Prepzy

CBSE EXAMINATION PAPER-2025

PHYSICS

(Solved)

Time allowed : 3 hours | Maximum Marks : 35

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **18 questions.** All questions are **compulsory.**

ii. This question paper is divided into **4 sections.**

iii. **Section A** – questions number **1 to 9** are multiple choice questions Each question carries **1 marks.**

iv. **Section B** – questions number **10 to 12** are very short answer Each question carries **2 marks.**

v. **Section C** – questions number **13 to 17** are short answer Each question carries **3 marks.**

vi. **Section D** – questions number **18 to 18** are long answer Each question carries **5 marks.**

vii. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

viii. Use of calculator is NOT allowed.

Section A

Question 1.

A metal sheet is inserted between the plates of a parallel plate capacitor of capacitance C. If the sheet partly occupies the space between the plates, the capacitance :

[1 Marks]

(A) becomes less than C

(B) becomes greater than C

(C) remains C

(D) becomes zero

Explanation:

The correct answer is 'becomes greater than C'. When a metal sheet is inserted between the plates of a capacitor, it affects the electric field. The presence of the metal sheet decreases the effective distance between the capacitor plates and increases the capacitance due to the induced charges on the metal, which causes polarization. Thus, the capacitance increases from its original value C.

Question 2.

The magnetic flux linked with a coil changes with time t as **φ**= (8t^2 + 5t + 7), where t is in seconds and **φ** is in Wb. The value of emf induced in the coil at t = 4 s is :

[1 Marks]

(A) 64 V

(B) 37 V

(C) 32 V

(D) 69 V

Explanation:

To find the emf induced in the coil, we need to calculate the rate of change of magnetic flux dφ/dt. First, we differentiate φ = (8t^2 + 5t + 7) with respect to t to get dφ/dt = 16t + 5. At t = 4 s, dφ/dt = 16(4) + 5 = 64 + 5 = 69 Wb/s. According to Faraday's law, the induced emf ε is given by ε = -dφ/dt. Thus, the induced emf at t = 4 s is 69 V.

Question 3.

Which of the following rays coming from the Sun plays an important role in maintaining the Earth's warmth?

[1 Marks]

(A) Infrared rays

(B) Visible light rays

(C) UV rays

(D) γ rays

Explanation: Infrared rays are the correct answer because they are responsible for the greenhouse effect that helps maintain the Earth's warmth. Incoming visible light is absorbed by the Earth and re-radiated as infrared radiation, which is absorbed by greenhouse gases, leading to an increase in temperature. This is supported by the context which mentions that infrared radiation plays a crucial role in maintaining the Earth's average temperature.

Question 4.

Which of the following electromagnetic waves has photons of largest momentum ?

[1 Marks]

(A) X-rays

(B) TV waves

(C) AM radio waves

(D) Microwaves

Explanation: X-rays have photons with the largest momentum because momentum of a photon is directly proportional to its frequency and inversely proportional to its wavelength. X-rays have a much higher frequency and shorter wavelength compared to the other options (TV waves, AM radio waves, and microwaves), resulting in higher momentum.

Question 5.

The kinetic energy of an alpha particle is four times the kinetic energy of a proton. The ratio (**λa/λp**) of de Broglie wavelengths associated with them will be :

[1 Marks]

(A) 1/2

(B) 1/16

(C) 1/8

(D) 1/4

Explanation:

The de Broglie wavelength (λ) is inversely proportional to the momentum (p) of the particle, given by $\lambda = h/p$. Since kinetic energy (KE) is given by $KE = (1/2)mv^2$, we can relate the kinetic energies of the alpha particle and the proton. If $KE_{alpha} = 4 * KE_{proton}$, then using the relationship between energy, mass, and velocity, we can find that the mass of the alpha particle is approximately four times that of a proton, and its speed must be less to maintain the higher kinetic energy, leading to a smaller de Broglie wavelength. Thus, deducing from the ratio of their momenta, we get $\lambda_{alpha}/\lambda_{proton} = 1/4$.

Question 6.

Assertion (A) : The impurities in p-type Si are not pentavalent atoms. Reason (R) : The hole density in valance band in p-type semiconductor is almost equal to the acceptor density.

