

AS Physics 9702

Unit 11 · Particle physics

Original worksheet

Name: _____ Date: _____

Suggested marks: 91. Work through the questions over more than one study session if needed. Use additional paper for extended working and graph paper where requested.

Show equations, substitutions, units and reasoning. Use the constants specified in each question. The questions are original practice, not an official Cambridge examination or mark scheme.

Scope: Cambridge International AS Physics 9702, 2025–2027 learning outcomes. The published 2028–2030 AS scope has been checked separately and is substantively unchanged. Version: 11 October 2026.

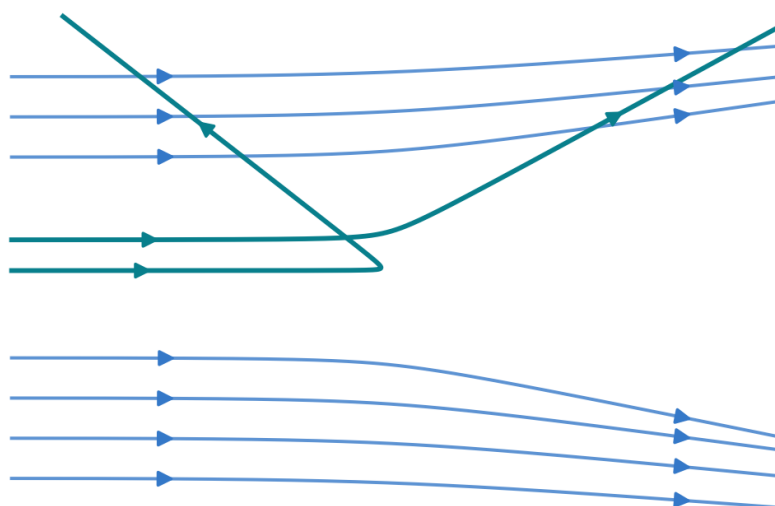
U11-Q1 · 7 marks

In a thin-foil scattering investigation, almost all incident α -particles are detected close to the forward direction, while very few are detected at angles above 90° . (a) State what each observation implies about the atom. (b) Explain how a close approach to the nucleus can produce a large deflection. (c) Describe the locations and charges of protons, neutrons and electrons in the simple nuclear model.

Figure for U11-Q1

α -particle paths

Selected paths of different incident particles



Not to scale. Relative frequencies are not represented.

U11-Q2 · 7 marks

Consider neutral $^{24}_{12}\text{Mg}$, neutral $^{26}_{12}\text{Mg}$, and the ion $^{26}_{12}\text{Mg}^{2+}$. (a) State A and Z for the second species and explain their meanings. (b) Give the proton, neutron and electron numbers in all three species. (c) Identify the isotope pair and explain why making the ion does not create a new isotope.

U11-Q3 · 16 marks

(a) For α , β^- , β^+ and γ radiation, state the emitted object, charge and approximate rest mass. Give masses either in kilograms or relative to u, using $1\text{ u} = 1.66 \times 10^{-27}\text{ kg}$ and electron mass $9.11 \times 10^{-31}\text{ kg}$. (b) Explain why a positron is the electron's antiparticle but a proton is not. (c) Name the neutral lepton emitted alongside each type of beta particle.

U11-Q4 · 6 marks

A nucleus $^{210}_{84}\text{Po}$ undergoes one α decay. (a) Find the daughter's A, Z and neutron number, and write the decay equation. The element with $Z = 82$ is Pb. (b) Check both conserved number totals. (c) A student writes a neutral helium atom as the emitted object. Explain the error.

U11-Q5 · 7 marks

A $^{32}_{15}\text{P}$ nucleus undergoes β^- decay. The element with $Z = 16$ is S. (a) Write a complete decay equation including the neutral emitted particle. (b) State changes to the nucleus's proton and neutron counts. (c) Give the nucleon-level and quark-level changes, checking charge at quark level.

U11-Q6 · 7 marks

A $^{11}_6\text{C}$ nucleus undergoes β^+ decay. The element with $Z = 5$ is B. (a) Write the complete decay equation. (b) State the nuclear proton/neutron change and explain why A remains constant. (c) Write the quark transformation, name the charged emitted particle and check charge conservation.

