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Dual Nature of Radiation and Matter — CBSE Class 12 Physics Chapter Test

FREE CHAPTER TEST · CLASS XII · PHYSICS (042) · PATTERN OF THE CBSE SAMPLE QUESTION PAPER 2026-27

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
1½ hours	37	17 (A 8 · B 3 · C 3 · D 1 · E 2)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 17 questions. All questions are compulsory.
2. This question paper is divided into five sections: A, B, C, D and E.
3. Section A (Q1–8) contains 6 multiple choice questions and 2 assertion-reason based questions of 1 mark each.
4. Section B (Q9–11) contains short answer questions of 2 marks each.
5. Section C (Q12–14) contains short answer questions of 3 marks each.
6. Section D (Q15) contains case study based questions of 4 marks each, with four sub-parts of 1 mark.
7. Section E (Q16–17) contains long answer questions of 5 marks each.
8. There is no overall choice. However, an internal choice has been provided in 1 question in Section B, 1 question in Section C, 2 questions in Section E. Attempt only one of the alternatives in such questions.
9. Use of calculators is not allowed. You may use: $h = 6.63 \times 10^{-34}$ J s, $c = 3 \times 10^{8}$ m s^{-1}, $e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg, $m_p = 1.67 \times 10^{-27}$ kg.
10. This chapter test follows the section structure, question types and marks per question of the CBSE Class XII Physics (042) Sample Question Paper 2026-27, at about half the length of the 70-mark board paper: 37 marks in 1½ hours.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 1½ hours before you look at them.

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Chapter: Dual Nature of Radiation and Matter · **Topics:** Electron emission and work function · Photoelectric effect and its laws · Einstein's photoelectric equation · Photons · de Broglie waves

SECTION A

This section comprises 8 questions of 1 mark each: 6 multiple choice questions (MCQs) and 2 assertion-reason based questions.

1. The energy of a photon of wavelength 600 nm is about 1

(A) 1.24 eV (B) 2.07 eV

(C) 3.31 eV (D) 4.14 eV

2. Light whose photons have an energy of 3.0 eV falls on a metal of work function 2.0 eV. The stopping potential is 1

(A) 3.0 V (B) 5.0 V

(C) 2.0 V (D) 1.0 V

3. The threshold wavelength for a metal of work function 2.5 eV is about 1

(A) 497 nm (B) 248 nm

(C) 994 nm (D) 310 nm

4. In the photoelectric effect, the maximum kinetic energy of the emitted electrons depends on the 1

(A) intensity of the light (B) time for which light falls

(C) frequency of the light (D) area of the surface lit

5. The de Broglie wavelength of an electron accelerated from rest through 100 V is about 1

(A) 0.123 nm (B) 1.23 nm

(C) 12.3 nm (D) 0.0123 nm

6. An electron and a proton have the same de Broglie wavelength. Then they have 1

(A) the same speed (B) the same kinetic energy

(C) the same momentum (D) the same total energy

7. **Assertion (A) :** Photoelectric emission begins practically at once (within about 10^{-9} s) when light of a suitable frequency falls on the metal, however faint the light. 1

Reason (R) : The stopping potential increases with the frequency of the incident light.

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

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

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

(D) Assertion (A) is false and Reason (R) is also false.

8. **Assertion (A) :** Increasing the intensity of the incident light increases the maximum kinetic energy of the photoelectrons. 1

Reason (R) : Each photon of more intense light carries more energy.

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

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

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

(D) Assertion (A) is false and Reason (R) is also false.

SECTION B

This section comprises 3 short answer questions of 2 marks each.

9. A green laser of wavelength 532 nm has a power of 5.0 mW. Find the energy of each photon (in eV) and the number of photons it emits per second. 2

10. (a) Write Einstein's photoelectric equation. Use it to explain why there is a threshold frequency below which no electrons are emitted, however intense the light. 2

OR

(b) Find the de Broglie wavelength of an electron of kinetic energy 50 eV, and of a ball of mass 0.10 kg moving at 10 m s^{-1}. Why are wave effects not observed for the ball?

11. In a photoelectric experiment, the stopping potential is 0.50 V for light of frequency 6.0×10^{14} Hz and 1.30 V for light of frequency 8.0×10^{14} Hz. Find Planck's constant from these data, and the threshold frequency of the metal. 2

SECTION C

This section comprises 3 short answer questions of 3 marks each.

