physics UK

Smarter practice. Stronger understanding

WORKSHEETS

ATTEMPT | CHECK | CORRECT | IMPROVE

AQA AS Particle Classification, Quarks and Conservation Laws worksheet

35–40 minutes independent practice + 15–20 minutes review | 40 marks

Specification points covered

- 3.2.1.5(a) Hadrons and the strong interaction.
- 3.2.1.5(b) Baryons and antibaryons.
- 3.2.1.5(c) Mesons, including pions and kaons.
- 3.2.1.5(d) Conservation of baryon number.
- 3.2.1.5(e) Proton stability and baryon decay.
- 3.2.1.5(f) Pion exchange and the strong nuclear force.
- 3.2.1.5(g) Kaon decay into pions.
- 3.2.1.5(h) Leptons, neutrinos and antiparticles.
- 3.2.1.5(i) Electron and muon lepton-number conservation.
- 3.2.1.5(j) Muon decay into an electron.
- 3.2.1.5(k) Strong production and weak decay of strange particles.
- 3.2.1.5(l) Strangeness and pair production.
- 3.2.1.5(m) Strangeness conservation in strong interactions.
- 3.2.1.5(n) Strangeness change in weak interactions.
- 3.2.1.5(o) Collaboration in particle physics.
- 3.2.1.6(a) Quark and antiquark properties.
- 3.2.1.6(b) Quark combinations in hadrons.
- 3.2.1.6(c) Use of u, d, s and their antiquarks.
- 3.2.1.6(d) Quark compositions of nucleons and antinucleons.
- 3.2.1.6(e) Quark compositions of specified pions and kaons.
- 3.2.1.6(f) Neutron decay.
- 3.2.1.7(a) Quark changes in beta decay.
- 3.2.1.7(b) Conservation of charge, baryon number, lepton numbers and strangeness.
- 3.2.1.7(c) Conservation of energy and momentum.

Mountain Array cosmic-ray event review

A detector high in the mountains records particle tracks and decay vertices from a rare cosmic-ray shower.
Audit each event with particle families, quark structure and conservation laws before accepting the software classification.

1. Reading the event display

1. The array identifies four particles in one cosmic-ray shower: a proton, a positive pion, a negative muon and a muon neutrino. Classify each particle as a baryon, meson or lepton. [4 marks]

2. The event display shows a proton track continuing through the detector, while a neutron, a kaon and a muon later decay. State which named particle is the only stable baryon and explain why the other tracks may end in decays. [3 marks]

2. Reconstructing particles

3. Complete the particle-property audit: state (a) the charge of u; (b) the charge of d; (c) the baryon number of any quark; (d) the strangeness of s; and (e) the strangeness of $\bar{s}$. **[5 marks]**

4. State the quark composition of a proton, a neutron, π^+ and K^0. Use only u, d, s and their antiquarks. **[4 marks]**

5. A proposed strong-interaction event is $\pi^- + p \rightarrow K^0 + X$. The candidates for X are n (Q = 0, B = 1, S = 0), Λ^0 (Q = 0, B = 1, S = -1) and $\bar{K}^0$ (Q = 0, B = 0, S = -1). Identify X by applying charge, baryon number and strangeness conservation. **[3 marks]**

3. Strange-particle evidence

6. Explain why the simultaneous production of K^0 and Λ^0 in Question 5 is described as production of strange particles in a pair. **[2 marks]**

7. A K^+ later decays by $K^+ \rightarrow \pi^+ + \pi^0$. Show how strangeness changes and state which fundamental interaction causes this decay. **[2 marks]**

8. The software tests three proposed decays: A $\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$; B $n \rightarrow p + e^- + \bar{\nu}_e$; C $p \rightarrow e^+ + \pi^0$. Decide which are allowed. For each decision, name a relevant conserved quantity. **[4 marks]**

4. Quark changes and event totals

9. State the quark change in (a) beta-minus decay of a neutron and (b) beta-plus decay of a proton. Name the nucleon produced in each case. **[3 marks]**

10. A fluorine-19 nucleus contains 9 protons and 10 neutrons. Calculate the total number of up quarks and the total number of down quarks in the nucleus. **[2 marks]**

11. Before one collision the total energy is 6.20 GeV and the total momentum is zero. The visible products carry 4.90 GeV and a total momentum of 1.10 GeV c^{-1} east. State the energy and momentum that an undetected product must carry. **[3 marks]**

5. Scientific case

12. Write a structured explanation of how the array team can identify a strange-particle event. Include hadron families, quark content, conservation at production, decay by the weak interaction and why independent collaboration is needed before a new event is accepted. **[5 marks]**

Review and improve

- □ I distinguish baryons, mesons and leptons from their structure.
- □ I test every relevant conservation law across a complete event.
- □ I separate strong production from weak decay when discussing strange particles.