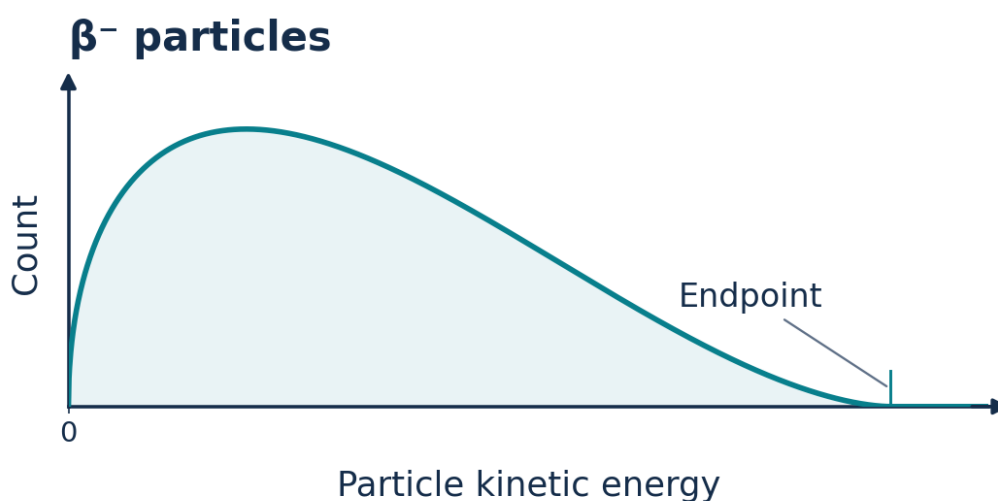
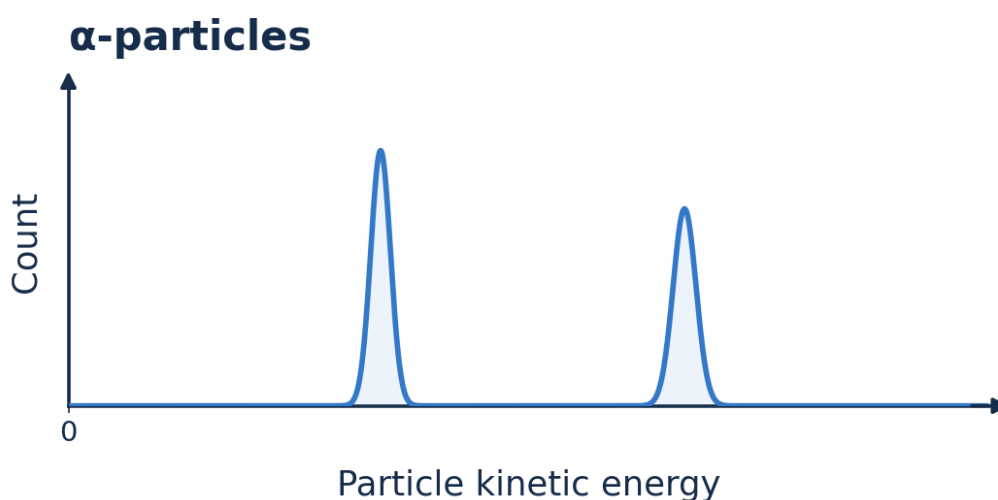
U11-Q7 · 7 marks

A spectrum from one source contains two narrow α -energy peaks. A β^- spectrum from a different source is continuous up to an endpoint. (a) Explain both observations. (b) In one beta event, total kinetic energy available is 1.10 MeV; the electron takes 0.43 MeV and daughter recoil energy is negligible at the precision required. Find the energy carried by the other emitted particle and name it. (c) Explain why a γ photon having zero rest mass does not mean it carries no energy.

Figure for U11-Q7

Particle energy spectra

Qualitative shapes from two different sources



Energy scales are qualitative and are not shared between panels.

U11-Q8 · 5 marks

(a) Define the unified atomic mass unit. (b) Convert 22.99 u to kilograms and 8.30×10^{-27} kg to u, using $1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$. (c) Explain why a nuclide with nucleon number 23 need not have a precisely measured atomic mass of exactly 23 u.

U11-Q9 · 11 marks

(a) Explain what is meant by a fundamental particle and state whether an individual quark is fundamental. (b) List all six quark flavours, grouped by charge, and state the charge of each corresponding antiquark. (c) Find the total charge and classify each hypothetical quark combination: u plus anti-s; d plus anti-u; ucc. (d) Explain why a pair consisting of u and d alone would not fit the meson definition.

U11-Q10 · 7 marks

(a) Give the quark compositions of proton and neutron and calculate their charges. (b) Classify each as fundamental or composite and as baryon, meson or lepton where appropriate: proton, neutron, electron, electron neutrino, and a quark-antiquark pair. (c) Explain why being electrically neutral does not imply that a particle is fundamental.

U11-Q11 · 5 marks

A hypothetical nucleus $^{214}_{83}\text{X}$ undergoes one α decay followed by two β^- decays. Use generic daughter labels; no chemical-symbol recall is required. (a) Give A and Z after every step. (b) Find the total charge carried by all emitted charged particles, in units of e, and use it to check the change in nuclear charge. (c) Name the two neutral emitted particles.

U11-Q12 · 3 marks

Diagnostic multiple choice. Which statement is correct? A: A positron is a proton because both carry +e. B: A neutron is fundamental because its charge is zero. C: An electron neutrino is a fundamental lepton. D: An electron contains three quarks. Choose one and explain why the others fail.

U11-Q13 · 3 marks

Diagnostic multiple choice. Which change represents β^- decay at quark level? A: $u \rightarrow d + e^- + \nu_e$. B: $d \rightarrow u + e^- + \bar{\nu}_e$. C: $d \rightarrow u + e^+ + \nu_e$. D: $u \rightarrow d + e^+ + \nu_e$. Choose one and check both the charge and the emitted neutral particle.

Use with the full notes

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