

CBSE Class 12 Physics 2023 - 55/C/2 - 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 **35 questions**. All questions are **compulsory**.
- (ii) The question paper is divided into Sections A, B, C, D, E.
- (iii) Section A - Questions 1 to 18 carry 1 mark each.
- (iv) Section B - Questions 19 to 25 carry 2 marks each.
- (v) Section C - Questions 26 to 30 carry 3 marks each.
- (vi) Section D - Questions 31 to 33 carry 5 marks each.
- (vii) Section E - Questions 34 to 35 carry 4 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:

$$\begin{aligned}c &= 3 \times 10^8 \text{ m/s} \\h &= 6.63 \times 10^{-34} \text{ Js} \\e &= 1.6 \times 10^{-19} \text{ C} \\\mu_0 &= 4\pi \times 10^{-7} \text{ T m A}^{-1} \\\epsilon_0 &= 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\\frac{1}{4\pi\epsilon_0} &= 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}\end{aligned}$$

$$\begin{aligned}\text{Mass of electron } (m_e) &= 9.1 \times 10^{-31} \text{ kg} \\\text{Mass of neutron} &= 1.675 \times 10^{-27} \text{ kg} \\\text{Mass of proton} &= 1.673 \times 10^{-27} \text{ kg} \\\text{Avogadro's number} &= 6.023 \times 10^{23} \text{ per gm mole} \\\text{Boltzmann constant} &= 1.38 \times 10^{-23} \text{ JK}^{-1}\end{aligned}$$

Section A

1. In a series LCR circuit, the capacitance is changed from C to $C/4$. For the resonant frequency to remain unchanged, the inductance should be changed from L to nL , where n is :

- (A) $\frac{1}{2}$ (B) 2
(C) 4 (D) $\frac{1}{4}$

2. An electron with velocity $\vec{v} = (v_x\hat{i} + v_y\hat{j})$ moves through a magnetic field $\vec{B} = (B_x\hat{i} - B_y\hat{j})$. The force $\vec{F}$ on the electron is : (e is the magnitude of its charge)

- (A) $-e(v_xB_y - v_yB_x)\hat{k}$ (B) $e(v_xB_y - v_yB_x)\hat{k}$
(C) $-e(v_xB_y + v_yB_x)\hat{k}$ (D) $e(v_xB_y + v_yB_x)\hat{k}$

3. A small bar, when placed near a magnet, is repelled by it. This is because the bar is made of :

- (A) Iron (B) Copper
(C) Aluminium (D) Nickel

4. When a negative charge ($-Q$) is brought near one face of a metal cube, the :

- (A) cube becomes positively charged (B) cube becomes negatively charged
(C) face near the charge becomes positively charged and the opposite face becomes negatively charged (D) face near the charge becomes negatively charged and the opposite face becomes positively charged

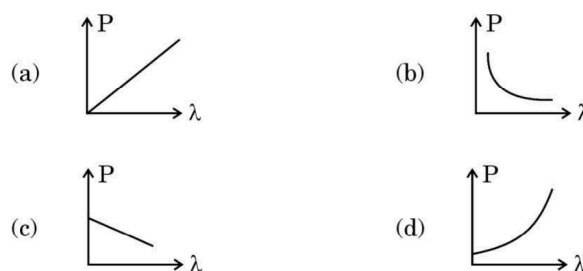
5. A metal detector is based on :

- (A) Self-induction (B) Mutual induction
(C) Electrical resonance (D) Power transmission

6. In Young's double-slit experiment, the intensity on the screen is I_0 at a point where path difference is λ . The intensity at the point where path difference is $\frac{\lambda}{4}$ is :

- (A) $\frac{I_0}{4}$ (B) $\frac{I_0}{2}$
(C) I_0 (D) zero

7. Which of the following figures represents the variation of a particle's momentum with the de Broglie wavelength associated with it ?



