InkPhysics

QUESTION WORKBOOK

Antimatter and photons

Particles · Year 12

AQA 3.2.1.3 · CIE 11.1 · OCR A 6.4.2, 6.4.4

10 questions · 30 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 Compare a particle and its antiparticle in terms of mass and charge. [2]

A2 A photon has a frequency of 1.0×10^{15} Hz. Calculate its energy ($h = 6.63 \times 10^{-34}$ J s). [2]

A3 Describe what happens in annihilation. [2]

SECTION B · Standard

B1 Calculate the energy of a photon of wavelength 500 nm ($c = 3.0 \times 10^{8}$ m s^{-1}). [3]

B2 Calculate the minimum energy, and hence the minimum photon frequency, needed for pair production of an electron and a positron (m_e = 9.11 × 10^{-31} kg, c = 3.0 × 10^{8} m s^{-1}). [4]

B3 An electron and a positron, effectively at rest, annihilate to produce two identical photons. Calculate the energy and frequency of each photon. [3]

B4 Express the energy of the 1.0 × 10^{15} Hz photon (6.63 × 10^{-19} J) in electronvolts. [3]

SECTION C · Stretch

C1 A photon of energy 2.0 MeV produces an electron–positron pair. Given that the rest energy of each is 0.511 MeV, calculate the total kinetic energy shared by the two particles, in joules. [4]

C2 Calculate the maximum wavelength of a photon that can create an electron–positron pair (rest energy of the pair = 1.022 MeV). [4]

C3 Explain why pair production normally occurs in the presence of a nearby nucleus. [3]