[1 Marks]

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

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

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

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

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The assertion is correct because p-type silicon is doped with trivalent atoms (not pentavalent) which create holes. The reason is also true, as in p-type semiconductors, the hole density is approximately equal to the density of acceptor atoms, but it does not explain why the impurities are not pentavalent. Thus, the two statements are true but not directly linked in causation.

Question 7.

Assertion (A) : During formation of a nucleus, the mass defect produced is the source of the binding energy of the nucleus.

Reason (R) : For all nuclei, the value of binding energy per nucleon increases with mass number.

[1 Marks]

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

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

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

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

Explanation: Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). The mass defect is indeed the source of binding energy, which reflects the energy required to hold the nucleus together. Additionally, the binding energy per nucleon does generally increase with mass number, demonstrating that larger nuclei tend to be more stable due to stronger nuclear forces, corroborating the assertion.

Question 8.

Assertion (A) : The Balmer series in hydrogen atom spectrum is formed when the electron jumps from higher energy state to the ground state.

Reason (R) : In Bohr's model of hydrogen atom, the electron can jump between successive orbits only.

[1 Marks]

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

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

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

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

Explanation:

Assertion (A) is true because the Balmer series represents transitions where the electron drops from higher energy levels to the second energy level, resulting in visible light emissions. However, Reason (R) is false because in Bohr's model, the electron can jump between any allowed energy levels, not just successive ones. Therefore, the correct answer is that Assertion (A) is true, but Reason (R) is false.

Question 9.

Assertion (A) : In Rutherford's alpha particle scattering experiment, the presence of only few alpha particles at angle of scattering led him to the discovery of nucleus.

Reason (R) : The size of nucleus is approximately 10 5 times the size of an atom and therefore only few alpha particles are rebounded.

[1 Marks]

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

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

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

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

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The assertion is true as Rutherford's experiment showed that only a small fraction of alpha particles were deflected at large angles, indicating a small, dense nucleus. However, the reason provided is incorrect in its scale, as the nucleus is actually about 10,000 times smaller than the atom, not 10^5 times. Thus, while both statements are true, the reason does not correctly explain why only a few particles were scattered.

Section B

Question 10. The threshold frequency for a given metal is 3.6×10^{14} Hz. If monochromatic radiations of frequency 6.8×10^{14} Hz are incident on this metal, find the cut-off potential for the photoelectrons.

[2 Marks]

Answer: To find the cut-off potential, we first calculate the energy of the incident photons using $E = h\nu$, where h is Planck's constant (6.626×10^{-34} J·s). The work function Ø can be calculated using $Ø = h\nu_0$, where ν_0 is the threshold frequency. Substituting the values gives $Ø = 6.626 \times 10^{-34} \times 3.6 \times 10^{14}$. The maximum kinetic energy K.E. of the photoelectrons is K.E. = $h\nu$ - Ø. Finally, the cut-off potential V_o is given by V_o = K.E./e, where e is the charge of an electron.

Question 11. A voltmeter of resistance 1000 Ω can measure up to 25 V. How will you convert it so that it can read up to 250 V?

[2 Marks]

Answer: To convert a 25 V voltmeter into one that can measure up to 250 V, a resistor of large value (R) needs to be connected in series. The required resistance can be calculated using the formula R = (Vmax/Vmax - Vg) * Rg, where Vmax is the new voltage limit (250

V), Vg is the voltmeter's limit (25 V), and Rg is the voltmeter's resistance (1000 Ω). This ensures accurate readings.

Question 12. The resistance of a wire at 25°C is 10.0 Ω. When heated to 125°C, its resistance becomes 10.5 Ω. Find (i) the temperature coefficient of resistance of the wire, and (ii) the resistance of the wire at 425°C.

[2 Marks]

Answer: To find the temperature coefficient (α), we use α = (R2 - R1) / (R1 * (T2 - T1)). Here, R1 = 10.0 Ω, R2 = 10.5 Ω, T1 = 25°C, and T2 = 125°C. Thus, α = (10.5 - 10.0) / (10.0 * (125 - 25)) = 0.0005/°C. To find the resistance at 425°C, we use R = R1(1 + α(T - T1)), R = 10.0(1 + 0.0005 * (425 - 25)) = 10.0(1 + 0.200) = 12.0 Ω.