12. (a) (i) Write Einstein's photoelectric equation in terms of the stopping potential. 3

(ii) Describe the graphs of stopping potential against frequency for two metals A and B, where A has the smaller work function. Do they have the same slope? What does the slope give?

(iii) Where does each graph cut the frequency axis?

OR

(b) Light of wavelength 400 nm falls on a metal of work function 2.3 eV. Find the maximum kinetic energy of the photoelectrons, the stopping potential and the maximum speed of the photoelectrons.

13. Show that the de Broglie wavelength of a particle of mass m and charge q accelerated from rest through a potential difference V is $h/\sqrt{(2mqV)}$. Hence find the ratio of the de Broglie wavelength of an electron to that of a proton, both accelerated through the same potential difference. 3

14. (i) How does the saturation photocurrent change when the intensity of the incident light is doubled (frequency fixed)? Why? 3

(ii) Does the stopping potential change? Why?

(iii) Why could the wave theory of light not explain the existence of a threshold frequency?

SECTION D

This section comprises 1 case study based question of 4 marks, with four sub-parts of 1 mark each.

15. Light sensors in some automatic doors and street lights use a photocell. Light falling on a metal surface of work function 2.1 eV inside the cell releases electrons, and the resulting current switches the circuit. ($h = 6.63 \times 10^{-34}$ J s, $c = 3 \times 10^{8}$ m s^{-1})

(I) The threshold wavelength of the metal is about

(A) 296 nm (B) 420 nm (C) 592 nm (D) 1180 nm [1]

(II) For light of wavelength 450 nm, the maximum kinetic energy of the emitted electrons is about

(A) 0.66 eV (B) 2.76 eV (C) 2.10 eV (D) 4.86 eV [1]

(III) Red light of wavelength 700 nm falling on the cell releases

(A) electrons with less kinetic energy (B) electrons with more kinetic energy (C) more electrons (D) no electrons [1]

(IV) If the intensity of the 450 nm light is doubled, the photocell

(A) emits electrons with twice the maximum kinetic energy (B) gives twice the current, with the same maximum kinetic energy (C) gives half the current (D) is not affected at all [1]

SECTION E

This section comprises 2 long answer questions of 5 marks each.

16. (a) (i) State the main experimental observations of the photoelectric effect and explain how the photon picture of light accounts for them. 5

(ii) When light of wavelength 250 nm falls on a metal, the stopping potential is 2.0 V. Find the work function of the metal and its threshold wavelength.

OR

(b) (i) State de Broglie's hypothesis. Derive the expression for the de Broglie wavelength of an electron accelerated from rest through a potential difference V, and show that it is about $1.23/\sqrt{V}$ nm.

(ii) Through what potential difference must an electron be accelerated to have a de Broglie wavelength of 0.10 nm? What is its speed then?

17. (a) (i) Write any four properties of photons. How is the intensity of light related to photons? 5

(ii) A 100 W lamp gives out 5.0 % of its power as light of average wavelength 550 nm. Find the number of photons of light it emits per second, and the momentum of each photon.

OR

(b) (i) Describe how the photoelectric current varies with the potential of the collector (anode) plate (I) for light of the same frequency but different intensities and (II) for light of the same intensity but different frequencies.

(ii) Light of wavelength 400 nm falls on three metals of work functions 1.9 eV, 2.5 eV and 4.3 eV. Which of them emit photoelectrons? Find the maximum kinetic energy of the electrons from each one that does.

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
(B)	(D)	(A)	(C)	(A)	(C)	(B)	(D)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (B). $E = hc/\lambda = 6.63 \times 10^{-34} \times 3 \times 10^{8}/(600 \times 10^{-9}) \approx 3.3 \times 10^{-19}$ J ≈ 2.07 eV.

Q2. Answer (D). $K_{max} = h\nu - \varphi_0 = 1.0$ eV, so $eV_0 = 1.0$ eV and $V_0 = 1.0$ V.

Q3. Answer (A). $\lambda_0 = hc/\varphi_0 = 6.63 \times 10^{-34} \times 3 \times 10^{8}/(2.5 \times 1.6 \times 10^{-19}) \approx 4.97 \times 10^{-7}$ m.

Q4. Answer (C). $K_{max} = h\nu - \varphi_0$ depends only on the frequency (for a given metal).

Q5. Answer (A). $\lambda = h/\sqrt{(2meV)} = 1.227/\sqrt{100}$ nm ≈ 0.123 nm.

Q6. Answer (C). $\lambda = h/p$: equal λ means equal momentum.

