivalent lens is the algebraic sum of the powers of the individual lenses.

Step 2: Key Formula or Approach:
1. The equivalent power (P_{eq}) of thin lenses in contact is given by:

$$P_{eq} = P_1 + P_2$$

2. The relationship between focal length (f) in meters and power (P) in diopters (D) is:

$$f(\text{in m}) = \frac{1}{P(\text{in D})}$$

Step 3: Detailed Explanation:
First, calculate the equivalent power of the combination.
Given $P_1 = -15$ D and $P_2 = +5$ D.

$$P_{eq} = P_1 + P_2 = -15 \text{ D} + 5 \text{ D} = -10 \text{ D}$$

Next, calculate the equivalent focal length from the equivalent power.

$$f_{eq}(\text{in m}) = \frac{1}{P_{eq}} = \frac{1}{-10} = -0.1 \text{ m}$$

The options are in centimeters, so we need to convert the focal length from meters to centimeters.

$$f_{eq}(\text{in cm}) = -0.1 \text{ m} \times 100\frac{\text{cm}}{\text{m}} = -10 \text{ cm}$$

Step 4: Final Answer:
The equivalent focal length of the combination is -10 cm.
Therefore, option (A) is the correct answer.

Quick Tip

Always be careful with units. The formula $f = 1/P$ gives the focal length in meters when the power is in diopters. Remember to convert to centimeters if the options require it (1 m = 100 cm).

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31. The image formed by objective lens of a compound microscope is

(A) virtual and diminished
(B) real and diminished
(C) real and large
(D) virtual and large

Correct Answer: (C) real and large

Solution:

Step 1: Understanding the Concept:
A compound microscope uses two convex lenses to produce a highly magnified image of a small object. The two lenses are the objective lens (closer to the object) and the eyepiece (closer to the eye).

Step 2: Detailed Explanation:
Objective Lens:
The object to be viewed is placed very close to the objective lens, but just outside its principal focus (f_o).
The objective lens has a short focal length. According to the lens formula, when an object is placed between f_o and $2f_o$ for a convex lens, it forms an image that is:

- **Real:** The rays of light actually converge to form the image. It can be projected onto a screen.
- **Inverted:** The image is upside down relative to the object.
- **Large (Magnified):** The image is larger than the object.

This real, inverted, and magnified image (called the intermediate image) is then formed inside the focal point of the eyepiece.

Eyepiece Lens:
The eyepiece acts as a simple magnifier for this intermediate image. Since the intermediate image is within the focal length of the eyepiece, the eyepiece forms a final image that is virtual, erect (with respect to the intermediate image), and highly magnified. The final image is inverted with respect to the original object.

Step 3: Final Answer:
The question specifically asks about the image formed by the **objective lens**. As explained above, this intermediate image is real and magnified (large).
Therefore, option (C) is the correct answer.

Quick Tip

To avoid confusion, remember the roles of the two lenses in a compound microscope:

- **Objective Lens:** Creates the first stage of magnification, forming a **real and large** intermediate image.
- **Eyepiece Lens:** Acts as a simple magnifier on this intermediate image, forming the final **virtual and large** image.

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32. A convex lens is dipped in a liquid, whose refractive index is equal to refractive index of the material of lens; then its focal length will

(A) become zero
(B) become infinite
(C) decrease
(D) increase

Correct Answer: (B) become infinite

Solution:

Step 1: Understanding the Concept:
The focal length of a lens depends not only on the curvature of its surfaces and the refractive index of its material but also on the refractive index of the medium in which it is placed. This relationship is described by the Lens Maker's Formula.

Step 2: Key Formula or Approach:
The Lens Maker's Formula is given by:

$$\frac{1}{f} = \left(\frac{\mu_{lens}}{\mu_{medium}} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

where:
f is the focal length of the lens.
μ_{lens} is the refractive index of the lens material.
μ_{medium} is the refractive index of the surrounding medium (the liquid).
R_1 and R_2 are the radii of curvature of the lens surfaces.

Step 3: Detailed Explanation:
The problem states that the refractive index of the liquid is equal to the refractive index of the material of the lens.
So, $\mu_{medium} = \mu_{lens}$.
Let's substitute this condition into the Lens Maker's Formula:

$$\frac{1}{f} = \left(\frac{\mu_{lens}}{\mu_{lens}} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = 0 \times \left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = 0$$

If $\frac{1}{f} = 0$, then the focal length f must be infinite ($f \to \infty$).
A lens with an infinite focal length does not converge or diverge light; it acts like a flat, transparent glass plate. Light rays pass through it undeviated.

Step 4: Final Answer:
When the refractive index of the lens matches that of the surrounding medium, its focal length becomes infinite.
Therefore, option (B) is the correct answer.

Quick Tip

Remember the three cases for a convex lens dipped in a liquid:

- If $\mu_{liquid} < \mu_{lens}$, it remains a convex lens (focal length increases).
- If $\mu_{liquid} = \mu_{lens}$, it acts like a plane glass plate (focal length becomes infinite).
- If $\mu_{liquid} > \mu_{lens}$, it behaves like a concave lens (focal length becomes negative).

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33. In earth's magnetic field B_H, if the frequency of oscillation of a magnetic needle is n, then

(A) $n \propto B_H$
(B) $n^2 \propto B_H$
(C) $n \propto B_H^2$
(D) $n^2 \propto \frac{1}{B_H}$

Correct Answer: (B) $n^2 \propto B_H$

Solution:

Step 1: Understanding the Concept:
A magnetic needle (or compass) is a magnetic dipole. When placed in a uniform magnetic field and slightly displaced, it experiences a restoring torque and undergoes simple harmonic motion (SHM). The frequency of this oscillation depends on the properties of the needle (its magnetic moment and moment of inertia) and the strength of the external magnetic field.

Step 2: Key Formula or Approach:
The time period (T) of oscillation of a magnetic dipole in a uniform magnetic field B_H is given by:

$$T = 2\pi\sqrt{\frac{I}{MB_H}}$$

where:
I is the moment of inertia of the magnetic needle.
M is the magnetic moment of the needle.
B_H is the horizontal component of the Earth's magnetic field.
The frequency (n) is the reciprocal of the time period ($n = 1/T$).

Step 3: Detailed Explanation:
Let's find the expression for frequency (n):

$$n = \frac{1}{T} = \frac{1}{2\pi\sqrt{\frac{I}{MB_H}}}$$

$$n = \frac{1}{2\pi}\sqrt{\frac{MB_H}{I}}$$

For a specific magnetic needle, its moment of inertia (I) and magnetic moment (M) are constant. The term $\frac{1}{2\pi}\sqrt{\frac{M}{I}}$ is a constant.
So, the relationship between frequency and the magnetic field is:

$$n \propto \sqrt{B_H}$$

The options involve n^2, so let's square both sides of this proportionality:

$$n^2 \propto (\sqrt{B_H})^2$$
$$n^2 \propto B_H$$

Step 4: Final Answer:
The square of the frequency of oscillation of the magnetic needle is directly proportional to the strength of the magnetic field.
Therefore, option (B) is the correct answer.

Quick Tip

This is a standard result in magnetism. It is helpful to remember the direct proportionality: $T \propto 1/\sqrt{B_H}$ and $n \propto \sqrt{B_H}$. From this, you can quickly derive that $n^2 \propto B_H$. This relationship is the basis for the vibration magnetometer.