



ANSWER BOOK

Quarks and antiquarks

Particles · Year 12

AQA 3.2.1.6 · CIE 11.2 · OCR A 6.4.2

10 questions · 30 marks

NAVY EDITION

SECTION A · Warm-up

- A1** Up quark: $+2/3$ e. Down quark: $-1/3$ e. [2]
- A2** Proton: up, up, down (uud). Neutron: up, down, down (udd). [2]
- A3** $+1/3$ (an antiquark has $-1/3$). [2]

SECTION B · Standard

- B1** Charge = $(+2/3) + (+2/3) + (-1/3) = +3/3 = +1e$. [3]
- B2** Charge = $(+2/3) + (-1/3) + (-1/3) = 0$. [3]
- B3** Charge = $(+2/3) + (+1/3) = +1e$ (the anti-down quark has charge $+1/3$). Baryon number = $(+1/3) + (-1/3) = 0$, confirming it is a meson. [3]
- B4** An antiproton is anti-up, anti-up, anti-down. Charge = $(-2/3) + (-2/3) + (+1/3) = -3/3 = -1e$. [3]

SECTION C · Stretch

- C1** Inside the neutron (udd) one down quark changes into an up quark, turning it into a proton (uud). The change emits a W^- boson, which becomes an electron and an electron antineutrino. [4]
- C2** Charge = $(+2/3) + (+1/3) = +1e$. Strangeness = 0 (up) + $(+1)$ (anti-strange) = $+1$. [4]
- C3** The composition must give the neutron's zero charge. uud gives $+1e$ (the proton), whereas udd gives $(+2/3) + (-1/3) + (-1/3) = 0$, matching the neutral neutron. [3]