Q7. Answer (B). A is true (one photon gives its energy to one electron at once). R is true ($eV_0 = h\nu - \varphi_0$) but does not explain A. Answer (B).

Q8. Answer (D). More intense light (same frequency) has more photons, each of the same energy hν, so K_{max} does not change. Both statements are false. Answer (D).

Q9. (2 marks) Answer: ≈ 2.34 eV; ≈ 1.3×10^{16} s^{-1}.
$E = hc/\lambda = 6.63 \times 10^{-34} \times 3 \times 10^{8}/532 \times 10^{-9} \approx 3.74 \times 10^{-19}$ J ≈ 2.34 eV. [1]
$n = P/E = 5.0 \times 10^{-3}/3.74 \times 10^{-19} \approx 1.3 \times 10^{16}$ photons per second. [1]

Q10. (2 marks) Answer: (a) $K_{max} = h\nu - \varphi_0$; (b) ≈ 0.17 nm; ≈ 6.6×10^{-34} m.
(a) $K_{max} = h\nu - \varphi_0$ (or $eV_0 = h\nu - \varphi_0$). [1]
An electron absorbs one photon of energy hν. If $h\nu < \varphi_0$ it cannot escape, and more intense light only means more such photons, none of which can free an electron. So emission needs $\nu \geq \nu_0 = \varphi_0/h$. [1]
OR (b) $\lambda = h/\sqrt{(2mK)} = 6.63 \times 10^{-34}/\sqrt{(2 \times 9.1 \times 10^{-31} \times 50 \times 1.6 \times 10^{-19})} \approx 1.7 \times 10^{-10}$ m (≈ 0.17 nm). [1]
For the ball $\lambda = h/mv = 6.63 \times 10^{-34}/(0.10 \times 10) \approx 6.6 \times 10^{-34}$ m — far too small to show any wave effect. [1]

Q11. (2 marks) Answer: 6.4×10^{-34} J s; 4.75×10^{14} Hz.
$eV_0 = h\nu - \varphi_0$: $e(1.30 - 0.50) = h(8.0 - 6.0) \times 10^{14}$, so $h = 1.6 \times 10^{-19} \times 0.80/2.0 \times 10^{14} = 6.4 \times 10^{-34}$ J s. [1]
$V_0 = 0$ at ν_0: $\nu_0 = 6.0 \times 10^{14} - 0.50/(0.80/2.0 \times 10^{14}) = 6.0 \times 10^{14} - 1.25 \times 10^{14} = 4.75 \times 10^{14}$ Hz. [1]

Q12. (3 marks) Answer: (a) same slope h/e; intercepts at ν_0; (b) ≈ 0.81 eV; ≈ 0.81 V; ≈ 5.3×10^{5} m s^{-1}.
(a) (i) $eV_0 = h\nu - \varphi_0$, i.e. $V_0 = (h/e)\nu - \varphi_0/e$. [1]
(ii) Both are straight lines with the same slope h/e (a universal constant, independent of the metal); B's line lies to the right of A's. [1]
(iii) At the threshold frequency $\nu_0 = \varphi_0/h$ of each metal, so A cuts the axis at a lower frequency than B. [1]
OR (b) $h\nu = hc/\lambda = 6.63 \times 10^{-34} \times 3 \times 10^{8}/(400 \times 10^{-9} \times 1.6 \times 10^{-19}) \approx 3.11$ eV; $K_{max} = 3.11 - 2.3 \approx 0.81$ eV. [1]
$V_0 \approx 0.81$ V. [1]
$v = \sqrt{(2K/m)} = \sqrt{(2 \times 0.81 \times 1.6 \times 10^{-19}/9.1 \times 10^{-31})} \approx 5.3 \times 10^{5}$ m s^{-1}. [1]

Q13. (3 marks) Answer: $\lambda = h/\sqrt{(2mqV)}$; ≈ 43.
$qV = \frac{1}{2}mv^2 = p^2/2m$, so $p = \sqrt{(2mqV)}$ and $\lambda = h/p = h/\sqrt{(2mqV)}$. [1]
Same q (magnitude) and V: $\lambda_e/\lambda_p = \sqrt{(m_p/m_e)}$ [1] = $\sqrt{(1.67 \times 10^{-27}/9.1 \times 10^{-31})} \approx \sqrt{1835} \approx 43$. [1]

Q14. (3 marks) Answer: (i) doubles; (ii) no change.

