

Worksheet 02: Hydrogen Emission Spectrum and Quantized Energy

Focus: electron transitions, convergence, visible/UV/IR lines, Bohr model | Suggested time: 55 minutes | Total: 42 marks

Student name	_____	Class	_____
Instructions	Answer all questions. Show working for calculations. Use the data booklet values where needed.	Calculator	Permitted where appropriate

Section A: Multiple choice

Choose the best answer for each question. Each question is worth 1 mark.

1. In the hydrogen emission spectrum, visible lines are produced mainly by transitions ending at:

A. $n = 1$	B. $n = 2$
C. $n = 3$	D. $n = \text{infinity}$

2. Which transition emits the highest-energy photon?

A. $n = 3 \rightarrow n = 2$	B. $n = 4 \rightarrow n = 2$
C. $n = 5 \rightarrow n = 2$	D. $n = 6 \rightarrow n = 1$

3. Lines in the hydrogen spectrum converge at high energy because:

A. the nucleus becomes smaller	B. energy levels become closer together at high n
C. electrons stop having wave properties	D. photons all have the same frequency

4. Ionization of hydrogen corresponds to the electron reaching:

A. $n = 0$	B. $n = 1$
C. $n = 2$	D. $n = \text{infinity}$

5. A transition that emits a shorter wavelength has:

A. a smaller energy change	B. a lower frequency
C. a larger energy change	D. no relationship to energy

6. The Bohr model was most successful at explaining:

A. spectra of all multi-electron atoms	B. the line spectrum of hydrogen
C. the exact position of every electron	D. the existence of neutrons

Section B: Short-answer questions

1. Describe how an emission line is produced when an excited hydrogen atom loses energy. [3 marks]

Answer: _____

2. The red hydrogen line at 656 nm is caused by $n = 3 \rightarrow n = 2$. State whether $n = 4 \rightarrow n = 2$ has a longer or shorter wavelength and explain why. [3 marks]

Answer: _____

Answer key and marking guidance

Award marks for scientifically correct alternative wording. Penalize only once for the same repeated error unless it causes a new error in reasoning.

Section A: Multiple choice

Q	Answer	Brief marking guidance
1	B	The visible series of hydrogen involves electrons falling to $n = 2$.
2	D	The transition to $n = 1$ from a high level has the largest energy change among these options.
3	B	Successive energy levels become closer together as n increases.
4	D	At $n = \text{infinity}$ the electron is no longer bound to the atom.
5	C	Shorter wavelength means higher frequency and higher photon energy.
6	B	Bohr's model matched hydrogen spectral lines but failed for more complex atoms.

Section B: Short-answer mark scheme

Q	Marks	Expected answer / marking points
1	3	Electron is in a higher/excited energy level (1); falls to a lower energy level (1); emits a photon with energy equal to the energy difference (1).
2	3	Shorter wavelength (1); $n = 4 \rightarrow n = 2$ has a larger energy difference than $n = 3 \rightarrow n = 2$ (1); larger energy means higher frequency and shorter wavelength (1).
3	2	Four transitions: $3 \rightarrow 2$, $4 \rightarrow 2$, $5 \rightarrow 2$, $6 \rightarrow 2$ (2); award 1 for correct reasoning but one error.
4	4	Strength: explains/predicts hydrogen line spectrum or discrete levels (1); includes quantized orbits/energy levels (1); limitation: does not explain multi-electron spectra or relative line intensities (1); assumes fixed electron paths unlike quantum model (1).

Section C: Data response / case study mark scheme

Q	Marks	Expected answer / marking points
1	3	$486 \text{ nm} = 4.86 \times 10^{-7} \text{ m}$ (1); $f = c/\lambda$ (1); $f = 6.17 \times 10^{14} \text{ s}^{-1}$ (1).
2	2	$3 \rightarrow 2$, $4 \rightarrow 2$, $5 \rightarrow 2$, $6 \rightarrow 2$ (2); award 1 for recognizing shorter wavelength means higher energy with minor ordering error.
3	3	Energy levels converge at higher n (1); differences between successive high levels become smaller (1); emitted wavelengths/frequencies therefore get closer together (1).
4	3	Ultraviolet (1); transitions to $n = 1$ involve larger energy changes than to $n = 2$ (1); larger energy means higher frequency/shorter wavelength (1).

Section D: Extended response mark scheme

Award up to 8 marks: Bohr model uses discrete energy levels/orbits (1); explains that photons are emitted when electrons fall to lower levels (1); accounts for specific hydrogen wavelengths/frequencies (1); explains convergence toward ionization qualitatively (1); limitation: fixed trajectories are not consistent with modern quantum theory (1); limitation: poor for multi-electron atoms or line intensities (1); quantum model uses orbitals/probability/wave description (1); balanced judgement that simpler models remain useful within limits (1).