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QUESTION WORKBOOK

Constituents of the atom

Particles · Year 12

AQA 3.2.1.1 · CIE 11.1.2, 11.1.3, 11.1.4, 11.1.5 · OCR A 6.4.1(b), 6.4.1(d)

19 questions · 54 marks

PRINT EDITION

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SECTION A · Warm-up

A1 State the charge and the relative mass of the proton, the neutron and the electron. [2]

A2 Calculate the specific charge of a proton ($e = 1.60 \times 10^{-19}$ C, $m_p = 1.67 \times 10^{-27}$ kg). [2]

A3 Explain what is meant by two isotopes of an element. [2]

A4 The nuclide of copper used in electrical wiring is written $^{63}_{29}Cu$. State what the number 63 and the number 29 each represent. [2]

A5 State the specific charge of the neutron. Explain your answer. [2]

A6 State one use of isotopic data. [1]

SECTION B · Standard

B1 Calculate the specific charge of an electron ($m_e = 9.11 \times 10^{-31}$ kg), and comment on how it compares with that of a proton. [3]

B2 A nucleus is written $^{14}_{6}C$. State the number of protons and neutrons it contains, and the number of electrons in the neutral atom. [3]

B3 Calculate the specific charge of an alpha particle (a helium-4 nucleus: charge +2e, mass ≈ $4m_p$). [3]

B4 An oxygen-16 atom loses two electrons to become an ion of charge +2e. Calculate the specific charge of this ion (mass ≈ $16m_p$). [3]

B5 A bare nucleus produced in an ion source has a charge of $+4.80 \times 10^{-19}$ C and a mass of 1.17×10^{-26} kg. The candidate nuclides are helium-4 (Z = 2), lithium-7 (Z = 3), beryllium-9 (Z = 4) and boron-11 (Z = 5). Determine which nuclide it is ($e = 1.60 \times 10^{-19}$ C; nucleon mass = 1.67×10^{-27} kg). [3]

B6 In an electrostatic paint sprayer, a paint droplet of mass 2.4×10^{-15} kg acquires a specific charge of 2.0×10^{-4} C kg^{-1} by losing electrons. Calculate the charge on the droplet and hence the number of electrons removed ($e = 1.60 \times 10^{-19}$ C). [3]

B7 Chlorine has two stable isotopes, $^{35}_{17}Cl$ and $^{37}_{17}Cl$. State the number of protons and the number of neutrons in each nucleus, and explain why the two isotopes have identical chemical properties. [3]

SECTION C · Stretch

C1 A uranium nucleus is written $^{238}_{92}U$. State the number of protons and neutrons, and calculate the specific charge of the nucleus (mass ≈ $238m_p$). [4]

C2 Compare the specific charge of a single proton (a hydrogen-1 nucleus) with that of an alpha particle by calculating both, and state which is greater. [4]

C3 Explain why the electron has by far the largest specific charge of the three sub-atomic particles. [3]

C4 A helium-3 nucleus contains 2 protons and 1 neutron. Show that the specific charge of a helium-3 nucleus is about 6×10^{7} C kg^{-1}. Go on to explain why this is greater than the specific charge of a helium-4 nucleus ($e = 1.60 \times 10^{-19}$ C; nucleon mass = 1.67×10^{-27} kg). [4]

C5 A mass spectrometer identifies ions by their specific charge. A singly ionised neon atom is measured to have a specific charge of 4.36×10^{6} C kg^{-1}. Neon has two common isotopes, neon-20 and neon-22. Deduce which isotope the measured ion is. Treat the mass of an ion of nucleon number A as $A \times 1.67 \times 10^{-27}$ kg; $e = 1.60 \times 10^{-19}$ C. [4]

C6 Explain why no bare nucleus can have a specific charge greater than that of a single proton. Treat the proton and neutron masses as equal. [3]