

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. A charge Q is placed at the centre of a cube. The electric flux through one of its face is

- (A) $\frac{Q}{\epsilon_0}$ (B) $\frac{Q}{2\epsilon_0}$
(C) $\frac{Q}{6\epsilon_0}$ (D) $\frac{Q}{3\epsilon_0}$

2. Two long parallel wires kept 2 m apart carry 3A current each, in the same direction. The force per unit length on one wire due to the other is

- (A) 4.5×10^5 N/m, attractive (B) 4.5×10^{-7} N/m, repulsive
(C) 9×10^{-7} N/m, repulsive (D) 9×10^5 N/m, attractive

3. Which of the following has its permeability less than that of free space?

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

4. A square shaped coil of side 10 cm, having 100 turns is placed perpendicular to a magnetic field which is increasing at 1 T/s. The induced emf in the coil is

- (A) 0.1 V (B) 0.5 V
(C) 0.75 V (D) 1.0 V

5. Choose the correct option related to wavelengths (λ) of different parts of electromagnetic spectrum.

- (A) $\lambda_{X\text{-rays}} < \lambda_{\text{micro waves}} < \lambda_{\text{visible}}$ (B) $\lambda_{\text{visible}} > \lambda_{X\text{-rays}} > \lambda_{\text{radio waves}}$
(C) $\lambda_{\text{radio waves}} > \lambda_{\text{visible}} > \lambda_{X\text{-rays}}$ (D) $\lambda_{\text{visible}} < \lambda_{\text{micro waves}} < \lambda_{\text{radio waves}} < \lambda_{X\text{-rays}}$

6. In a Young's double-slit experiment, the screen is moved away from the plane of the slits. What will be its effect on the following?

- (i) Angular separation of the fringes.
(ii) Fringe-width.

- (A) Both (i) and (ii) remain constant. (B) (i) remains constant, but (ii) decreases.
(C) (i) remains constant, but (ii) increases. (D) Both (i) and (ii) increase.

7. The energy of a photon of wavelength λ is:

- (A) $hc\lambda$ (B) hc/λ
(C) λ/hc (D) $\lambda h/c$

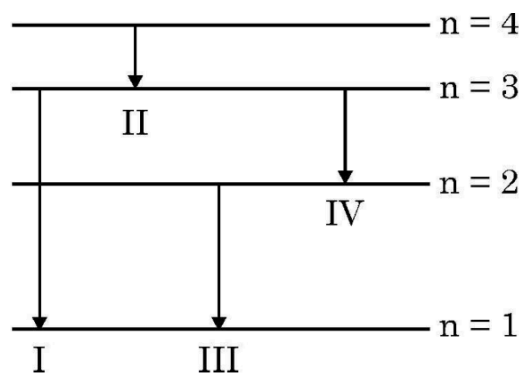
8. The ratio of the nuclear densities of two nuclei having mass numbers 64 and 125 is

- (A) $\frac{64}{125}$ (B) $\frac{4}{5}$
(C) $\frac{5}{4}$ (D) 1

9. During the formation of a p-n junction:

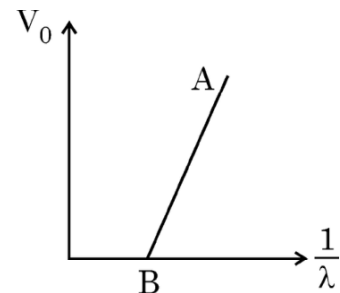
- (A) diffusion current keeps increasing. (B) drift current remains constant.
(C) both the diffusion current and drift current remain constant. (D) diffusion current remains almost constant but drift current increases till both currents become equal.

10. The diagram shows four energy level of an electron in Bohr model of hydrogen atom. Identify the transition in which the emitted photon will have the highest energy.



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

11. Figure shows a plot of stopping potential (V_0) versus $\frac{1}{\lambda}$ where λ is the wavelength of the radiation causing photoelectric emission from a surface. The slope of the line is equal to



- (A) $\frac{h}{e}$ (B) $\frac{hc}{e}$
(C) $\frac{h}{c}$ (D) $\frac{h^2 c}{e}$

12. The capacitors, each of $4\mu F$ are to be connected in such a way that the effective capacitance of the combination is $6\mu F$. This can be achieved by connecting

- (A) All three in parallel (B) All three in series
(C) Two of them connected in series and the combination in parallel to the third. (D) Two of them connected in parallel and the combination in series to the third.

