

CBSE Class 12 Physics 2025 - 55/S/3 - Compartment

Question Paper

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 Hours

Maximum Marks: 70

General Instructions

- (i) This question paper contains **33 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C, D, E.
- (iii) Section A - Questions 1 to 16 carry 1 mark each.
- (iv) Section B - Questions 17 to 21 carry 2 marks each.
- (v) Section C - Questions 22 to 28 carry 3 marks each.
- (vi) Section D - Questions 29 to 30 carry 4 marks each.
- (vii) Section E - Questions 31 to 33 carry 5 marks each.
- (viii) There is no overall choice. Where an internal choice is provided, attempt only one of the alternatives.

You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8 \text{ m/s}$	Mass of electron (m_e) = $9.1 \times 10^{-31} \text{ kg}$
$h = 6.63 \times 10^{-34} \text{ Js}$	Mass of neutron = $1.675 \times 10^{-27} \text{ kg}$
$e = 1.6 \times 10^{-19} \text{ C}$	Mass of proton = $1.673 \times 10^{-27} \text{ kg}$
$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$	Avogadro's number = $6.023 \times 10^{23} \text{ per gm mole}$
$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$	Boltzmann constant = $1.38 \times 10^{-23} \text{ JK}^{-1}$
$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	

Section A

1. A point charge of 20 nC is fixed at the origin of x-y plane. The work done in taking a second point charge of -50 nC from point (4 cm, 0) to point (0, 5 cm) is:

- (A) $45 \mu\text{J}$ (B) $-45 \mu\text{J}$
(C) $90 \mu\text{J}$ (D) $-90 \mu\text{J}$

2. In Bohr model of the hydrogen atom, the kinetic energy of an electron in $n = 2$ orbit is:

- (A) 1.7 eV (B) 3.4 eV
(C) 6.8 eV (D) 10.2 eV

3. A galvanometer having a coil resistance of 48Ω shows full-scale deflection for a current of 2.0 A. It can be converted into an ammeter of range (0 – 10 A) by connecting:

- (A) in series a resistance of 8Ω (B) in parallel a resistance of 8Ω
(C) in parallel a resistance of 12Ω (D) in series a resistance of 12Ω

4. A charge Q is enclosed by a spherical Gaussian surface of radius R . If the radius is doubled, then the total electric flux through the surface:

- (A) becomes four times (B) remains the same
(C) becomes half (D) becomes twice

5. A rectangular loop of area vector $\vec{A} = [\hat{i} + \sqrt{3}\hat{j}] \times 10^{-2} \text{ m}^2$ is placed in a magnetic field $\vec{B} = [4.0t^2 + 2.0]\hat{i}$, where B is in tesla and t in seconds. At $t = 1.0$ s, the magnitude of induced emf in the loop is:

- (A) 80 mV (B) 0.11 V
(C) 0.22 V (D) 0.8 V

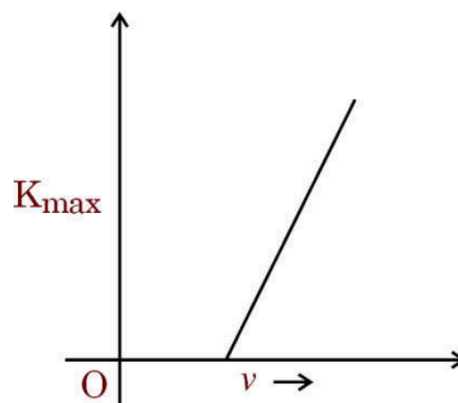
6. Which of the following electromagnetic waves are known as 'heat waves'?

- (A) UV rays (B) IR rays
(C) X-rays (D) Gamma rays

7. Which of the following assumptions has been used to obtain the relation $\frac{v_s}{v_p} = \frac{N_s}{N_p}$ for a transformer?

- (A) The resistance of the primary coil is large. (B) The same flux links both the primary and the secondary coils.
(C) The resistance of secondary coil is large. (D) The transformer is 100% efficient.

