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Atoms — 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, $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}, $1/4\pi\varepsilon_0 = 9 \times 10^{9}$ N m^2 C^{-2}.
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: Atoms · **Topics:** Alpha-particle scattering and Rutherford's model · Atomic spectra · Bohr's model of the hydrogen atom · Energy levels and line spectra · de Broglie's explanation of Bohr's postulate

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 the electron in the n = 3 orbit of a hydrogen atom is 1

(A) −4.53 eV (B) −3.40 eV

(C) −1.51 eV (D) −0.85 eV

2. The radius of the first Bohr orbit of hydrogen is 0.53 Å. The radius of the n = 2 orbit is 1

(A) 1.06 Å (B) 2.12 Å

(C) 0.265 Å (D) 4.77 Å

3. The energy needed to ionise a hydrogen atom in its ground state is 1

(A) 3.4 eV (B) 10.2 eV

(C) 1.51 eV (D) 13.6 eV

4. In the alpha-particle scattering experiment, most alpha particles passed through the gold foil undeflected. This shows that 1

(A) most of the atom is empty space (B) electrons move in fixed orbits

(C) the positive charge is spread uniformly through the atom (D) the nucleus contains neutrons

5. The Lyman series of hydrogen lies in the 1

(A) infrared region (B) visible region

(C) microwave region (D) ultraviolet region

6. The wavelength of the photon emitted when the electron of a hydrogen atom drops from n = 2 to n = 1 is about 1

(A) 656 nm (B) 122 nm

(C) 91 nm (D) 486 nm

7. **Assertion (A) :** The spectrum of atomic hydrogen consists of discrete lines. 1
Reason (R) : The total energy of the electron in a Bohr orbit is negative.

(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) :** In Bohr's model, the angular momentum of the electron in a stationary orbit is an integral multiple of $h/2\pi$. 1

Reason (R) : An electron in a Bohr orbit radiates energy continuously.

(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. Find the speed of the electron in the ground state of a hydrogen atom. What is its speed in the n = 3 orbit? 2

10. (a) An alpha particle of kinetic energy 5.0 MeV moves head-on towards a gold nucleus (Z = 79). Find its distance of closest approach. 2

OR

(b) What is meant by the impact parameter in the alpha-particle scattering experiment? How is the scattering angle for b = 0 different from that for a large b?

11. Hydrogen atoms are excited to the n = 4 level. How many different spectral lines can they emit as they return to the ground state? Which transition gives the longest wavelength? 2

SECTION C

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

12. (a) State Bohr's postulates for the hydrogen atom. Using them, derive the expression for the radius of the n-th orbit. 3

OR

(b) (i) Using de Broglie's hypothesis, explain Bohr's second postulate of quantisation of angular momentum.

(ii) Find the de Broglie wavelength of the electron in the first Bohr orbit (radius 0.53 Å).

13. Using the Rydberg formula with $R = 1.097 \times 10^{7}\ m^{-1}$, find the longest and the shortest wavelengths of the Balmer series of hydrogen. In which region of the spectrum do they lie? 3

14. A hydrogen atom in its ground state absorbs a photon of energy 12.09 eV. (i) To which level is it raised? (ii) How many spectral lines can it emit while returning to the ground state? (iii) Which of these lines is in the visible region? 3

SECTION D

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

15. A glass tube filled with hydrogen at low pressure glows when a high voltage is applied. Seen through a spectroscope, its light is not a continuous band but a set of bright lines — a red line at 656 nm, a blue-green line at 486 nm and two violet lines. These lines belong to the Balmer series.

(I) The red line (656 nm) is due to the transition
(A) n = 2 to n = 1 (B) n = 3 to n = 2 (C) n = 4 to n = 2 (D) n = 3 to n = 1 [1]

(II) The energy of a photon of the red line is about
(A) 10.2 eV (B) 3.40 eV (C) 0.66 eV (D) 1.89 eV [1]

(III) The light consists of separate lines because
(A) the energy levels of the atom are discrete (B) the glass absorbs the other colours (C) hydrogen atoms are very small (D) the voltage is very high [1]

(IV) The least energy needed to ionise a hydrogen atom that is in the n = 2 level is
(A) 13.6 eV (B) 10.2 eV (C) 3.4 eV (D) 1.51 eV [1]

SECTION E

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

16. (a) (i) Using Bohr's postulates, derive the expression for the total energy of the electron in the n-th orbit of a hydrogen atom, and show that it is about $-13.6/n^2$ eV. 5
(ii) The electron of a hydrogen atom is in the n = 4 level. Find its energy, the energy needed to remove it from the atom, and the frequency of the photon emitted when it drops to n = 2.

OR

(b) (i) Describe the alpha-particle scattering experiment of Geiger and Marsden. State its main observations and what Rutherford concluded from them.
(ii) Give two reasons why Rutherford's model of the atom could not be correct according to classical physics.

