

Exercise walk-through

20.1

Atomic models and line spectra

International Baccalaureate · IB Diploma · Physics · HL

20.1 Atomic models and line spectra

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS energy level • emission spectrum

Objective

Atomic models and line spectra. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

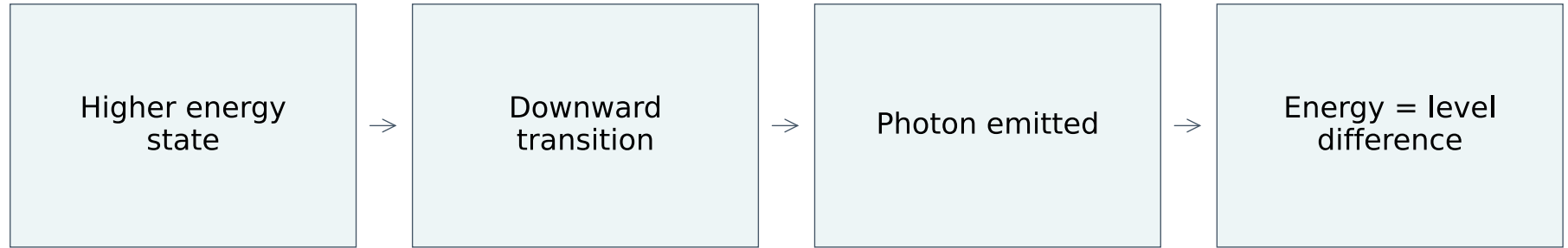
■ What would explain this observation?

- An excited gas produces separate coloured lines rather than every wavelength. The pattern is evidence for discrete atomic energy differences.
 - Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.
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■ Build the model

- Atoms have a small positive nucleus and electrons. Emission and absorption spectra arise from transitions between discrete **energy levels** . A photon energy equals the level difference and obeys $E = hf$.

- **emission spectrum** : Wavelength pattern of radiation emitted by a source;
energy level: An allowed energy state in a model.



■ Choose evidence that can test it

- An emitted photon corresponds to a transition to a lower energy level. Absorption requires a compatible energy difference. Rutherford scattering supported a small dense nucleus, but that experiment alone did not establish the complete quantum model.
 - Read a labelled energy-level diagram before calculating. Keep joules and electron-volts distinct and use the given constants. Compare attributed spectra at a common wavelength scale and avoid looking at unsafe light sources.
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■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.

- Known: energy levels are -6.0 and -2.0 eV. A downward transition releases 4.0 eV $= 6.4 \times 10^{-19}$ J using $1 \text{ eV} = 1.6 \times 10^{-19}$ J. With $h = 6.4 \times 10^{-34}$ J s for this rounded exercise, frequency is 1.0×10^{15} Hz.

Example:

Levels are -7.0 and -2.0 eV. Find the energy emitted in the downward transition. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- Negative bound-state energies are relative to a chosen zero; they do not mean a negative photon energy is emitted. A larger downward energy difference gives higher

frequency.

- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A negative bound-state energy means an emitted photon has negative energy. This claim is false: Negative bound-state energies are relative to a chosen zero; they do not mean a negative photon energy is emitted. A larger downward energy difference gives higher frequency.

Key:

Atomic models and line spectra: An emitted photon corresponds to a transition to a lower energy level. Absorption requires a compatible energy difference. Rutherford scattering supported a small dense nucleus, but that experiment alone did not establish the complete

quantum model.



Exercises 2.1·2.3

2.1 What produces a higher-frequency emitted photon? Choose one answer.

- **A** A larger downward energy difference
- **B** Any transition upward without absorption
- **C** A smaller Planck constant for the same atom

[1]

2.2 Levels are -7.0 and -2.0 eV. Find the energy emitted in the downward transition. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: A negative bound-state energy means an emitted photon has negative energy.

[2]

Exercises 2.1-2.3

2.1 What produces a higher-frequency emitted photon? Choose one answer.

- **A** A larger downward energy difference
- **B** Any transition upward without absorption
- **C** A smaller Planck constant for the same atom

[1]

2.1 A An emitted photon corresponds to a transition to a lower energy level. Absorption requires a compatible energy difference. Rutherford scattering supported a small dense nucleus, but that experiment alone did not establish the complete quantum model.

2.2 Levels are -7.0 and -2.0 eV. Find the energy emitted in the downward transition. Show the relation, substitution and units.

[2]

2.2 Photon energy = upper – lower = $(-2.0) - (-7.0) = 5.0$ eV.

2.3 Decide whether this claim is true and justify: A negative bound-state energy means an emitted photon has negative energy.

[2]

2.3 False. Negative bound-state energies are relative to a chosen zero; they do not mean a negative photon energy is emitted. A larger downward energy difference gives higher frequency.

Exercises 2.4·3.1

2.4 Wavelength pattern of radiation emitted by a source: write the technical term. [1]

3 Exam-style questions

3.1 Levels are -8 , -3 and -1 eV. List all downward photon energies and identify the shortest wavelength. State why these are discrete candidates. [4]

Exercises 2.4·3.1

2.4 Wavelength pattern of radiation emitted by a source: write the technical term. [1]

3 Exam-style questions

2.4 emission spectrum. emission spectrum means Wavelength pattern of radiation emitted by a source.

3.1 Levels are -8 , -3 and -1 eV. List all downward photon energies and identify the shortest wavelength. State why these are discrete candidates. [4]

3.1 Differences are 5, 7 and 2 eV; 7 eV has shortest wavelength because $E=hc/\lambda$. Selection rules and populations may suppress a candidate transition.