

Chapter 12 · Atoms

CBSE Class 12 Physics (042) · Unit VIII · Unit VII + VIII = 12 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS Hydrogen line spectra: qualitative treatment only. Know the series names and which region each falls in — do not spend time on detailed spectral calculations.

Fully examinable: the alpha-particle scattering experiment, Rutherford's model, Bohr's postulates, and the expressions for radius, velocity and energy of the n^{th} orbit.

60-SECOND RECALL

Bohr quantisation	$mvr = nh/2\pi$
Radius	$r_n \propto n^2 \cdot r_1 = 0.53 \text{ \AA}$ (Bohr radius)
Velocity	$v_n \propto 1/n \cdot v_1 = c/137$
Energy	$E_n = -13.6/n^2 \text{ eV}$
Transition	$h\nu = E_f - E_i$
Rydberg	$1/\lambda = R(1/n_f^2 - 1/n_i^2)$, $R = 1.097 \times 10^7 \text{ m}^{-1}$
Ionisation energy (H)	13.6 eV

1. Alpha-Particle Scattering and Rutherford's Model

THE OBSERVATIONS AND WHAT EACH PROVED

Observation	Conclusion
Most α -particles passed straight through	The atom is mostly empty space
A small fraction were deflected through large angles	There is a heavy, positively charged centre
About 1 in 8000 bounced straight back	The nucleus is very small and very dense

Nucleus size $\approx 10^{-15} \text{ m}$ against an atom $\approx 10^{-10} \text{ m}$ — a factor of 10^5 .

Distance of closest approach: $r_0 = 2kZe^2/K$, where K is the α -particle's kinetic energy.

WHY RUTHERFORD'S MODEL FAILED — a guaranteed 2-marker

- 1. Stability:** an electron in a circular orbit is **accelerating**, so by classical electromagnetism it must **continuously radiate energy**, spiral inward and collapse into the nucleus within about 10^{-8} s . Atoms are in fact stable.
- 2. Spectrum:** as it spiralled, the frequency would change continuously, giving a **continuous spectrum**. Real atoms emit a **line spectrum**.

2. Bohr's Model

THE THREE POSTULATES — write them in this order

1. **Stable orbits:** an electron revolves only in certain stationary orbits in which it does not radiate energy.
2. **Quantisation:** the angular momentum is an integral multiple of $h/2\pi$: $mvr = nh/2\pi$.
3. **Transition:** energy is emitted or absorbed only when an electron jumps between orbits, with $h\nu = E_f - E_i$.

THE THREE EXPRESSIONS — derive from Coulomb force = centripetal force

$$r_n = n^2 h^2 \epsilon_0 / \pi m Z e^2 \rightarrow r_n \propto n^2 / Z, r_1 = 0.53 \text{ \AA} \text{ for hydrogen}$$

$$v_n = Ze^2 / 2\epsilon_0 n h \rightarrow v_n \propto Z/n, v_1 = c/137$$

$$E_n = -13.6 Z^2 / n^2 \text{ eV} \rightarrow E_n \propto -1/n^2$$

$$KE = -E_n \cdot PE = 2E_n \cdot \text{Total } E = KE + PE = E_n$$

TRAP — the meaning of the minus sign E_n is negative because the electron is bound. Energy must be supplied to free it. $E = 0$ corresponds to the electron just escaping ($n = \infty$).

Ionisation energy of hydrogen = +13.6 eV (from $n = 1$ to $n = \infty$). The first excitation energy is $13.6 - 3.4 = 10.2 \text{ eV}$ — these two are not the same thing.

As n increases the orbits get farther apart in radius but the energy levels crowd together.

3. Hydrogen Spectrum

qualitative only

THE FIVE SERIES — learn the landing level and the region

Series	Transitions to	Region
Lyman	$n = 1$	Ultraviolet
Balmer	$n = 2$	VISIBLE — the only visible series
Paschen	$n = 3$	Infrared
Brackett	$n = 4$	Infrared
Pfund	$n = 5$	Infrared

$$1/\lambda = R(1/n_f^2 - 1/n_i^2)$$

Within a series, the line from the next level is the longest wavelength and the one from $n = \infty$ is the series limit (shortest wavelength).

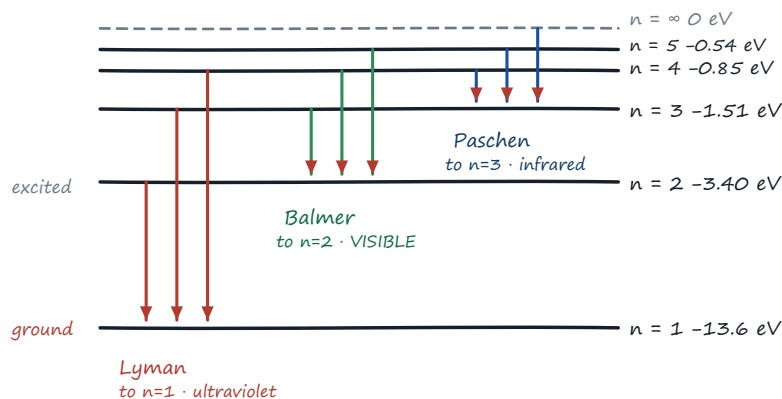
WORKED EXAMPLE Find the energy and wavelength emitted when an electron falls from $n = 3$ to $n = 2$ in hydrogen.

$$E_3 = -13.6/9 = -1.51 \text{ eV} \cdot E_2 = -13.6/4 = -3.40 \text{ eV}$$

$$\Delta E = -1.51 - (-3.40) = 1.89 \text{ eV}$$

$\lambda = 1240/1.89 = 656 \text{ nm} \rightarrow \text{red}$, and it belongs to the **Balmer** series (lands on $n = 2$), which is why it is visible.

Hydrogen energy levels — $E_n = -13.6/n^2 \text{ eV}$ (spacing shrinks as n grows)



$$h\nu = E_i - E_f \cdot \text{ionisation energy} = 13.6 \text{ eV} \cdot \text{only Balmer is visible}$$

Energies are **negative** because the electron is bound; zero is taken at $n = \infty$. The syllabus wants **hydrogen line spectra qualitatively only** — know which series lands where, not the Rydberg derivation.

4. Question Triggers what the wording is really asking

If the question says...	The answer is...
"most α -particles went straight through"	Atom is mostly empty
"few bounced straight back"	Nucleus is small, heavy, dense
"why is Rutherford's atom unstable"	Accelerating electron radiates and spirals in
"visible lines of hydrogen"	Balmer series ($n_f = 2$)
"energy needed to remove the electron"	Ionisation energy = 13.6 eV
"radius of the n^{th} orbit"	$r \propto n^2$, $r_1 = 0.53 \text{ \AA}$
"ratio of KE to total energy"	KE = -E , so the ratio is -1

MOST-ASKED BOARD QUESTIONS

- [3M] State Bohr's postulates and derive the expression for the **radius of the n^{th} orbit**.
- [3M] Derive the expression for the **energy of an electron** in the n^{th} orbit and draw the energy level diagram.
- [2M] Describe the **α -particle scattering experiment** and its conclusions.
- [2M] Why did **Rutherford's model fail**? Give both reasons.
- [2M] Numerical on transition energy and emitted wavelength.
- [1M] Which series of hydrogen lies in the **visible region**? $\rightarrow$ **Balmer**

THE HABIT THAT SCORES — Start every Bohr derivation from the same single line: **Coulomb force = centripetal force**, then bring in **$mvr = nh/2\pi$** . Radius, velocity and energy all fall out of those two equations, so you never need to memorise three separate results.