A-LEVEL PHYSICS • EXERCISE SHEET

22.4 Energy levels in atoms and line spectra

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

Build the skills to answer exam questions on **energy levels** and line spectra.

You must be able to:

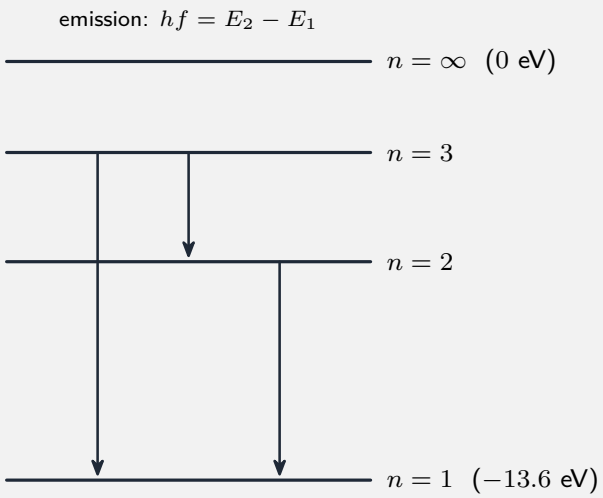
- explain **discrete energy levels** and line spectra
- use $hf = E_2 - E_1$

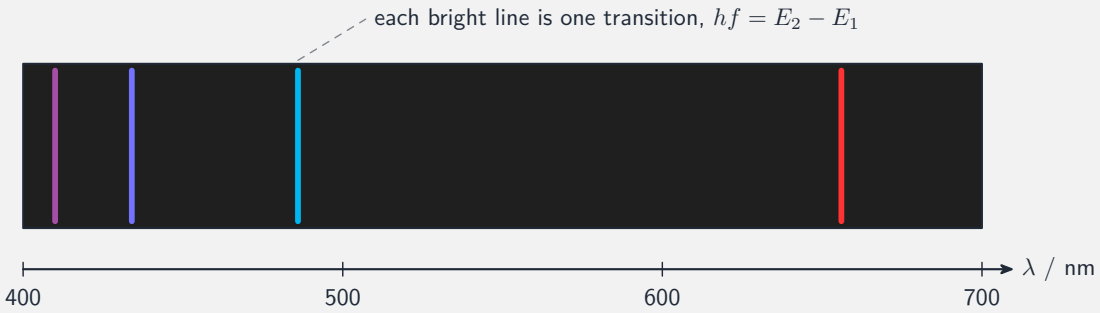
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

Energy levels

An atom's electrons can only sit at **discrete** energy levels (written **negative**, with 0 for a free electron):





Line spectra from atomic energy levels

When an electron **drops** from E_2 to a lower E_1, it emits a photon:

$$hf = E_2 - E_1.$$

Because the levels are **discrete**, only certain photon energies (wavelengths) appear — an **emission spectrum** is a set of **bright lines** on a dark background (a fingerprint of the element). An **absorption spectrum** is dark lines on a bright background.

2 Practice

Now apply the methods above.

2.1 State what is meant by **discrete** energy levels. [1]

2.2 Write the equation linking photon frequency to two energy levels. [1]

2.3 State why the energy levels are written as **negative** values. [1]

2.4 State what an **emission spectrum** looks like. [1]

3 Exam-style questions

3.1 An **emission** line spectrum consists of: [1]

- **A** a continuous range of colours
- **B** dark lines on a bright background

- **C** bright lines on a dark background
- **D** a single colour only

3.2 An electron drops from an energy level of −3.4 eV to −13.6 eV. Calculate the **energy** of the emitted photon, in eV and in joules. [3]

3.3 Calculate the **wavelength** of the photon emitted in question 3.2. [3]

3.4 Explain why only **certain** wavelengths appear in an emission spectrum. [2]

---

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **22.4 Energy levels in atoms and line spectra** past-paper sheet in the Library, or try this in **Practice mode**:

- 9702/42 N25 —Q8 (energy levels and line spectra)

Energy-level transitions reuse the photon ideas of **22.1 Energy and momentum of a photon**, so practise that sheet too.

Solutions

2.1 The electron can only have **certain fixed energies** —never values in between.

2.2 $hf = E_2 - E_1$.

2.3 Energy is measured from 0 for a **free** electron, and a bound electron has **less** energy than that —so it is negative.

2.4 A series of **sharp bright lines** on a dark background.

3.1 C —bright lines on a dark background.

3.2 $\Delta E = -3.4 - (-13.6) = 10.2$ eV; in joules $= 10.2 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-18}$ J.

3.3 $\lambda = \dfrac{hc}{E} = \dfrac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{1.6 \times 10^{-18}} = 1.2 \times 10^{-7}$ m.

3.4 The energy levels are **discrete**, so the differences $E_2 - E_1$ —and hence the photon energies/wavelengths —can only take **certain values**.