Section C

Question 13.

(a) Draw the energy-band diagrams for conductors, semiconductors and insulators at T = 0 K. How is an electron-hole pair formed in a semiconductor at room temperature?

(b) Carbon and silicon both, are members of the IV group of the periodic table and have the same lattice structure. Carbon is an insulator whereas silicon is a semiconductor. Explain.

[3 Marks]

Answer: The energy-band diagrams reveal crucial differences among conductors, semiconductors, and insulators at T = 0 K. In conductors, the conduction and valence bands overlap, allowing free electron movement. For semiconductors, there is a small band gap (about 1.1 eV for silicon) that prevents electron flow at absolute zero but allows thermally generated electron-hole pairs at room temperature. Carbon, while structurally similar, has a significant band gap (5.4 eV) making it an insulator due to lack of available electrons, which contrasts silicon's conductive potential.

Question 14.

A parallel plate capacitor has plate area A and plate separation d. Half of the space between the plates is filled with a material of dielectric constant K in two ways as shown in the figure.

Find the values of the capacitance of the capacitors in the two cases.

[3 Marks]

Answer: To find the capacitance of a parallel plate capacitor partially filled with a dielectric, we consider two configurations. In the first case, where the dielectric occupies only half the separation, the capacitance can be calculated by treating the capacitor as two capacitors in series: one with the dielectric and one without. The equivalent capacitance, C1, is given by C1 = (C0 * Cd) / (C0 + Cd), where C0 is the capacitance without dielectric, and Cd is the capacitance with dielectric. In the second case, where the dielectric fills half the area of the plates, we treat them as capacitors in parallel. The equivalent capacitance, C2, is C2 = C0 + Cd. Both cases depend on the dielectric constant and plate dimensions.

Question 15.

In Young's double slit experiment, the separation between the two slits is 1·0 mm and the screen is 1·0 m away from the slits. A beam of light consisting of two wavelengths 500 nm and 600 nm is used to obtain interference fringes. Calculate :

(i) the distance between the first maxima for the two wavelengths.

(ii) the least distance from the central maximum, where the bright fringes due to both wavelengths coincide.

[3 Marks]

Answer: To find the distance between the first maxima for the wavelengths 500 nm and 600 nm in Young's double slit experiment, we use the formula for the position of maxima: y = (n * λ * L) / d. Here, n=1 (for first maximum), λ is the wavelength, L is the distance to the screen (1 m), and d is the distance between the slits (1 mm). \nFor λ = 500 nm (500 x 10^-9 m): \n y1 = (1 * 500 x 10^-9 m * 1 m) / (1 x 10^-3 m) = 0.5 m = 50 cm. \nFor λ = 600 nm (600 x 10^-9 m): \n y2 = (1 * 600 x 10^-9 m * 1 m) / (1 x 10^-3 m) = 0.6 m = 60 cm. \nTherefore, the distance between the first maxima is |y2 - y1| = |60 cm - 50 cm| = 10 cm.\nTo find the least distance where the bright fringes coincide, we use the condition for coinciding maxima which is n1 * λ1 = n2 * λ2. Solving for the least common multiple gives us n1=6 for 500 nm and n2=5 for 600 nm. Their corresponding positions lead to y = 0.6 m for 600 nm and y = 0.5 m for 500 nm, indicating coinciding at L = 6 * (1/500)*1 m and L = 5 * (1/600)*1 m. The least distance is 30 cm.

Question 16. Differentiate between half-wave and full-wave rectification. With the help of a circuit diagram, explain the working of a full-wave rectifier.

[3 Marks]

Answer: Half-wave rectification allows current to flow only during one half of the AC cycle, utilizing only one diode. It results in a pulsating DC output that contains significant ripple. In contrast, full-wave rectification employs two diodes, allowing current flow during both halves of the AC cycle, leading to a more consistent DC output. The full-wave rectifier circuit features two diodes connected to the secondary of a transformer. During each half cycle, one diode conducts, forwarding the current to the load, thus improving efficiency and reducing ripple in the output voltage waveform. This results in a smoother DC signal suitable for various applications.

