InkPhysics

QUESTION WORKBOOK

Rutherford scattering and the nuclear atom

Nuclear physics · Year 13

AQA 3.8.1.1, 3.8.1.2 · CIE 11.1.1, 11.1.7 · OCR A 6.4.1(a), 6.4.1(c), 6.4.3(b)(i), 6.4.3(b)(ii)

18 questions · 54 marks

PRINT EDITION

SECTION A · Warm-up

A1 Describe the main observations of the Rutherford alpha-particle scattering experiment. [2]

A2 In the Rutherford scattering experiment, most alpha particles passed straight through the gold foil, while a tiny fraction were deflected through large angles. State the conclusions about the structure of the atom drawn from these observations. [2]

A3 State what is meant by background radiation and give two of its origins. [2]

A4 State the nature of an alpha particle and of gamma radiation. [2]

A5 State a material that will absorb each of alpha, beta and gamma radiation. [3]

SECTION B · Standard

B1 A source emits three types of radiation. One is stopped by paper. A second passes through paper but is stopped by a few millimetres of aluminium. A third passes through both and is only reduced by lead. Identify each radiation. [3]

B2 A gamma source produces an intensity of 800 arbitrary units at a distance of 1.0 m. Assuming an inverse-square law, calculate the intensity at 2.0 m. [2]

B3 A detector reads 1600 counts per second at a distance of 0.50 m from a gamma source. Assuming an inverse-square law, calculate the expected reading at 2.0 m. [2]

B4 Explain why the great majority of alpha particles pass through a thin gold foil almost undeflected. [3]

B5 Before Rutherford's experiment, the atom was modelled as a sphere of positive charge with electrons embedded in it. Explain why the deflection of some alpha particles through more than 90° could not be explained by this model. [3]

B6 A detector placed 150 mm from a sealed gamma source records a corrected count rate of 3600 counts per second. Assuming the intensity obeys an inverse-square law, determine the distance from the source at which the corrected count rate falls to 400 counts per second. Give your answer in metres. [3]

B7 A domestic smoke detector contains a source that emits only alpha particles. Explain why the source presents very little hazard while sealed in the detector, but would be dangerous if the source material were swallowed. [3]

SECTION C · Stretch

C1 With a gamma source in place, a detector at 0.10 m records 520 counts per second, including a background count of 20 counts per second. Use the inverse-square law to predict the measured count rate at 0.20 m. [4]

C2 Explain why a few alpha particles in the scattering experiment were deflected through very large angles, and state which particles are deflected the most. [3]

C3 Compare the ionising power and the penetrating power of alpha, beta and gamma radiation. [3]

C4 A factory rolls aluminium foil about 0.1 mm thick. The thickness is monitored continuously by a radioactive source above the moving foil and a detector below it. Four sources are available. W: alpha emitter, half-life 432 years; X: beta emitter, half-life 29 years; Y: beta emitter, half-life 15 hours; Z: gamma emitter, half-life 5.3 years. Suggest, with reasons, which source the factory should choose. [4]

C5 A student measures the count rate near a sealed gamma source. With the detector 0.20 m from the source the measured count rate is 340 counts per second; at 0.40 m it is 100 counts per second. Both readings include a constant background count rate. Assuming the gamma intensity obeys an inverse-square law, determine the background count rate. [4]

C6 Describe an experiment to test whether the intensity of the gamma radiation from a small sealed source obeys an inverse-square law. Include the measurements taken, how the data are analysed, and the precautions taken to keep the experimenter's dose low. [6]