



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

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 ($e = 1.60 \times 10^{-19} \text{ C}$, $m_p = 1.67 \times 10^{-27} \text{ kg}$). [2]

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

A4 The nuclide of copper used in electrical wiring is written ${}^{63}_{29}\text{Cu}$. 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 ($m_e = 9.11 \times 10^{-31} \text{ kg}$), and comment on how it compares with that of a proton. [3]

B2 A nucleus is written $^{14}_6\text{C}$. 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 $\approx 4m_p$). [3]

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

- B5** A bare nucleus produced in an ion source has a charge of $+4.80 \times 10^{-19} \text{ C}$ and a mass of $1.17 \times 10^{-26} \text{ kg}$. 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 ($e = 1.60 \times 10^{-19} \text{ C}$; nucleon mass $= 1.67 \times 10^{-27} \text{ kg}$). [3]

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

- B7** Chlorine has two stable isotopes, $^{35}_{17}\text{Cl}$ and $^{37}_{17}\text{Cl}$. 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 $^{238}_{92}\text{U}$. State the number of protons and neutrons, and calculate the specific charge of the nucleus (mass $\approx 238m_p$). [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 $6 \times 10^7 \text{ C kg}^{-1}$. Go on to explain why this is greater than the specific charge of a helium-4 nucleus ($e = 1.60 \times 10^{-19} \text{ C}$; nucleon mass = $1.67 \times 10^{-27} \text{ kg}$). [4]

- C5** A mass spectrometer identifies ions by their specific charge. A singly ionised neon atom is measured to have a specific charge of $4.36 \times 10^6 \text{ C kg}^{-1}$. 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 $A \times 1.67 \times 10^{-27} \text{ kg}$; $e = 1.60 \times 10^{-19} \text{ C}$. [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]
