

## Dual Nature of Radiation and Matter — CBSE Pattern Test 1

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

### Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 12 Physics · Dual Nature of Radiation and Matter · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A ( $1 \times 10$ ), Section B ( $2 \times 4$ ), Section C ( $3 \times 4$ ) and Section D ( $5 \times 2$ ) — total 40 marks. Time allowed: 90 minutes.  
(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.  
(3) For MCQ questions choose the single correct option; for VSA answers write a single line.  
(4) Take  $g = 10 \text{ m/s}^2$ . All symbols carry their usual meaning. Use of a calculator is not permitted.

#### Section A — MCQ & VSA ( $10 \times 1 = 10$ marks)

- The photoelectric effect demonstrates the
  - particle nature of light
  - wave nature of light
  - polarisation of light
  - dispersion of light
- The photoelectric current is proportional to the
  - intensity of incident light
  - frequency of incident light
  - work function
  - stopping potential
- Einstein's photoelectric equation is
  - $h\nu = \phi_0 + K_{\text{max}}$
  - $h\nu = \phi_0 - K_{\text{max}}$
  - $h\nu = \phi_0 \times K_{\text{max}}$
  - $h\nu = K_{\text{max}} / \phi_0$
- The stopping potential  $V_0$  is related to  $K_{\text{max}}$  by
  - $K_{\text{max}} = eV_0$
  - $K_{\text{max}} = V_0/e$
  - $K_{\text{max}} = e/V_0$
  - $K_{\text{max}} = V_0$
- The threshold frequency is given by
  - $\phi_0/h$
  - $h/\phi_0$
  - $h\phi_0$
  - $\phi_0 h$
- A graph of  $K_{\text{max}}$  against frequency is a straight line whose slope is
  - Planck's constant  $h$
  - the work function
  - the threshold frequency
  - $e/h$
- The de Broglie wavelength of a particle of mass  $m$  moving with velocity  $v$  is
  - $h/mv$

- (B)  $mv/h$   
 (C)  $hmv$   
 (D)  $h/(m+v)$
8. The Davisson-Germer experiment demonstrated the  
 (A) wave nature of electrons  
 (B) particle nature of light  
 (C) photoelectric effect  
 (D) existence of the nucleus
9. What is the work function of a metal?
10. State the de Broglie hypothesis.

### Section B — Short Answer I ( $4 \times 2 = 8$ marks)

11. The threshold wavelength of a metal is 500 nm. Find its work function. (Take  $hc = 1240 \text{ eV}\cdot\text{nm}$ )
12. Light of wavelength 400 nm falls on a metal of work function 2 eV. Find the maximum kinetic energy of the emitted electrons.
13. Calculate the de Broglie wavelength of an electron accelerated through a potential of 100 V.
14. What is the stopping potential? Write its relation to the maximum kinetic energy.

### Section C — Short Answer II ( $4 \times 3 = 12$ marks)

15. State the laws of photoelectric emission and explain how Einstein's equation accounts for them.
16. Derive Einstein's photoelectric equation and explain threshold frequency, work function and stopping potential.
17. Draw the graphs of (i) photocurrent versus potential and (ii)  $K_{\text{max}}$  versus frequency, and explain each.
18. State the de Broglie hypothesis and derive the de Broglie wavelength of an electron accelerated through a potential  $V$ .

### Section D — Long Answers ( $2 \times 5 = 10$ marks)

19. Describe an experiment to study the photoelectric effect. State its laws and explain how Einstein's photoelectric equation explains the dependence of photocurrent and stopping potential on intensity and frequency.
20. What is the de Broglie hypothesis? Derive the expression for the de Broglie wavelength of an accelerated electron and describe the Davisson-Germer experiment that verifies it.

### Answer Key (Marking Scheme)

- Q1 — (A) particle nature of light. Q2 — (A) intensity of incident light. Q3 — (A)  $h\nu = \phi_0 + K_{\text{max}}$ . Q4 — (A)  $K_{\text{max}} = eV_0$ .
- Q5 — (A)  $\phi_0/h$ . Q6 — (A) Planck's constant  $h$ . Q7 — (A)  $h/mv$ . Q8 — (A) wave nature of electrons.
- Q9 — The minimum energy required to eject an electron from a metal surface.
- Q10 — Every moving particle has an associated wave of wavelength  $\lambda = h/mv$ .
- Q11 —  $\phi_0 = 1240/500 = 2.48 \text{ eV}$ .
- Q12 —  $E = 1240/400 = 3.1 \text{ eV}$ ;  $K_{\text{max}} = 3.1 - 2 = 1.1 \text{ eV}$ .
- Q13 —  $\lambda = 12.27/\sqrt{100} \text{ \AA} = 1.23 \text{ \AA} \approx 1.23 \times 10^{-10} \text{ m}$ .
- Q14 — The minimum reverse potential that stops the photocurrent;  $K_{\text{max}} = eV_0$ .

Q15 — Laws as in notes; Einstein's equation  $h\nu = \phi_0 + K_{\text{max}}$  gives the frequency dependence and explains instantaneous emission.

Q16 — See notes;  $h\nu = \phi_0 + K_{\text{max}}$ , with  $\phi_0 = h\nu_0$  and  $K_{\text{max}} = eV_0$ .

Q17 — Saturation current intensity; stopping potential depends only on frequency;  $K_{\text{max}}-\nu$  line has slope  $h$  and intercept  $-\phi_0$ .

Q18 —  $\lambda = h/mv$ ; with  $eV = \frac{1}{2}mv^2$ ,  $\lambda = h/\sqrt{2meV}$ .

Q19 — Photocell with collector voltage; laws of emission; Einstein's equation explains all observations.

Q20 —  $\lambda = h/\sqrt{2meV} = 12.27/\sqrt{V} \text{ \AA}$ ; Davisson and Germer diffracted electrons from a nickel crystal, confirming the wave nature.