Rajasthan Board Class 12 Physics Question Paper with Solutions(Memory Based)

Time Allowed :3 Hours	Maximum Marks :70	Total questions :5

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Each activity has to be answered in full sentence/s. One word answers will not be given complete credit. Just the correct activity number written in case of options will not be given credit.
2. Web diagrams, flow charts, tables, etc. are to be presented exactly as they are with answers.
3. In point 2 above, just words without the presentation of the activity format, will not be given credit. Use of colour pencils/pens etc. is not allowed. (Only blue/black pens are allowed.)
4. Multiple answers to the same activity will be treated as wrong and will not be given any credit.
5. Maintain the sequence of the Sections/Question Nos./Activities throughout the activity sheet.

1. What is the SI unit of electric flux?

Correct Answer: Volt–meter (V·m)

Solution:

Concept: Electric flux (Φ_E) is defined as the surface integral of the electric field over a surface:

$$\Phi_E = \vec{E} \cdot \vec{A}$$

From Gauss's Law:

$$\Phi_E = \frac{Q}{\varepsilon_0}$$

Thus, the unit of electric flux can be determined from either definition.

Step 1: The SI unit of electric field E is:

$$\text{N/C} \quad \text{or} \quad \text{V/m}$$

Step 2: The SI unit of area A is:

$$\text{m}^2$$

Step 3: Therefore, electric flux unit:

$$(\text{V/m}) \times (\text{m}^2) = \text{V}\cdot\text{m}$$

Alternatively,

$$(\text{N/C}) \times (\text{m}^2) = \text{N}\cdot\text{m}^2/\text{C}$$

Both forms are equivalent SI units.

Quick Tip

Electric flux unit can be quickly remembered as:

$$\text{Electric field} \times \text{Area}$$

So just multiply the unit of E by m^2.

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2. Define the dielectric constant of a medium.

Correct Answer: The dielectric constant of a medium is the ratio of the permittivity of the medium to the permittivity of free space.

Solution:

Concept: The dielectric constant (also called relative permittivity) measures how much a medium reduces the electric field compared to vacuum. It indicates how well a material can store electric energy in an electric field.

Mathematically, it is defined as:

$$K = \frac{\varepsilon}{\varepsilon_0}$$

where: ε = permittivity of the medium ε_0 = permittivity of free space

Step 1: When a dielectric is placed in an electric field, it becomes polarized. This reduces the effective electric field inside the material.

Step 2: The extent of this reduction is measured by the dielectric constant K. A higher value of K means stronger polarization and greater ability to store electric energy.

Step 3: Thus, dielectric constant is a dimensionless quantity that compares electrical behavior of a medium with vacuum.

Quick Tip

Dielectric constant is also called **relative permittivity**.

$$K = \frac{\text{Permittivity of medium}}{\text{Permittivity of vacuum}}$$

It has **no unit**.

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3. Define Curie temperature in magnetism.

Correct Answer: Curie temperature is the temperature above which a ferromagnetic material loses its permanent magnetism and becomes paramagnetic.

Solution:

Concept: Ferromagnetic materials (like iron, cobalt, and nickel) exhibit strong spontaneous magnetization due to alignment of magnetic domains. However, temperature affects this alignment.

Step 1: At low temperatures, magnetic domains are aligned in the same direction, producing strong magnetization.

Step 2: As temperature increases, thermal agitation disturbs the alignment of magnetic domains.

Step 3: At a specific temperature called the **Curie temperature** (T_C), thermal energy becomes strong enough to destroy the ordered alignment.

Step 4: Above this temperature, the material loses ferromagnetism and behaves like a paramagnetic substance.

> Quick Tip
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> **Below Curie temperature:** Ferromagnetic behavior **Above Curie temperature:** Paramagnetic behavior Curie temperature is a characteristic property of each material.

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4. Using Gauss's law, obtain an expression for the electric field at a point due to a uniformly charged infinite plane sheet.

Correct Answer: The electric field due to an infinite plane sheet of charge is

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

where σ is surface charge density.

Solution:

Concept: Gauss's law states that the total electric flux through a closed surface is equal to the charge enclosed divided by permittivity of free space.

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0}$$

For an infinite plane sheet, the electric field is: - Perpendicular to the sheet - Same magnitude everywhere (symmetry)

Step 1: Choose a Gaussian surface Take a cylindrical Gaussian surface (pillbox) with: - One face above the sheet - One face below the sheet - Axis perpendicular to the sheet

Step 2: Electric flux through the surface Electric field is perpendicular to the plane and parallel to the curved surface. So flux through curved surface = 0.