Question 17.

A rectangular glass slab ABCD (refractive index 1·5) is surrounded by a transparent liquid (refractive index 1·25) as shown in the figure. A ray of light is incident on face AB at an angle i such that it is refracted out grazing the face AD. Find the value of angle i.

[3 Marks]

Answer: Given: Refractive index of glass, n2 = 1.5; Refractive index of liquid, n1 = 1.25
Explanation:
When light passes from the liquid to glass at face AB, it refracts inside the glass at angle r. The ray inside the glass then emerges from face AD at grazing incidence, meaning the refraction angle at AD is 90deg.
At the face AD, using Snell's law: n2 * sin r2 = n1 * sin 90deg => 1.5 * sin r2 = 1.25 * 1 => sin r2 = 1.25 / 1.5 = 0.8333. So, r2 = arcsin(0.8333) ≈ 56deg.
Since AB and AD are perpendicular faces of the rectangular slab, the sum of refracted angles inside the glass is 90deg (r + r2 = 90deg). Thus, r = 90deg - 56deg = 34deg.
At face AB, applying Snell's law: n1 * sin i = n2 * sin r => 1.25 * sin i = 1.5 * sin 34deg => sin i = (1.5 / 1.25) * sin 34deg = 1.2 * 0.5592 = 0.671.
Therefore, i = arcsin 0.671 ≈ 42deg.
Final answer: The angle of incidence i is approximately 42deg.

Section D

Question 18.

(i) Define the term mutual inductance. Deduce the expression for the mutual inductance of two long coaxial solenoids of the same length having different radii and different number of turns.

(ii) The current through an inductor is uniformly increased from zero to 2 A in 40 s. An emf of 5 mV is induced during this period. Find the flux linked with the inductor at t = 10 s.

[5 Marks]

Answer: (i) Definition of Mutual Inductance: Mutual inductance is the property of two coils whereby a change in current in one coil induces an emf in the other coil. If I_2 is the current in coil 2 and Φ_1 is the magnetic flux linked with coil 1 due to coil 2, then $\Phi_1 = MI_2$ where M is the mutual inductance.

Derivation of Mutual Inductance M for two long coaxial solenoids:
Consider two long coaxial solenoids of the same length l. The inner solenoid S_1 has radius r_1 and number of turns per unit length n_1. The outer solenoid S_2 has radius r_2 and number

of turns per unit length n_2.

The magnetic field inside the outer solenoid S_2 due to current I_2 is $B = \mu_0 n_2 I_2$.

Since the inner solenoid lies within the outer, the flux linked with the inner solenoid is due to this magnetic field.

Flux linked with one turn of inner solenoid = B × area of cross-section of inner solenoid = $\mu_0 n_2 I_2 \pi r_1^2$.

Total flux linked with inner solenoid having N_1 turns = N_1 × (flux per turn) = $n_1 l \times \mu_0 n_2 I_2 \pi r_1^2$.

Thus, $\Phi_1 = \mu_0 \pi r_1^2 n_1 n_2 l I_2$.

From definition, $\Phi_1 = M I_2$, so mutual inductance $M = \mu_0 \pi r_1^2 n_1 n_2 l$.

(ii) Calculation of flux linked at t = 10 s:

Given: Current I increases uniformly from 0 to 2 A in 40 s. emf $\varepsilon = 5$ mV $= 5 \times 10^{-3}$ V.

emf induced in an inductor, $\varepsilon = L\, dI/dt$ where L is the inductance.

Since I changes uniformly, $dI/dt = (2 - 0) / 40 = 1/20$ A/s = 0.05 A/s.

So, $L = \varepsilon / (dI/dt) = (5 \times 10^{-3}) / 0.05 = 0.1$ H.

The flux linked with the inductor at any time t is $\Phi = L I$.

At t = 10 s, current I = (2 / 40) × 10 = 0.5 A.

Therefore, flux $\Phi = 0.1 \times 0.5 = 0.05$ Wb.

Final answers:

(i) $M = \mu_0 \pi r_1^2 n_1 n_2 l$

(ii) Flux linked at t = 10 s is 0.05 Weber.