FREE REVISION PACK

# Wave–Particle Duality

AQA A-level Physics · 7407 / 7408 · Specification 3.2.2.4

Easy | Medium | Multiple choice · past-paper questions

| 5 | 5 | ≈ 10 min |
|---|---|---|
| QUESTIONS | TOTAL MARKS | SUGGESTED TIME* |

## Contents


| Q | LEVEL | FOCUS | SOURCE | MARKS |
|---|---|---|---|---|
| 1 | Easy | Linking two effects to waves and particles | AQA June 2018 · AS Paper 2 · Q12 | 1 mark |
| 2 | Easy | Muon and electron at the same speed | AQA November 2021 · A-level Paper 1 · Q16 | 1 mark |
| 3 | Easy | Ratio of de Broglie wavelengths at equal speed | AQA June 2024 · A-level Paper 1 · Q12 | 1 mark |
| 4 | Medium | de Broglie wavelength from kinetic energy | AQA June 2018 · AS Paper 2 · Q11 | 1 mark |
| 5 | Medium | What makes electron-diffraction rings wider? | AQA June 2023 · A-level Paper 1 · Q13 | 1 mark |


**Key ideas to have ready**

- Light behaves as particles (the photoelectric effect) and as waves (diffraction and interference).
- Particles have a de Broglie wavelength $\lambda = h / p = h / (mv)$. Electron diffraction is evidence for the wave nature of particles.
- Kinetic energy and momentum: $E_k = p^2 / (2m)$, so $p = \sqrt{(2mE_k)}$ and $\lambda = h / \sqrt{(2mE_k)}$.
- In electron diffraction, a longer wavelength (lower momentum) gives wider rings.

**How to use this pack**

1. The questions are grouped into levels (Easy and Medium). Work through them in order, and check your answers at the end of each level before moving on.
2. Every question is multiple choice with one correct answer. Write down your working anyway; that is how you find mistakes.
3. The separate mark scheme uses the same numbers and explains every answer.

Levels are based on how students did in AQA's examiner reports where that information exists, plus our own difficulty rating. *About 1.5 minutes per question.

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## Easy

Definitions and one-step ideas. Most students get these right.

Questions 1–3

Only **one** answer per question is allowed. For each question, completely fill in the circle alongside the appropriate answer.

AQA June 2018 · AS Paper 2 · Q12

**1** Which row links both the photoelectric effect and electron diffraction to the properties of waves and particles?

**[1 mark]**

| | Photoelectric effect | Electron diffraction | |
|---|---|---|---|
| **A** | Particle property | Particle property | ⬭ |
| **B** | Wave property | Wave property | ⬭ |
| **C** | Particle property | Wave property | ⬭ |
| **D** | Wave property | Particle property | ⬭ |

AQA November 2021 · A-level Paper 1 · Q16

**2** A muon and an electron are travelling at the same speed.

Which row gives the particle with the greater kinetic energy and the particle with the longer de Broglie wavelength?

**[1 mark]**

| | Greater kinetic energy | Longer de Broglie wavelength | |
|---|---|---|---|
| **A** | muon | muon | ⬭ |
| **B** | muon | electron | ⬭ |
| **C** | electron | muon | ⬭ |
| **D** | electron | electron | ⬭ |

AQA June 2024 · A-level Paper 1 · Q12

**3** An electron and a proton move with the same speed.

What is $\frac{\text{de Broglie wavelength of electron}}{\text{de Broglie wavelength of proton}}$?

**[1 mark]**

**A** $5.5 \times 10^{-4}$ ⬭

**B** $2.3 \times 10^{-2}$ ⬭

**C** $42$ ⬭

**D** $1800$ ⬭

## Medium

Two or three steps. Roughly a third to a half of students get these right.

Questions 4–5

AQA June 2018 · AS Paper 2 · Q11

**4** A particle of mass $m$ has a kinetic energy of $E$.

What is the de Broglie wavelength of this particle?

**[1 mark]**

**A** $\frac{h}{\sqrt{(2Em^2)}}$ ⬭

**B** $\frac{h}{\sqrt{2E}}$ ⬭

**C** $\frac{h}{\sqrt{\left(\frac{2E}{m^2}\right)}}$ ⬭

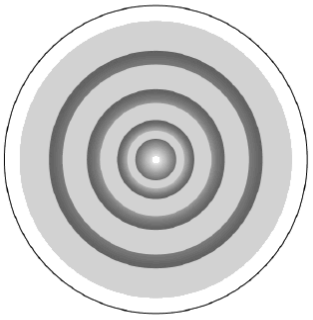
**D** $\frac{h}{\sqrt{2Em}}$ ⬭

AQA June 2023 · A-level Paper 1 · Q13

**5** Electrons with a certain kinetic energy pass through a powdered crystalline sample and are incident on a fluorescent screen.
The diagram shows a sketch of the diffraction pattern produced.



A change is made and this second pattern is produced.



Which change could produce the second pattern?

**[1 mark]**

**A** decreasing the kinetic energy of the electrons ○

**B** replacing the electrons with protons with the same kinetic energy ○

**C** using a crystalline sample with a wider spacing between its atoms ○

**D** moving the screen closer to the crystalline sample ○

**End of questions.** Check your answers with the matching mark scheme. More free packs and 1-to-1 tuition:
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