13. An ideal inductor is connected across an AC source of voltage. The current in the circuit

- (A) is ahead of the voltage in phase by π . (B) lags voltage in phase by π .
(C) is ahead of voltage in phase by $\pi/2$. (D) lags voltage in phase by $\pi/2$.

14. According to Huygens principle, the amplitude of secondary wavelets is

- | | |
|---|--|
| (A) equal in both the forward and the backward directions. | (B) maximum in the forward direction and zero in the backward direction. |
| (C) large in the forward direction and small in the backward direction. | (D) small in the forward direction and large in the backward direction. |

15. In Bohr model of hydrogen atom, the radius of the n^{th} orbit is proportional to:

- | | |
|-----------|-------------|
| (A) n^2 | (B) $1/n^2$ |
| (C) n | (D) $1/n$ |

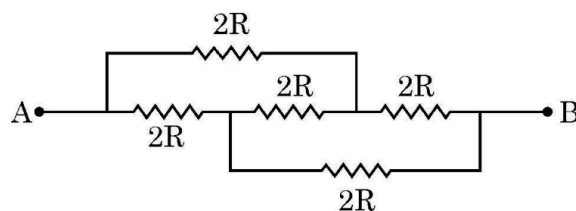
16. **Assertion (A):** In insulators, the forbidden gap is very large.

Reason (R): The valence electrons in an atom of an insulator are very tightly bound to the nucleus.

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|---|---|
| (A) Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of (A). | (B) Both Assertion (A) and Reason (R) are true and (R) is NOT the correct explanation of (A). |
| (C) Assertion (A) is true and Reason (R) is false. | (D) Assertion (A) is false and Reason (R) is also false. |

17. **Assertion (A):** The equivalent resistance between points A and B in the given network is $2R$.

Reason (R): All the resistors are connected in parallel.



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|---|---|
| (A) Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of (A). | (B) Both Assertion (A) and Reason (R) are true and (R) is NOT the correct explanation of (A). |
| (C) Assertion (A) is true and Reason (R) is false. | (D) Assertion (A) is false and Reason (R) is also false. |

18. **Assertion (A):** The deflecting torque acting on a current carrying loop is zero when its plane is perpendicular to the direction of magnetic field.

Reason (R): The deflecting torque acting on a loop of magnetic moment $\vec{m}$ in a magnetic field $\vec{B}$ is given by the dot product of $\vec{m}$ and $\vec{B}$.

- | | |
|---|---|
| (A) Both Assertion (A) and Reason (R) are true and (R) is the correct explanation of (A). | (B) Both Assertion (A) and Reason (R) are true and (R) is NOT the correct explanation of (A). |
| (C) Assertion (A) is true and Reason (R) is false. | (D) Assertion (A) is false and Reason (R) is also false. |

Section B

19. Draw a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Indicate the region in which the nuclear force is (a) attractive and (b) repulsive.

20. (a) How will the De Broglie wavelength associated with an electron be affected when the (i) velocity of the electron decreases? and (ii) accelerating potential is increased? Justify your answer.

OR

(b) How would the stopping potential for a given photosensitive surface change if (i) the frequency of the incident radiation were increased? and (ii) the intensity of incident radiation were decreased? Justify your answer.

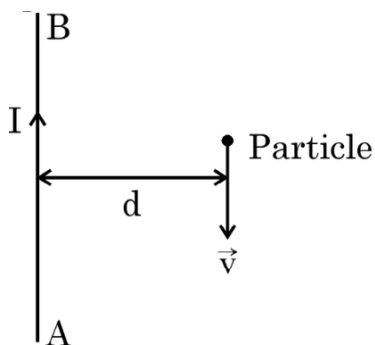
21. Identify the electromagnetic radiation and write its wavelength range, which is used to kill germs in water purifier. Name the two sources of these radiations.

22. An electric dipole of dipole moment ($\vec{p}$) is kept in a uniform electric field $\vec{E}$. Show graphically the variation of torque acting on the dipole (τ) with its orientation (θ) in the field. Find the orientation in which torque is (i) zero and (ii) maximum.

23. (a) Write the expression for the Lorentz force on a particle of charge q moving with a velocity $\vec{v}$ in a magnetic field $\vec{B}$. When is the magnitude of this force maximum? Show that no work is done by this force on the particle during its motion from a point $\vec{r}_1$ to point $\vec{r}_2$.

