InkPhysics

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

PRINT EDITION

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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 2.0×10^{-24} kg m s^{-1}. Calculate its de Broglie wavelength ($h = 6.63 \times 10^{-34}$ J s). [2]

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

SECTION B · Standard

B1 An electron moves at 1.0×10^{6} m s^{-1}. Calculate its de Broglie wavelength ($m_e = 9.11 \times 10^{-31}$ 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 ($e = 1.60 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg). [4]

B3 An electron and a proton travel at the same speed of 1.0×10^{5} m s^{-1}. Calculate the de Broglie wavelength of each ($m_p = 1.67 \times 10^{-27}$ 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 1.0×10^{-10} m ($h = 6.63 \times 10^{-34}$ J s, $m_e = 9.11 \times 10^{-31}$ kg, $e = 1.60 \times 10^{-19}$ C). [4]

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