8. The figure shows the variation of maximum kinetic energy ($K_{\max}$) of emitted electrons as a function of the frequency ν of radiation incident on a photosensitive surface. The slope of the curve is:



- (A) h (B) $\frac{h}{\nu}$
(C) $\frac{h}{e}$ (D) he

9. The electric field due to a uniformly and negatively charged thin spherical shell at a point outside the shell at a distance r from its centre is:

- | | |
|---|--|
| (A) proportional to $\frac{1}{r}$
and is directed
outward | (B) proportional to $\frac{1}{r}$
and is directed
inward |
| (C) proportional to $\frac{1}{r^2}$
and is directed
outward | (D) proportional to $\frac{1}{r^2}$
and is directed
inward |

10. The potential energy of a pair of nucleons is minimum when they are separated by about:

- | | |
|-----------------------------|-----------------------------|
| (A) 0.8×10^{-15} m | (B) 0.8×10^{-10} m |
| (C) 2.0×10^{-13} m | (D) 2.0×10^{-14} m |

11. Two long, straight, parallel conductors carry the same current and attract each other with a force F per unit length. If the current is doubled in each conductor and their separation is made half, the force per unit length becomes:

- | | |
|-------------------|----------|
| (A) $\frac{F}{2}$ | (B) $2F$ |
| (C) $4F$ | (D) $8F$ |

12. Whenever a magnet is moved either towards or away from a conducting coil, an emf is induced whose magnitude is independent of the:

- | | |
|--|----------------------------|
| (A) number of turns in
the coil | (B) resistance of the coil |
| (C) speed with which
the magnet is
moved | (D) area of the coil |

Question numbers 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.

(A)

Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B)

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C)

Assertion (A) is true, but Reason (R) is false.

(D)

Both Assertion (A) and Reason (R) are false.

13. Assertion (A): In process of photoelectric emission using a monochromatic light, all emitted electrons do not have the same kinetic energy.

Reason (R): If radiation falling on a photosensitive surface consists of different wavelengths, the energy of emitted photoelectrons by absorbing photons of different wavelengths, shall be different.

14. Assertion (A): The electrical conductivity of a pure Ge crystal increases with increase in its temperature.

Reason (R): The number of electrons excited by thermal excitation from the valence band to the conduction band, in a semiconductor, increases with increase in temperature.

15. Assertion (A): Electrostatic force is a conservative force.

Reason (R): In an electrostatic field, the work done between two points per unit positive charge depends on the path followed.

16. Assertion (A): The image of an object placed between f and $2f$ from a convex lens can be seen on a screen. If the screen is removed, image is not formed.

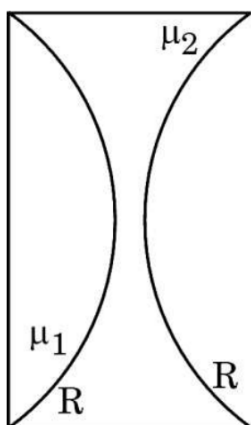
Reason (R): Rays from a given point on the object placed between f and $2f$, after passing through a convex lens, do not converge on a point in space.

Section B

17. An electron of mass m and charge e is accelerated from rest through a potential difference V . Prove that, after acceleration, the de Broglie wavelength associated with the electron is proportional to $\frac{1}{\sqrt{V}}$.

18. With the help of a circuit diagram, describe the method to obtain the p-n junction diode characteristic when it is forward biased. Draw the shape of the characteristic.

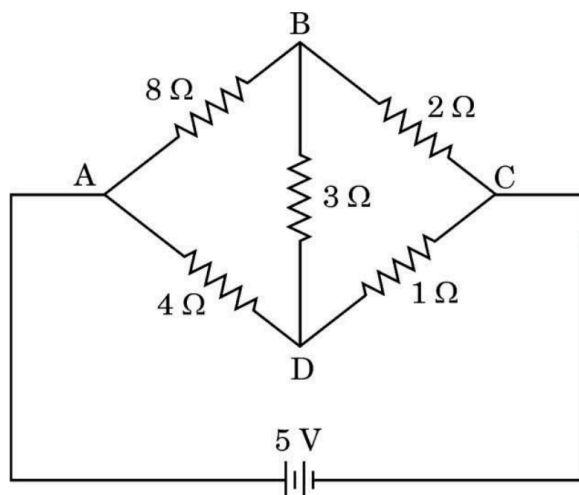
19. (a) A plano-convex lens of refractive index μ_1 is placed coaxially in contact with a biconcave lens of refractive index μ_2 , as shown in the figure. All curved faces are of radius of curvature R each. Obtain the expression for the focal length of the combined lens.



OR

(b) A convex lens is kept coaxially on the left side of a concave mirror at a distance of $5f$ from it where f is focal length of each of them. An object is kept at a distance of $2f$ on the left side of the convex lens. Draw the ray diagram showing the formation of image by this combination. Find the distance of the final image from the mirror.

20. The figure shows a network of resistors connected across a battery. Find the current supplied by the battery of emf 5 V and internal resistance $\frac{2}{3}\Omega$.



21. In a Young's double-slit experiment with light of wavelength 520 nm , the fringe width is 0.52 mm . What will be the fringe width if the entire apparatus is immersed in water (refractive index $\frac{4}{3}$)?