OR

(b) A long straight wire AB carries a current I . A particle (mass m and charge q) moves with a velocity $\vec{v}$, parallel to the wire, at a distance d from it as shown in the figure. Obtain the expression for the force experienced by the particle and mention its directions.

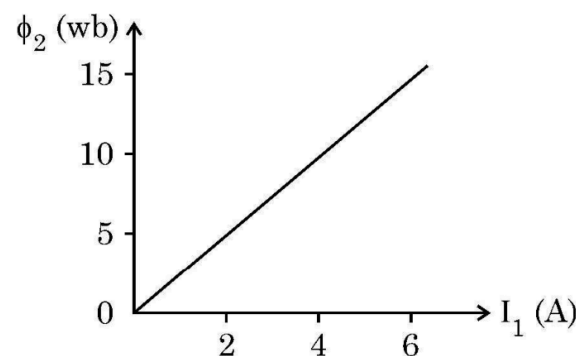


24. A potential difference (V) is applied across a conductor of length ' L ' and cross-sectional area ' A '. How will the drift velocity of electrons and the current density be affected if another identical conductor of the same material were connected in series with the first conductor? Justify your answers.

25. Two coils C_1 and C_2 are placed close to each other. The magnetic flux ϕ_2 linked with the coil C_2 varies with the current I_1 flowing in coil C_1 , as shown in the figure. Find

(i) the mutual inductance of the arrangement, and

(ii) the rate of change of current $\left(\frac{dI_1}{dt}\right)$ that will induce an emf of 100 V in coil C_2 .



Section C

26. (a) A plane wave-front propagating in a medium of refractive index ' μ_1 ' is incident on a plane surface making an angle of incidence (i). It enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$). Use Huygen's construction of secondary wavelets to trace the refracted wave-front. Hence verify Snell's law of refraction.

OR

(b) Using Huygen's construction, show how a plane wave is reflected from a surface. Hence verify the law of reflection.

27. A current of 1A flows through a coil when it is connected across a DC battery of 100 V. If DC battery is replaced by an AC source of 100 V and angular frequency 100 rad s^{-1} , the current reduces to 0.5 A. Find

- (i) impedance of the circuit.
- (ii) self-inductance of coil.
- (iii) phase difference between the voltage and the current.

28. The primary coil having N_p turns of an ideal transformer is supplied with an alternating voltage V_p . Obtain an expression for the voltage V_s induced in its secondary coil having N_s turns. Mention two main sources of power loss in real transformers.

29. (a) Briefly describe how the current sensitivity of a moving coil galvanometer can be increased.

(b) A galvanometer shows full scale deflection for current I_g . A resistance R_1 is required to convert it into a voltmeter of range $(0 - V)$ and a resistance R_2 to convert it into a voltmeter of range $(0 - 2V)$. Find the resistance of the galvanometer.

30. (a) (i) Write the limitations of Rutherford's model of atom.

(ii) The wavelength of the second line of the Balmer series in the hydrogen spectrum is $4861 \text{ \AA}$. Calculate the wavelength of the first line of the same series.

OR

(b) (i) Increase in the intensity of the radiation causing photo-electric emission from a surface, does not affect the maximum K.E. of the photo electrons. Explain.

(ii) The photon emitted during the de-excitation from the first excited level to the ground state of hydrogen atom is used to irradiate a photo cathode in which stopping potential is 5 V. Calculate the work function of the cathode used.

Section D

31. (a) Draw the circuit arrangement for studying V-I characteristics of a p-n junction diode in (i) forward biasing and (ii) reverse biasing. Draw the typical V-I characteristics of a silicon diode. Describe briefly the following terms: (i) minority carrier injection in forward biasing and (ii) breakdown voltage in reverse biasing.

OR

(b) Name two important processes involved in the formation of a p-n junction diode. With the help of a circuit diagram, explain the working of junction diode as a full wave rectifier. Draw its input and output waveforms. State the characteristic property of a junction diode that makes it suitable for rectification.

32. (a) (i) Draw a ray diagram to show the working of a compound microscope. Obtain the expression for the total magnification for the final image to be formed at the near point.

(ii) In a compound microscope an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. If the eye-piece has a focal length of 5 cm and the final image is formed at the near point, find the magnifying power of the microscope.

OR

(b) (i) Draw a ray diagram for the formation of image of an object by an astronomical telescope, in normal adjustment. Obtain the expression for its magnifying power.