8. The binding energy per nucleon of ${}_8O^{16}$ is 7.97 MeV and that of ${}_8O^{17}$ is 7.75 MeV. The energy (in MeV) required to remove a neutron from ${}_8O^{17}$ is :

- (A) 0.42 MeV (B) 7.86 MeV
(C) 4.23 MeV (D) 3.64 MeV

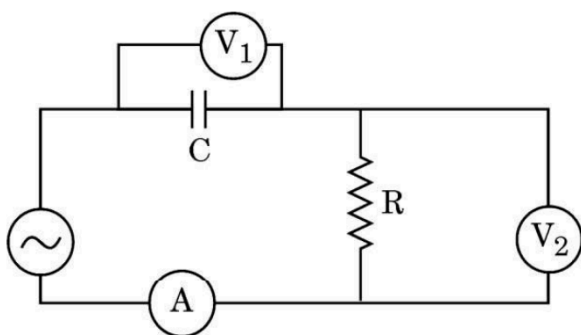
9. The impact parameter for an alpha particle approaching a target nucleus is maximum when the scattering angle (θ) is :

- (A) 0° (B) 90°
(C) 180° (D) 45°

10. Two nuclei have their mass numbers in the ratio of 1 : 27. What is the ratio of their nuclear densities ?

- (A) 1 : 27 (B) 1 : 1
(C) 1 : 9 (D) 1 : 3

11. The given figure shows a capacitor C and a resistor R connected in series to an ac source. V_1 and V_2 are voltmeters and A is an ammeter.



Which of the following statements is correct ?

- (A) Current in the circuit lags in phase with voltage shown in V_2 .
(B) The voltage shown in V_1 is ahead in phase with voltage shown in V_2 .
(C) The current in the circuit and V_1 are always in the same phase.
(D) The voltage shown in V_1 lags in phase with voltage shown in V_2 .

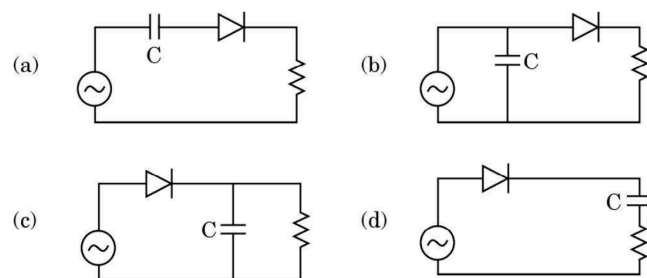
12. A plane wave is incident on a concave mirror of radius of curvature R. The reflected wave is a spherical wave of radius :

- (A) $\frac{R}{4}$ (B) $\frac{R}{2}$
(C) R (D) 2R

13. Light of frequency $1.5\nu_0$ is incident on a photosensitive material of threshold frequency ν_0 . If the frequency of the incident radiation is kept constant and intensity is increased, the photo current will :

- (A) increase (B) decrease
(C) not change (D) first decrease and then become zero

14. In which of the following diagrams is the capacitor 'C' connected correctly to provide smooth output of a half-wave rectifier ?



15. A planar loop is rotated in a magnetic field about an axis perpendicular to the field. The polarity of induced emf changes once in each :

- (A) 1 revolution (B) $\left(\frac{1}{2}\right)$ revolution
(C) $\left(\frac{1}{4}\right)$ revolution (D) $\left(\frac{3}{4}\right)$ revolution
-

16. Questions number 16 to 18 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.

Assertion (A): The temperature coefficient of resistance is positive for metals and negative for semi-conductors.

Reason (R): The charge carriers in metals are negatively charged whereas in semiconductors they are positively charged.

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|--|---|
| (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) Assertion (A) is false and Reason (R) is also false. |
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17. Questions number 16 to 18 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) Assertion (A) is false and Reason (R) is also false.

Assertion (A): The magnetic field produced by a current carrying solenoid is independent of its length and cross-sectional area.

Reason (R): The magnetic field produced inside the solenoid is uniform.

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|---|---|
| (A) Both A and R true, R is the correct explanation of A. | (B) Both A and R true, R is NOT the correct explanation of A. |
| (C) A is true, R is false. | (D) A is false, R is also false. |
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18. Questions number 16 to 18 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.

Assertion (A): Silicon is preferred over germanium for making semiconductor devices.

Reason (R): The energy gap for germanium is more than the energy gap for silicon.

- | | |
|--|---|
| (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) Assertion (A) is false and Reason (R) is also false. |
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Section B

19. A tank, in which a transparent liquid of refractive index μ is filled to a height H , has a bright point source placed at its bottom. Let r be the radius of the circular area of the liquid surface through which light can emerge out. Find the ratio (r/H) .