Section C

22. Define electric field. Write its SI unit. A point charge $q = 25 \mu\text{C}$ is located at the point (0, 0) in x-y plane. Find (i) the magnitude of electric field at point (3 cm, 4 cm), and (ii) the angle the field makes with the x-axis.

23. (a) A $20 \mu\text{F}$ capacitor is connected to a $220 \text{ V}, \frac{125}{\pi}$ Hz ac source.

(i) Find the capacitive reactance and the peak value of current in the circuit.

(ii) If the frequency of the ac source is doubled, by what factor will the capacitive reactance and the current be changed?

OR

(b) An electron (mass $9 \times 10^{-31} \text{ kg}$ and charge $1.6 \times 10^{-19} \text{ C}$) is moving in a circle with a speed of $3.2 \times 10^7 \text{ m/s}$ in a magnetic field of $4.5 \times 10^{-4} \text{ T}$ perpendicular to it. Calculate: (i) the radius of the circular path, (ii) its frequency of rotation, and (iii) its energy.

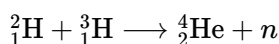
24. Define binding energy (BE) of a nucleus. An unstable nucleus has mass number $A = 240$ and $\frac{BE}{A} = 7.6 \text{ MeV}$. It splits in two fragments, each of $A = 120$ with $\frac{BE}{A} = 8.5 \text{ MeV}$. Calculate the energy released.

25. Define electric flux. Is it a scalar or a vector quantity?

A point charge q is kept at a distance of $\frac{d}{2}$ directly above the centre of a square of side d . Use Gauss' law to obtain the expression for the electric flux through this square.

Now if this point charge is moved to a point at a distance 'd' directly above the centre of the square and the side of the square is doubled, explain how the electric flux through the square will be affected.

26. What is thermonuclear fusion? Calculate the energy released in MeV in the fusion reaction given below:



Given: $m({}^2_1\text{H}) = 2.014102 \text{ u}$, $m({}^3_1\text{H}) = 3.016049 \text{ u}$, $m({}^4_2\text{He}) = 4.002603 \text{ u}$, $m_n = 1.008665 \text{ u}$, $1 \text{ u} = 930 \text{ MeV}/c^2$.

27. Two cells are connected in parallel by connecting their positive terminals together and connecting their negative terminals together. Derive expression for the equivalent emf and the equivalent internal resistance of the combination.

28. A rectangular loop ($1 \text{ cm} \times 5 \text{ cm}$) of wire carrying current of 0.4 A is placed in a magnetic field $\vec{B} = (0.03\hat{i} + 0.04\hat{k}) \text{ T}$ such that the outward unit vector normal to the plane of the loop is $(0.60\hat{i} - 0.80\hat{j})$. Calculate: (a) the magnetic moment $\vec{m}$ of the loop, and (b) the torque $\vec{\tau}$ acting on the loop.

Section D

Question numbers 29 and 30 are Case Study-based questions. Read the following paragraphs and answer the questions that follow.

29. According to the band theory of solids, a semiconductor has a valence band and a conduction band separated by a gap, known as energy band gap. Pure semiconductors are called intrinsic semiconductors. At room temperature, some electrons from the valence band can acquire enough energy to cross the band gap and enter the conduction band. The number of conduction electrons is equal to the number of holes in an intrinsic semiconductor. The number of charge carriers can be changed by doping of a suitable impurity in a pure semiconductor. Such semiconductors are known as extrinsic semiconductors. These are of two types (n-type and p-type).

A p-n junction is the basic building block of semiconductor devices. Two important processes occur during formation of a p-n junction: diffusion and drift. A 'depletion layer' is formed in a p-n junction. This is responsible for a junction potential barrier. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. A diode can be forward-biased or reverse-biased. The barrier height and the depletion layer width in a p-n junction changes depending on the nature of the biasing.

29(i). Which of the following statements is not true?

- | | |
|--|---|
| (A) The resistance of an intrinsic semiconductor decreases with the increase of temperature. | (B) Doping pure Si with trivalent impurities gives p-type semiconductors. |
| (C) The majority charge carriers in n-type semiconductors are holes. | (D) A p-n junction can act as a semiconductor diode. |

OR

29(i). In a unbiased p-n junction:

- | | |
|--|--|
| (A) the diffusion current is zero everywhere. | (B) the drift current is zero everywhere. |
| (C) the electric potential is zero everywhere. | (D) the drift current and the diffusion current cancel each other. |

29(ii). The impurity atoms with which pure Ge should be doped to convert it into an n-type semiconductor, is:

- | | |
|---------------|-----------------|
| (A) Boron | (B) Phosphorous |
| (C) Aluminium | (D) Indium |