17. (a) (i) Using Bohr's theory, derive the Rydberg formula for the wavelengths of the lines of the hydrogen spectrum. Name the series ending on n = 1, 2 and 3, and the region of each. 5
(ii) Using $R = 1.097 \times 10^7\ m^{-1}$, find the shortest wavelengths (series limits) of the Lyman and Paschen series.

OR

(b) (i) Draw (describe) the energy level diagram of the hydrogen atom, giving the energies of the first four levels. Define ionisation energy and first excitation energy.
(ii) A sample of hydrogen atoms is excited to the n = 5 level. How many spectral lines can it emit? Find the wavelength of the line for the transition n = 5 to n = 3 ($R = 1.097 \times 10^7\ m^{-1}$), and the ratio of the radii of the n = 5 and n = 3 orbits.

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

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

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 (C). $E_n = -13.6/n^2$ eV $= -13.6/9 \approx -1.51$ eV.

Q2. Answer (B). $r_n \propto n^2$: $4 \times 0.53 = 2.12$ Å.

Q3. Answer (D). From $E_1 = -13.6$ eV to $E = 0$ needs 13.6 eV.

Q4. Answer (A). Only a tiny fraction came near a nucleus; most of the atom's volume offers no obstacle.

Q5. Answer (D). Lyman lines end on n = 1 and have photon energies of 10.2 eV to 13.6 eV: ultraviolet (91 nm to 122 nm).

Q6. Answer (B). $\Delta E = 13.6(1 - \frac{1}{4}) = 10.2$ eV; $\lambda = hc/\Delta E \approx 1.24 \times 10^{-6}/10.2$ m ≈ 122 nm.

Q7. Answer (B). A is true; it is explained by the discrete (quantised) energy levels. R is true (the electron is bound) but does not explain why the lines are discrete. Answer (B).

Q8. Answer (C). A is Bohr's second postulate. R is false: in a stationary orbit the electron does not radiate (first postulate). Answer (C).

Q9. (2 marks) Answer: $\approx 2.2 \times 10^6$ m s^{-1}; $\approx 7.3 \times 10^5$ m s^{-1}.
$v_1 = e^2/(2\varepsilon_0 h) = (1.6 \times 10^{-19})^2/(2 \times 8.854 \times 10^{-12} \times 6.63 \times 10^{-34}) \approx 2.2 \times 10^6$ m s^{-1} (about c/137). [1]
$v \propto 1/n$: $v_3 = v_1/3 \approx 7.3 \times 10^5$ m s^{-1}. [1]

Q10. (2 marks) Answer: (a) $\approx 4.6 \times 10^{-14}$ m; (b) b = 0 gives 180°; large b, small deflection.
(a) At closest approach all the kinetic energy has become potential energy: $K = (1/4\pi\varepsilon_0)(2e)(Ze)/d$. [1]
$d = 9 \times 10^9 \times 2 \times 79 \times (1.6 \times 10^{-19})^2/(5.0 \times 1.6 \times 10^{-13}) \approx 4.6 \times 10^{-14}$ m. [1]
OR (b) The impact parameter is the perpendicular distance of the initial velocity of the alpha particle from the centre of the nucleus. [1] For b = 0 (head-on) the particle is turned back ($\theta = 180°$); for a large b it passes far away and is hardly deflected. [1]

Q11. (2 marks) Answer: 6; 4 → 3.
Lines $= n(n-1)/2 = 4 \times 3/2 = 6$ (4→3, 4→2, 4→1, 3→2, 3→1, 2→1). [1]
Longest wavelength = smallest energy gap: n = 4 → n = 3. [1]

Q12. (3 marks) Answer: (a) $r_n = n^2h^2\varepsilon_0/(\pi me^2)$; (b) $mvr = nh/2\pi$; $\approx 3.3 \times 10^{-10}$ m.
(a) (1) The electron moves in certain stable circular orbits without radiating. (2) In these orbits the angular momentum is $mvr = nh/2\pi$. (3) It emits or absorbs a photon of energy $h\nu = E_i - E_f$ when it jumps between orbits. [1]
Centripetal force from Coulomb attraction: $mv^2/r = e^2/(4\pi\varepsilon_0 r^2)$, so $mv^2 = e^2/(4\pi\varepsilon_0 r)$. With $v = nh/(2\pi mr)$: $m(nh/2\pi mr)^2 = e^2/(4\pi\varepsilon_0 r)$. [1]
$r_n = n^2h^2\varepsilon_0/(\pi me^2)$ — proportional to n^2. [1]
OR (b) (i) A stationary orbit must hold a whole number of electron waves: $2\pi r = n\lambda$. [1] With $\lambda = h/mv$: $2\pi r = nh/mv$, so $mvr = nh/2\pi$. [1]
(ii) n = 1: $\lambda = 2\pi r_1 = 2\pi \times 0.53 \times 10^{-10} \approx 3.3 \times 10^{-10}$ m. [1]

Q13. (3 marks) Answer: ≈ 656 nm; ≈ 365 nm; visible (short end near UV).
$1/\lambda = R(1/2^2 - 1/n^2)$, n = 3, 4, … [1]
Longest (n = 3): $1/\lambda = R \times 5/36$, $\lambda = 36/(5 \times 1.097 \times 10^7) \approx 656$ nm. [1]
Shortest ($n \to \infty$): $\lambda = 4/R \approx 365$ nm. The series is mostly visible, its short end in the near ultraviolet. [1]