Flux only passes through the two flat faces:

$$\Phi = EA + EA = 2EA$$

Step 3: Charge enclosed If surface charge density = σ, then charge enclosed:

$$Q_{\text{enc}} = \sigma A$$

Step 4: Apply Gauss's law

$$2EA = \frac{\sigma A}{\varepsilon_0}$$

Cancel A:

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

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

Step 5: Direction of electric field - Away from sheet if charge is positive - Towards sheet if charge is negative

Quick Tip

Electric field of an infinite plane sheet is **uniform** and does not depend on distance from the sheet.

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

This is a standard Gauss's law result.

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5. State Gauss's law. Determine the electric field intensity at a point due to an infinitely long uniformly charged straight wire.

Correct Answer: Gauss's law states that the total electric flux through a closed surface equals the charge enclosed divided by ε_0. The electric field at distance r from an infinite line charge is:

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

where λ is linear charge density.

Solution:

Concept: Gauss's law relates electric flux through a closed surface to the charge enclosed:

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0}$$

For highly symmetric charge distributions (spherical, cylindrical, planar), Gauss's law helps directly calculate electric field.

Step 1: Statement of Gauss's law The total electric flux through any closed surface is equal to $1/\varepsilon_0$ times the total charge enclosed inside the surface.

Step 2: Symmetry of an infinite line charge For an infinitely long straight wire: - Electric field is radial (perpendicular to wire) - Same magnitude at equal distance r - Cylindrical symmetry exists

Step 3: Choose Gaussian surface Take a cylindrical Gaussian surface: - Radius = r - Length = L - Wire along axis of cylinder

Step 4: Electric flux through surface Electric field is: - Perpendicular to curved surface - Parallel to flat ends

So flux through flat ends = 0. Flux only through curved surface:

$$\Phi = E \times (2\pi r L)$$

Step 5: Charge enclosed If linear charge density = λ, then:

$$Q_{\text{enc}} = \lambda L$$

Step 6: Apply Gauss's law

$$E(2\pi rL) = \frac{\lambda L}{\varepsilon_0}$$

Cancel L:

$$E(2\pi r) = \frac{\lambda}{\varepsilon_0}$$

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

Step 7: Nature of electric field - Decreases as $1/r$ - Radially outward for positive charge - Radially inward for negative charge

Quick Tip

Remember standard Gauss law results: Line charge: $E \propto \frac{1}{r}$ Plane sheet: Constant field Point charge: $E \propto \frac{1}{r^2}$

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6. State Huygens' Principle. Use it to prove the laws of reflection or laws of refraction at a plane surface.

Correct Answer: Huygens' principle states that every point on a wavefront acts as a source of secondary wavelets which spread in all directions with the speed of the wave. Using Huygens' construction, we obtain: - Law of reflection: $i = r$ or - Law of refraction: $n_1 \sin i = n_2 \sin r$

Solution:

Concept: Huygens' principle explains wave propagation using secondary wavelets. The new wavefront at any time is the envelope (tangent surface) of these secondary wavelets.

$$\text{New wavefront} = \text{Envelope of secondary wavelets}$$

This principle helps derive reflection and refraction laws geometrically.

Step 1: Statement of Huygens' Principle Every point on a wavefront behaves like a source of secondary spherical wavelets. The forward envelope of these wavelets gives the new wavefront.

Step 2: Reflection using Huygens' Principle Consider a plane wavefront incident on a plane mirror at an angle i.

- Let AB be the incident wavefront. - Point A touches the mirror first. - After time t, point B reaches the mirror.

During this time, a secondary wavelet from A spreads as a circle (in 2D).

Step 3: Construct reflected wavefront Draw a tangent from point B to the secondary wavelet from A. This tangent gives the reflected wavefront.

From geometry of construction:

$$\angle i = \angle r$$

Thus, angle of incidence equals angle of reflection.

(OR) Refraction using Huygens' Principle

Step 4: Refraction setup Let a wavefront travel from medium 1 to medium 2 with speeds v_1 and v_2.

- Point A enters second medium first - Point B still in first medium

Wavelets from A travel slower or faster depending on medium.

Step 5: Construct refracted wavefront After time t: - Distance traveled by A = $v_2 t$ - Distance traveled by B = $v_1 t$

Using right triangle geometry:

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

Using refractive index relation:

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

We get:

$$n_1 \sin i = n_2 \sin r$$

This is Snell's law of refraction.

Quick Tip

Huygens' principle explains wave behavior geometrically. Reflection: $i = r$ Refraction: $n_1 \sin i = n_2 \sin r$ It proves light behaves as a wave.