29(iii). The energy band gap in Ge at 0 K is about:

- | | |
|-------------|------------|
| (A) 0.72 eV | (B) 1.1 eV |
| (C) 3.0 eV | (D) 5.4 eV |

29(iv). In a p-n junction diode under reverse bias, the barrier height:

- | | |
|---|---|
| (A) is reduced and the depletion layer width decreases. | (B) is reduced and the depletion layer width increases. |
| (C) increases and the depletion layer width also increases. | (D) increases and the depletion layer width decreases. |

30. A compound microscope is an optical instrument used for observing highly magnified images of tiny objects. It consists of two convex lenses. The lens near the object is called the objective and the lens near the eye is called the eyepiece. The magnifying power of a compound microscope is given by $m = m_o m_e$, where m_o is the magnification produced by objective lens and m_e is the magnification produced by eyepiece lens. The expression for m_e depends on whether the final image is formed at the near point or at infinity (normal adjustment).

30(i). A compound microscope consists of an objective lens of focal length $f_o = 2.0$ cm and an eyepiece of focal length $f_e = 6.25$ cm separated by a distance 15 cm. How far should an object be placed from the objective so that the final image is formed at infinity?

- (A) 3.45 cm (B) 5 cm
(C) 1.29 cm (D) 2.59 cm

OR

30(i). A person with normal near point 25 cm, using a compound microscope with an objective of focal length 0.8 cm and eyepiece of focal length 2.5 cm can bring an object placed at 0.9 cm from the objective in sharp focus. If the image formed by the objective is at a distance of 2.27 cm from the eyepiece, the separation between the two lenses is:

- (A) 7.47 cm (B) 8.47 cm
(C) 9.47 cm (D) 10.47 cm

30(ii). A compound microscope consists of an objective of focal length 2 cm and an eyepiece of focal length 10 cm. The eyepiece is kept 20 cm away from the objective. Find the magnifying power of the microscope if the final image is formed at infinity.

- (A) 7 (B) 10
(C) 14 (D) 16

30(iii). The intermediate image formed in a compound microscope is:

- (A) real, inverted and magnified (B) real, erect and magnified
(C) virtual, erect and magnified (D) virtual, inverted and magnified

30(iv). The focal lengths of the objective and the eyepiece of a compound microscope are f_o and f_e respectively. Which of the following statements is correct, in normal adjustment?

- (A) The object is at a distance less than f_o from the objective. (B) The object is at a distance more than f_o and less than $2f_o$ from the objective.
(C) The intermediate image is formed at a distance slightly more than f_e from the eyepiece. (D) The intermediate image is formed at $2f_e$ from the eyepiece.

Section E

31. (a) (i) A parallel plate capacitor A of capacitance C is charged by a battery to a potential 'V'. The battery is disconnected and an uncharged identical capacitor B is connected across it. Calculate for the capacitor A the new value of the: (I) charge (II) potential difference (III) energy stored. Justify your answers.

(ii) Draw the pattern of electric field lines due to:
(I) a positively charged conducting sphere, and
(II) an electric dipole.

OR

(b) (i) Write Coulomb's law of electrostatics in vector form. Apply it to determine the electric field at a point due to a system of point charges.

(ii) ABC is an equilateral triangle of side l . Two point charges $+2\mu\text{C}$ each, are located at points B and C. Find the sign and magnitude of the point charge q to be kept at the midpoint M of the side BC, so that the net electric field at point A becomes zero.

32. (a) A ray of light is incident on one face of a triangular glass prism of refractive index n and is refracted out from the opposite face. Deduce the expression for refractive index of glass prism in terms of the angle of minimum deviation and angle of the prism. Write the condition on n for refraction to take place on the opposite face.

OR

(b) State Huygens principle. Using it, draw a diagram and discuss the case of refraction of plane wave of light from a rarer medium to a denser medium at their plane interface. Hence derive Snell's law.

33. (a) (i) A series combination of L, C and R is connected to an ac source $V = V_m \sin \omega t$. Obtain:

(I) the impedance of the circuit using phasor diagram,

(II) the expression for the instantaneous current I , and

(III) the phase relationship of current to the applied voltage.

(ii) Define power factor of an ac circuit. State the conditions under which it is: (I) maximum, (II) minimum.

OR

(b) (i) Prove that the voltage is ahead of the current in phase by $\frac{\pi}{2}$ rad in an ac circuit containing an ideal inductor.

(ii) The currents through two inductors of self-inductance 12 mH and 24 mH are increasing with time at the same rate. Draw graphs showing the variation of the: (I) magnitude of emf induced with the rate of change of current in each inductor. (II) energy stored in each inductor with the current flowing through it.

- End of Question Paper -