



QUESTION WORKBOOK

Wave-particle duality

Quantum phenomena · Year 12

AQA 3.2.2.4 · CIE 22.3 · OCR A 4.5.3

10 questions · 30 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

- A1** State the two pieces of evidence showing that light and electrons each have both wave and particle properties. [2]

- A2** A particle has a momentum of $2.0 \times 10^{-24} \text{ kg m s}^{-1}$. Calculate its de Broglie wavelength ($h = 6.63 \times 10^{-34} \text{ J s}$). [2]

- A3** State the de Broglie equation and define each term. [2]

SECTION B · Standard

- B1** An electron moves at $1.0 \times 10^6 \text{ m s}^{-1}$. Calculate its de Broglie wavelength ($m_e = 9.11 \times 10^{-31} \text{ kg}$). [3]

- B2** An electron is accelerated from rest through a potential difference of 100 V. Calculate (a) its speed and (b) its de Broglie wavelength ($e = 1.60 \times 10^{-19} \text{ C}$, $m_e = 9.11 \times 10^{-31} \text{ kg}$). [4]

- B3** An electron and a proton travel at the same speed of $1.0 \times 10^5 \text{ m s}^{-1}$. Calculate the de Broglie wavelength of each ($m_p = 1.67 \times 10^{-27} \text{ kg}$) and state which is larger. [3]

- B4** Explain what the diffraction of electrons by a thin crystal shows about the nature of electrons. [3]

SECTION C · Stretch

- C1** A cricket ball of mass 0.16 kg is bowled at 30 m s^{-1} . Calculate its de Broglie wavelength and explain why no diffraction of the ball is ever observed. [4]

- C2** Calculate the accelerating potential difference needed to give an electron a de Broglie wavelength of $1.0 \times 10^{-10} \text{ m}$ ($h = 6.63 \times 10^{-34} \text{ J s}$, $m_e = 9.11 \times 10^{-31} \text{ kg}$, $e = 1.60 \times 10^{-19} \text{ C}$). [4]

- C3** Explain how and why the electron diffraction pattern changes when the electrons are accelerated to a higher speed. [3]