

CLASS 12

PHYSICS

EXTRA QUESTIONS

Class 12 Physics Chapter 11 Dual Nature of Radiation and Matter – Extra Questions with Answers

These extra practice questions for Class 12 Physics Chapter 11 – Dual Nature of Radiation and Matter go beyond the NCERT textbook exercises to reinforce the photoelectric effect, Einstein's photoelectric equation, and de Broglie's matter waves. Useful for board exam revision and quick concept checks.

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Very Short Answer Type Questions (1 Mark)

Q1. Define work function of a metal. State its SI unit.

Ans: The work function is the minimum energy needed to just free an electron from the surface of a metal, without giving it any extra kinetic energy. It is measured in joules (J), though it is more commonly expressed in electron-volts (eV) for convenience.

Q2. What is meant by “threshold frequency” in the photoelectric effect?

Ans: The threshold frequency is the minimum frequency of incident light below which no photoelectric emission occurs from a given metal surface, no matter how intense the light is. At exactly the threshold frequency, emitted electrons have zero kinetic energy.

Q3. Two metals A and B have work functions 4 eV and 2 eV respectively. Which metal will emit photoelectrons first as the frequency of incident light is gradually increased from a low value?

Ans: **Metal B** (work function 2 eV) will start emitting photoelectrons first, since a lower work function means a lower threshold frequency is needed to begin emission.

Q4. Write the mathematical expression for the de Broglie wavelength of a particle in terms of its momentum.

Ans: $\lambda = h/p$, where h is Planck's constant and p is the momentum of the particle.

Short Answer Type Questions (2–3 Marks)

Q5. State the three main experimental observations of the photoelectric effect that could not be explained by the wave theory of light.

Ans: (1) Photoelectric emission is instantaneous, with no observable time lag, even for very weak incident light — wave theory predicts electrons would need time to accumulate enough energy. (2) Below the threshold frequency, no emission occurs at all, regardless of intensity — wave theory predicts sufficiently intense light of any frequency should eventually eject electrons. (3) The maximum kinetic energy of emitted electrons depends only on the frequency of light, not its intensity — wave theory predicts more intense light should give electrons more energy.

Q6. State Einstein's photoelectric equation and explain each term.

Ans: $KE_{\max} = h\nu - \phi_0$, where $h\nu$ is the energy of the incident photon absorbed by the electron, ϕ_0 is the work function (minimum energy needed to escape the metal surface), and $KE_{\max}$ is the maximum kinetic energy carried away by the emitted photoelectron. Since each photon interacts with only one electron and transfers its energy instantaneously, this equation explains both the frequency threshold and the lack of a time lag.

Q7. Why does the de Broglie wavelength of a moving cricket ball have no observable effect, while the de Broglie wavelength of an electron accelerated through a small voltage is significant enough to cause diffraction?

Ans: $\lambda = h/(mv)$, and Planck's constant h is extremely small (6.626×10^{-34} Js). A cricket ball's mass and speed make its momentum enormous by comparison, giving a wavelength far too small (many orders of magnitude smaller than the ball itself) to ever produce observable wave effects. An electron's mass is about 10^{-31} kg, so even at modest speeds its momentum is small enough that λ becomes comparable to atomic spacings in a crystal, making diffraction effects readily observable — as demonstrated by the Davisson-

Germer experiment.

Higher Order Thinking Skills (HOTS)

Q8. In a photoelectric experiment, the stopping potential is found to increase linearly with the frequency of incident light, but the graph does not pass through the origin. What does the intercept on the frequency axis represent, and how would the graph shift for a metal with a higher work function?

Ans: The equation $eV_0 = h\nu - \phi_0$ can be rewritten as $V_0 = (h/e)\nu - (\phi_0/e)$, a straight line with slope h/e . The frequency-axis intercept is the **threshold frequency $\nu_0 = \phi_0/h$** — the point where $V_0 = 0$. For a metal with a higher work function, the entire line shifts to the right (a larger threshold frequency is needed before any stopping potential becomes positive), while the slope h/e stays exactly the same since it depends only on universal constants, not on the metal.

Q9. An electron and a proton are each accelerated from rest through the same potential difference. Which one has the larger de Broglie wavelength, and why?

Ans: For a charge q accelerated through potential V , kinetic energy $= qV$, and momentum $p = \sqrt{2mqV}$ — then $\lambda = h/p = h/\sqrt{2mqV}$. Since both particles carry the same charge magnitude and are accelerated through the same V , λ is inversely proportional to $\sqrt{m}$. The **electron has the larger de Broglie wavelength**, since its mass ($\approx 9.11 \times 10^{-31} \text{ kg}$) is about 1836 times smaller than the proton's mass, making the electron's $\sqrt{m}$ much smaller and hence λ much larger.

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