(ii) The magnifying power of an astronomical telescope in normal adjustment is 2.9 and the objective and the eyepiece are separated by a distance of 150 cm. Find the focal lengths of the two lenses.

33. (a) (i) Explain how free electrons in a metal at constant temperature attain an average velocity under the action of an electric field. Hence obtain an expression for it.

(ii) Consider two conducting wires A and B of the same diameter but made of different materials joined in series across a battery. The number density of electrons in A is 1.5 times that in B. Find the ratio of drift velocity of electrons in wire A to that in wire B.

OR

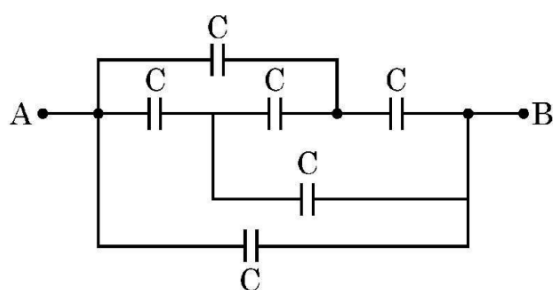
(b) (i) A cell of emf (E) and internal resistance (r) is connected across a variable load resistance (R). Draw plots showing the variation of terminal voltage V with (i) R and (ii) the current (I) in the load.

(ii) Three cells, each of emf E but internal resistances $2r$, $3r$ and $6r$ are connected in parallel across a resistor R . Obtain expressions for (i) current flowing in the circuit, and (ii) the terminal potential difference across the equivalent cell.

Section E

34. A capacitor is a system of two conductors separated by an insulator. The two conductors have equal and opposite charges with a potential difference between them. The capacitance of a capacitor depends on the geometrical configuration (shape, size and separation) of the system and also on the nature of the insulator separating the two conductors. They are used to store charges. Like resistors, capacitors can be arranged in series or parallel or a combination of both to obtain desired value of capacitance.

34(i). Find the equivalent capacitance between points A and B in the given diagram.

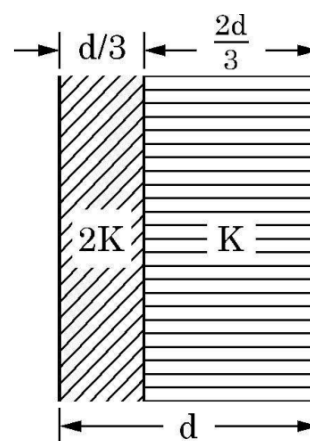


34(ii). A dielectric slab is inserted between the plates of a parallel plate capacitor. The electric field between the plates decreases. Explain.

34(iii). (iii) A capacitor A of capacitance C , having charge Q is connected across another uncharged capacitor B of capacitance $2C$. Find an expression for (a) the potential difference across the combination and (b) the charge lost by capacitor A.

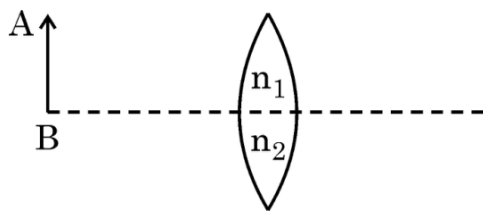
OR

(iii) Two slabs of dielectric constants $2K$ and K fill the space between the plates of a parallel plate capacitor of plate area A and plate separation d as shown in figure. Find an expression for capacitance of the system.



35. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Considering image formation by a single spherical surface successively at the two surfaces of a lens, lens maker's formula is obtained. It is useful to design lenses of desired focal length using surfaces of suitable radii of curvature. This formula helps us obtain a relation between u , v and f for a lens. Lenses form images of objects and they are used in a number of optical devices, for example microscopes and telescopes.

35(i). An object AB is kept in front of a composite convex lens, as shown in figure. Will the lens produce one image? If not, explain.



35(ii). A real image of an object formed by a convex lens is observed on a screen. If the screen is removed, will the image still be formed? Explain.

35(iii). (iii) A double convex lens is made of glass of refractive index 1.55 with both faces of the same radius of curvature. Find the radius of curvature required if focal length is 20 cm.

OR

(iii) Two convex lenses A and B of focal lengths 15 cm and 10 cm respectively are placed coaxially ' d ' distance apart. A point object is kept at a distance of 30 cm in front of lens A. Find the value of ' d ' so that the rays emerging from lens B are parallel to its principal axis.

- End of Question Paper -