

## Dual Nature of Radiation and Matter — CBSE Pattern Test 2

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

### Test 2 — 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 work function of a metal is the
  - minimum energy needed to eject an electron
  - maximum kinetic energy of an electron
  - threshold frequency
  - stopping potential
- Photoelectric emission occurs only when the incident frequency is
  - greater than the threshold frequency
  - less than the threshold frequency
  - equal to zero
  - independent of threshold
- Increasing the intensity of incident light (above threshold) increases the
  - number of photoelectrons
  - kinetic energy of photoelectrons
  - threshold frequency
  - work function
- The stopping potential depends on the
  - frequency of light
  - intensity of light
  - distance of source
  - area of the metal
- The intercept of the  $K_{\text{max}}-\nu$  graph on the frequency axis gives the
  - threshold frequency
  - work function
  - stopping potential
  - Planck's constant
- The de Broglie wavelength of an electron accelerated through potential  $V$  is proportional to
  - $1/\sqrt{V}$
  - $\sqrt{V}$
  - $V$
  - $1/V$
- In the Davisson-Germer experiment, electrons are diffracted by
  - a nickel crystal

- (B) a glass prism  
 (C) a single slit  
 (D) a diffraction grating
8. For a particle of kinetic energy  $E$ , the de Broglie wavelength is  
 (A)  $h/\sqrt{2mE}$   
 (B)  $\sqrt{2mE}/h$   
 (C)  $h/(2mE)$   
 (D)  $2mE/h$
9. Write Einstein's photoelectric equation.
10. What is stopping potential?

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

11. Light of wavelength 300 nm is incident on a metal of work function 2.2 eV. Find the stopping potential. (Take  $hc = 1240 \text{ eV}\cdot\text{nm}$ )
12. An electron is accelerated through 500 V. Find its de Broglie wavelength.
13. The maximum kinetic energy of a photoelectron is 1.5 eV. Find the stopping potential.
14. Find the de Broglie wavelength of an electron moving with a speed of  $10^6 \text{ m/s}$ .

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

15. What is the photoelectric effect? State its laws and explain them using Einstein's photoelectric equation.
16. What is the de Broglie hypothesis? Derive its expression for a particle of mass  $m$  and kinetic energy  $E$ .
17. Explain, using graphs, how the stopping potential and the maximum kinetic energy vary with the frequency and intensity of incident light.
18. Describe the Davisson-Germer experiment and state its significance.

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

19. Explain the photoelectric effect. Derive Einstein's photoelectric equation and use it to explain the effect of (i) intensity and (ii) frequency on photoelectric emission. Draw the  $K_{\text{max}}$ -frequency graph.
20. State the de Broglie hypothesis. Derive the de Broglie wavelength of an electron accelerated through a potential  $V$  and describe how the Davisson-Germer experiment verifies the wave nature of electrons.

### Answer Key (Marking Scheme)

- Q1 — (A) minimum energy needed to eject an electron. Q2 — (A) greater than the threshold frequency. Q3 — (A) number of photoelectrons. Q4 — (A) frequency of light.
- Q5 — (A) threshold frequency. Q6 — (A)  $1/\sqrt{V}$ . Q7 — (A) a nickel crystal. Q8 — (A)  $h/\sqrt{2mE}$ .
- Q9 —  $h\nu = \phi_0 + K_{\text{max}}$ .
- Q10 — The minimum reverse potential that just stops the photocurrent.
- Q11 —  $E = 1240/300 \approx 4.13 \text{ eV}$ ;  $V_0 = 4.13 - 2.2 = 1.93 \text{ V}$ .
- Q12 —  $\lambda = 12.27/\sqrt{500} \text{ \AA} \approx 0.55 \text{ \AA}$ .
- Q13 —  $V_0 = K_{\text{max}}/e = 1.5 \text{ V}$ .
- Q14 —  $\lambda = h/mv \approx 7.3 \times 10^{-10} \text{ m}$ .

Q15 — Laws as in notes;  $h\nu = \phi_0 + K_{\text{max}}$  explains them.

Q16 —  $\lambda = h/mv$ ; with  $E = \frac{1}{2}mv^2$ ,  $\lambda = h/\sqrt{2mE}$ .

Q17 — Stopping potential and  $K_{\text{max}}$  depend only on frequency (linear); saturation current depends on intensity.

Q18 — Electrons diffracted by a nickel crystal; verifies de Broglie's hypothesis.

Q19 — See Q15;  $K_{\text{max}}-\nu$  line has slope  $h$ , intercept  $-\phi_0$ , showing a threshold frequency.

Q20 —  $\lambda = h/\sqrt{2meV} = 12.27/\sqrt{V} \text{ \AA}$ ; Davisson-Germer diffraction confirms it.