20. (a) The electric field of an electromagnetic wave passing through vacuum is represented as $E_x = E_0 \sin(kz - \omega t)$. Identify the parameter which is related to the (i) wavelength, and (ii) the frequency of the wave in the above equation.

(b) Write two properties of a medium that determine the velocity of light in that medium.

21. A sphere S_1 of radius r_1 enclosing a charge Q_1 is surrounded by another concentric sphere S_2 of radius r_2 ($r_2 > r_1$). If there is a charge $-Q_2$ in the space between S_1 and S_2 , find the ratio of electric flux through S_1 and S_2 .

22. Light of wavelength $3500 \text{ \AA}$ is incident on two metals A and B, whose work functions are 4.2 eV and 1.9 eV respectively. Which of them will yield photoelectrons? Make the necessary calculations to justify your answer.

23(a). A uniform electric field E of 500 N/C is directed along the $+x$ axis. O, B and A are three points in the field having x and y coordinates (in cm) (0, 0), (4, 0) and (0, 3) respectively. Calculate the potential difference between the points (i) O and A, and (ii) O and B.

OR

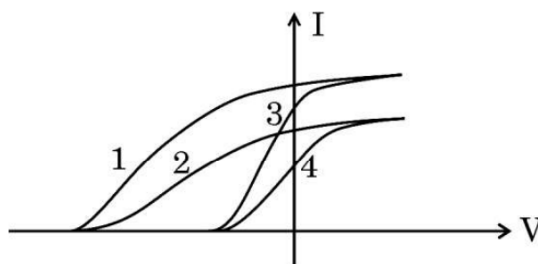
23(b). Three point charges $1 \mu C$, $-1 \mu C$ and $2 \mu C$ are kept at the vertices A, B and C respectively of an equilateral triangle of side 1 m. A_1 , B_1 and C_1 are the midpoints of the sides AB, BC and CA respectively. Calculate the net amount of work done in displacing the charge from A to A_1 , from B to B_1 and from C to C_1 .

24(a). When is more power delivered to a light bulb — just after it is turned on, when the glow of its filament is increasing, or after its glow becomes steady? Why?

OR

24(b). A battery is connected first across the series combination and then across the parallel combination, of three resistances R , $2R$ and $3R$. In which of the three resistances, in the two cases, will power dissipated be maximum? Justify your answer.

25. The figure shows the variation of photoelectric current (I) versus applied voltage (V) for two photosensitive materials and for two different intensities of the incident radiation. Identify the pairs of curves that correspond to different materials but for the same intensity of incident radiation. Justify your answers in brief.



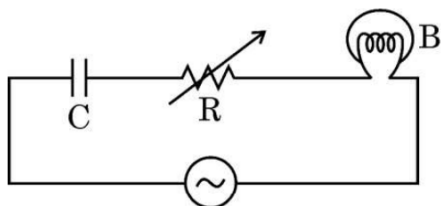
Section C

26. A 4 m long horizontal straight metallic rod is held at some height above the surface of Earth, in east-west direction. If it is allowed to fall from rest, find the :

- (a) emf induced in the rod 2 s after it starts falling,
- (b) polarity of the emf induced, and
- (c) the end of the rod which is at the higher potential.

The horizontal component of the Earth's magnetic field at the place is $0.3 \times 10^{-4} \text{ Wb/m}^2$ and take $g = 10 \text{ m/s}^2$.

27. The figure shows a capacitor C, a variable resistor R and a bulb B connected in series to the ac source of frequency (ν). The bulb glows with some brightness.



How will the glow of the bulb be affected, if the

- (a) separation between the plates of the capacitor is doubled, keeping resistance R and frequency (ν) the same ?
- (b) resistance R is decreased keeping the value of capacitance C and frequency (ν) same ?
- (c) frequency of ac source is decreased for the same value of C and R ? Justify your answer in each case.

28(a). (i) In a hydrogen atom, an electron jumps from the second excited state to the first excited state. Name the spectral series of the hydrogen spectrum in which the emitted radiation can be found.

(ii) Find the ratio of the wavelengths of the "most energetic" spectral lines in the Balmer series to that in the Paschen series of the Hydrogen spectrum.