(i) It doubles: twice as many photons strike the surface per second, freeing twice as many electrons. [1]

(ii) No: each photon still has energy hν, so $K_{max} = eV_0$ is unchanged. [1]

(iii) In wave theory the energy delivered depends on the intensity, so any frequency should eject electrons if the light is intense enough (or after a long enough time); this is not what is observed. [1]

Q15. (4 marks) Answer: (I) C; (II) A; (III) D; (IV) B.

(I) (C) $\lambda_0 = hc/\varphi_0 = 6.63 \times 10^{-34} \times 3 \times 10^8/(2.1 \times 1.6 \times 10^{-19}) \approx 592$ nm. [1]

(II) (A) $hc/\lambda \approx 2.76$ eV; $K_{max} \approx 2.76 - 2.1 = 0.66$ eV. [1]

(III) (D) 700 nm > λ_0 (photon energy ≈ 1.78 eV < 2.1 eV): no emission. [1]

(IV) (B) Twice the photons give twice the electrons; each photon's energy is unchanged. [1]

Q16. (5 marks) Answer: (a) ≈ 2.97 eV; ≈ 418 nm; (b) $\lambda \approx 1.23/\sqrt{V}$ nm; ≈ 151 V; $\approx 7.3 \times 10^6$ m s⁻¹.

(a) (i) Any three with explanation [3]: (1) There is a threshold frequency ν_0 for each metal — a photon must have $h\nu \geq \varphi_0$ to free an electron. (2) Above ν_0, K_{max} rises linearly with ν and does not depend on intensity — $K_{max} = h\nu - \varphi_0$. (3) The photocurrent is proportional to the intensity — intensity is the number of photons per second. (4) Emission is instantaneous — energy is delivered in one photon, not accumulated.

(ii) $hc/\lambda = 6.63 \times 10^{-34} \times 3 \times 10^8/(250 \times 10^{-9} \times 1.6 \times 10^{-19}) \approx 4.97$ eV; $\varphi_0 = 4.97 - 2.0 \approx 2.97$ eV. [1] $\lambda_0 = hc/\varphi_0 \approx 1.243 \times 10^{-6}/2.97$ m ≈ 418 nm. [1]

OR (b) (i) Moving particles of matter have wave properties: a particle of momentum p has wavelength $\lambda = h/p$ (as a photon of momentum p has $\lambda = h/p$). [1] For an electron accelerated through V: $eV = p^2/2m$, so $\lambda = h/\sqrt{(2meV)} = 6.63 \times 10^{-34}/\sqrt{(2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times V)} \approx 1.23/\sqrt{V}$ nm. [2]

(ii) $V = h^2/(2me\lambda^2) = (6.63 \times 10^{-34})^2/(2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 10^{-20}) \approx 151$ V. [1] $v = h/(m\lambda) \approx 7.3 \times 10^6$ m s⁻¹. [1]

Q17. (5 marks) Answer: (a) $\approx 1.4 \times 10^{19}$ s⁻¹; $\approx 1.2 \times 10^{-27}$ kg m s⁻¹; (b) 1.9 eV and 2.5 eV metals; ≈ 1.21 eV, ≈ 0.61 eV.

(a) (i) Any four [1½]: energy $E = h\nu$; momentum $p = h/\lambda = h\nu/c$; travel at c in vacuum; zero rest mass; electrically neutral (not deflected by E or B); in collisions energy and momentum are conserved, but the number of photons may change. For a given frequency, the intensity is proportional to the number of photons crossing unit area per second. [½]

(ii) Light power = 5.0 W; $E = hc/\lambda \approx 3.62 \times 10^{-19}$ J; $n = 5.0/3.62 \times 10^{-19} \approx 1.4 \times 10^{19}$ s⁻¹. [2] $p = h/\lambda = 6.63 \times 10^{-34}/550 \times 10^{-9} \approx 1.2 \times 10^{-27}$ kg m s⁻¹. [1]

OR (b) (i) Current against anode potential [3]: at a fixed frequency, curves for higher intensity have higher saturation currents but meet the voltage axis at the same stopping potential $-V_0$. At a fixed intensity, curves for higher frequency have the same saturation current but a larger stopping potential. The current falls to zero at $-V_0$, where $eV_0 = K_{max}$.

(ii) $h\nu = hc/400$ nm ≈ 3.11 eV. Only the metals of work function 1.9 eV and 2.5 eV emit (4.3 eV > 3.11 eV). [1] $K_{max} \approx 1.21$ eV and 0.61 eV. [1]

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