InkPhysics

ANSWER BOOK

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 EDITION

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SECTION A · Warm-up

A1 An antiparticle has the same mass as its corresponding particle but the opposite charge (and opposite values of other quantities such as lepton number). [2]

A2 $E = hf = 6.63 \times 10^{-34} \times 1.0 \times 10^{15} = 6.63 \times 10^{-19}$ J. [2]

A3 A particle meets its antiparticle and the two are destroyed, their mass-energy being converted into two photons that travel off in opposite directions. [2]

SECTION B · Standard

B1 $E = hc/\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^{8})/(500 \times 10^{-9}) = 3.98 \times 10^{-19}$ J. [3]

B2 Rest energy of one particle = $m_e c^2 = 9.11 \times 10^{-31} \times (3.0 \times 10^{8})^2 = 8.20 \times 10^{-14}$ J. For a pair, E_{min} $= 2m_e c^2 = 1.64 \times 10^{-13}$ J. $f_{min} = E/h = 2.47 \times 10^{20}$ Hz. [4]

B3 Each photon carries the rest energy of one particle: $E = m_e c^2 = 8.20 \times 10^{-14}$ J. $f = E/h = 1.24 \times 10^{20}$ Hz. [2]

B4 $E = (6.63 \times 10^{-19})/(1.60 \times 10^{-19}) = 4.14$ eV. [3]

SECTION C · Stretch

C1 Rest energy of the pair = $2 \times 0.511 = 1.022$ MeV. Kinetic energy shared = $2.0 - 1.022 = 0.978$ MeV $= 0.978 \times 10^{6} \times 1.60 \times 10^{-19} = 1.56 \times 10^{-13}$ J. [4]

C2 $E_{min} = 1.022 \times 10^{6} \times 1.60 \times 10^{-19} = 1.64 \times 10^{-13}$ J. $\lambda_{max} = hc/E = (6.63 \times 10^{-34} \times 3.0 \times 10^{8})/1.64 \times 10^{-13} = 1.22 \times 10^{-12}$ m. [4]

C3 A single photon has momentum, and this momentum must be conserved when the pair is created. A nearby massive nucleus can recoil and take up momentum, allowing both energy and momentum to be conserved; without it the process could not satisfy both. [3]