OR

28(b). (i) An α -particle having kinetic energy K approaches a nucleus of atomic number Z. It gets close to the nucleus and then approaches a distance (d) and reverses its direction. Obtain an expression for the distance of closest approach (d) in terms of the kinetic energy of the α -particle.

(ii) A proton and an alpha particle approach a target nucleus in head-on position, with equal velocities. Find the ratio of their distances of closest approach to the target nucleus.

29(a). (i) In which case is the diffraction effect more dominant — when the slit is formed by two blades or when the slit is formed by two fingers ?

(ii) Yellow light ($\lambda = 6000 \text{ \AA}$) illuminates a single slit of width $1 \times 10^{-4} \text{ m}$. Calculate (i) the distance between two dark lines on either side of the central maximum, in the diffraction pattern observed on a screen kept 1.5 m away from the slit, and (ii) the angular spread of the first minimum.

OR

29(b). (i) If a monochromatic source of light is replaced by a source of white light in Young's double slit experiment, what will be the colour of the central bright fringe ? Give reason for your answer.

(ii) In a Young's double slit experiment, the separation between the slits is 0.3 mm and the screen is placed 1.5 m away from the slits. The distance between the central bright fringe and the sixth bright fringe is found to be 1.8 cm. Find the wavelength of light used in the experiment.

30. (a) It is not advisable to use a galvanometer as such to measure current directly. Why ?

(b) Why should the value of resistance connected in parallel to a galvanometer be low ?

(c) Is the reading shown by an ammeter in a circuit less than or more than the actual value of current flowing in the circuit ? Why ?

Section D

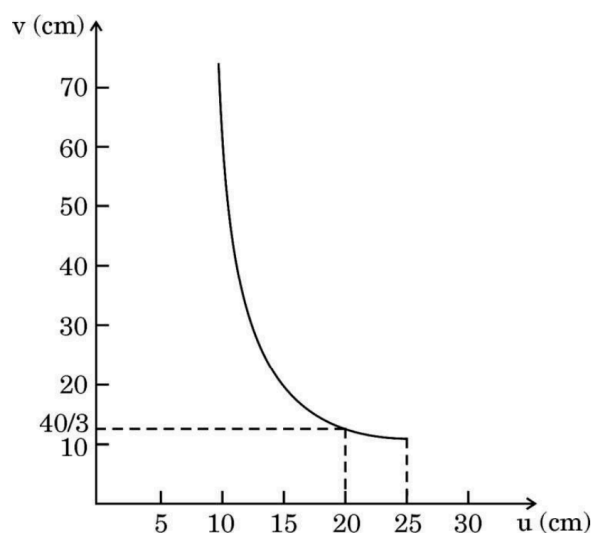
31(a). Draw a ray diagram for formation of a real and diminished image of an object kept in front of a concave mirror. Hence derive the mirror equation.

(b) A concave mirror of focal length 10 cm produces a real image which is 3 times the size of the object. Find the distance of the object from the mirror.

OR

31(b). (a) Two converging lenses of focal lengths f_1 and f_2 are placed coaxially in contact. Derive the expression for the focal length of the combination using the ray diagram for the formation of the image of an object by the combination.

(b) The given figure shows the variation of image distance v with object distance u for a lens.

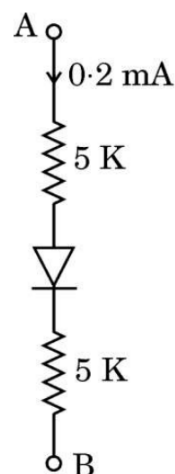


(i) What is the nature of this lens ?

(ii) Using this graph, find the focal length of the lens.

32(a). (i) Draw the circuit diagram used to study $I - V$ characteristics of a p-n junction diode in conducting mode. Mark on the graph the threshold voltage of the diode. Explain the significance of this voltage.

(ii) In the circuit shown in the figure, the forward voltage drop across the diode is 0.3 V (a series circuit A–5K–diode–5K–B carrying 0.2 mA). Find the voltage difference between A and B.



OR

32(b). (i) Briefly describe the classification of solids into metals, insulators and semi-conductors on the basis of energy level diagrams.

(ii) In a silicon diode, the current increases from 10 mA to 20 mA when the voltage changes from 0.6 V to 0.7 V. Calculate the dynamic resistance of the diode.