Q14. (3 marks) Answer: (i) n = 3; (ii) 3; (iii) 3 → 2.
(i) $E = -13.6 + 12.09 = -1.51$ eV $= -13.6/n^2$, so n = 3. [1]
(ii) Three lines: 3→2, 2→1 and 3→1. [1]
(iii) 3→2 (Balmer, $\Delta E \approx 1.89$ eV, $\lambda \approx 656$ nm, red). [1]

Q15. (4 marks) Answer: (I) B; (II) D; (III) A; (IV) C.
(I) (B) The longest Balmer line, 3 → 2. [1]
(II) (D) $13.6(¼ - 1/9) \approx 1.89$ eV (or $hc/\lambda \approx 1.24 \times 10^{-6}/656 \times 10^{-9} \approx 1.89$ eV). [1]
(III) (A) Each line is the difference between two fixed energy levels. [1]
(IV) (C) $E_2 = -13.6/4 = -3.4$ eV, so 3.4 eV is needed. [1]

Q16. (5 marks) Answer: (a) $E_n = -me^4/(8\varepsilon_0^2h^2n^2) \approx -13.6/n^2$ eV; −0.85 eV; 0.85 eV; $\approx 6.2 \times 10^{14}$ Hz; (b) tiny massive positive nucleus; unstable, continuous spectrum.
(a) (i) From $mv^2 = e^2/(4\pi\varepsilon_0 r)$: $K = ½mv^2 = e^2/(8\pi\varepsilon_0 r)$ and $U = -e^2/(4\pi\varepsilon_0 r)$, so $E = -e^2/(8\pi\varepsilon_0 r)$. [1] With $r_n = n^2h^2\varepsilon_0/(\pi me^2)$: $E_n = -me^4/(8\varepsilon_0^2h^2n^2)$. [1] Putting in the constants, $me^4/(8\varepsilon_0^2h^2) \approx 2.16 \times 10^{-18}$ J ≈ 13.5 eV (13.6 eV with more precise values of the constants), so $E_n \approx -13.6/n^2$ eV. [1]
(ii) $E_4 = -13.6/16 = -0.85$ eV; 0.85 eV removes it. [1] $\Delta E = 3.40 - 0.85 = 2.55$ eV; $\nu = \Delta E/h = 2.55 \times 1.6 \times 10^{-19}/6.63 \times 10^{-34} \approx 6.2 \times 10^{14}$ Hz. [1]
OR (b) (i) A thin beam of alpha particles (from a radioactive source, through lead slits) fell on a thin gold foil; a movable zinc-sulphide screen and microscope counted the scattered particles at different angles. [1] Most passed straight through; a few were deflected through large angles; about 1 in 8000 came back (more than 90°). [1] So the positive charge and almost all the mass are concentrated in a tiny nucleus (about 10^{-14} m to 10^{-15} m), with the electrons far outside. [1]
(ii) An electron going round the nucleus is accelerated, so by classical theory it should radiate continuously and spiral into the nucleus — the atom would not be stable. [1] Its frequency of revolution would change continuously, giving a continuous spectrum, but atoms give line spectra. [1]

Q17. (5 marks) Answer: (a) $1/\lambda = R(1/n_f^2 - 1/n_i^2)$; ≈ 91.2 nm; ≈ 820 nm; (b) 10 lines; ≈ 1.28 μm; 25 : 9.
(a) (i) $h\nu = E_i - E_f = (me^4/8\varepsilon_0^2h^2)(1/n_f^2 - 1/n_i^2)$. With $\nu = c/\lambda$: $1/\lambda = R(1/n_f^2 - 1/n_i^2)$, $R = me^4/(8\varepsilon_0^2h^3c)$. [2] n_f = 1: Lyman (ultraviolet); 2: Balmer (visible); 3: Paschen (infrared). [1]
(ii) Lyman limit: $\lambda = 1/R \approx 91.2$ nm. [1] Paschen limit: $\lambda = 9/R \approx 820$ nm. [1]
OR (b) (i) Levels at −13.6, −3.40, −1.51, −0.85 eV, … crowding together towards 0 eV. [1] Ionisation energy is the energy to take the electron from the ground state to E = 0 (13.6 eV); the first excitation energy is the energy to raise it to n = 2 (10.2 eV). [1]
(ii) Lines = 5 × 4/2 = 10. [1] $1/\lambda = R(1/9 - 1/25) = R \times 16/225$, $\lambda = 225/(16 \times 1.097 \times 10^7) \approx 1.28 \times 10^{-6}$ m, in the infrared. [1] $r \propto n^2$: $r_5/r_3 = 25/9$. [1]

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: radius, speed and energies from the fundamental constants, wavelengths from the energy levels and from the Rydberg formula, the closest approach by stepping an alpha particle towards the nucleus.