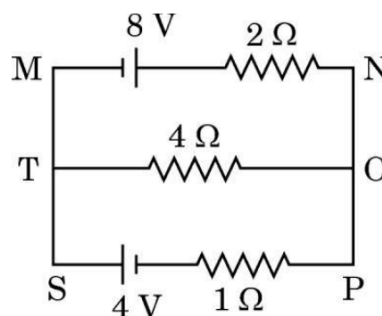
33(a). (i) Derive the relation between the current and the drift velocity of free electrons in a conductor. Briefly explain the variation of resistance of a conductor with rise in temperature.

(ii) An ammeter, together with an unknown resistance in series, is connected across two identical batteries, each of emf 1.5 V, connected (i) in series, and (ii) in parallel. If the current recorded in the two cases be $\left(\frac{1}{2}\right)$ A and $\left(\frac{1}{3}\right)$ A respectively, calculate the internal resistance of each battery.

OR

33(b). (i) State Kirchhoff's rules. Use them to obtain the condition of balance for a Wheatstone Bridge.

(ii) Use Kirchhoff's rule to determine the currents flowing through the branches MN, TO and SP in the circuit shown in the figure (M-N: 8V cell and 2Ω resistor; T-O: 4Ω resistor; S-P: 4V cell and 1Ω resistor, all three branches connected in parallel between the M/T/S and N/O/P rails).



Section E

34. A parallel plate capacitor is an arrangement of two identical metal plates kept parallel, a small distance apart. The capacitance of a capacitor depends on the size and separation of the two plates and also on the dielectric constant of the medium between the plates. Like resistors, capacitors can also be arranged in series or parallel or a combination of both. By virtue of electric field between the plates, charged capacitors store energy.

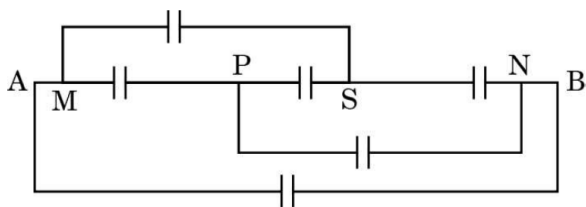
34(a). The capacitance of a parallel plate capacitor increases from $10\ \mu\text{F}$ to $80\ \mu\text{F}$ on introducing a dielectric medium between the plates. Find the dielectric constant of the medium.

34(b). n capacitors, each of capacitance C , are connected in series. Find the equivalent capacitance of this combination.

34(c). (c) A capacitor is connected to a battery and charged to a potential (V). After some time, the battery is disconnected and a dielectric is introduced between the plates. What effect will this have on the potential difference between the plates and on the energy stored in the capacitor? Justify your answer.

OR

34(c). (c) If the capacitance of each capacitor is C , find the equivalent capacitance between points A and B, for the network shown in the figure (A–M–P–S–N–B with capacitors arranged in a bridge-like series-parallel combination).



35. A prism is a solid transparent medium bounded by three rectangular faces with a triangular base and a top. A ray of light incident at angle i on one face of a prism suffers two refractions on passing through a prism. Hence it deviates through a certain angle δ from its original path. The angle of deviation becomes minimum ($\delta = \delta_m$) for a certain value of angle i . In such a condition, the refracted ray inside the prism becomes parallel to its base. An expression for refractive index μ of the material of the prism can be obtained in terms of angle A and angle δ_m .

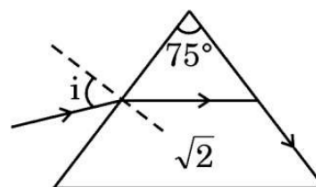
35(a). Show in a figure the variation of angle δ with angle of incidence i .

35(b). Show that for a prism of small angle A , the refractive index μ of its material can be written as $\mu = 1 + \frac{\delta_m}{A}$.

35(c). (c) A ray of light passes through an equilateral prism such that both the angle of incidence and the angle of emergence are equal to the angle of prism A . Find the refractive index of the material of the prism, in terms of A .

OR

35(c). (c) A ray of light passes through a prism of angle 75° , as shown in the figure. The refractive index of the material of the prism, with respect to its surrounding is $\sqrt{2}$. Find the angle of incidence i .



- End of Question Paper -