InkChemistry

ANSWER BOOK

Protons, neutrons, electrons and isotopes

Atomic structure · Unit C01

AQA 3.1.1.1, 3.1.1.2 · OCR A 2.1.1

16 questions · 58 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 PNE-Q11

B1 a helium nucleus has a charge of +2, so it holds 2 protons, but its relative mass is 4. **B1** the extra mass of 2 must come from particles with mass and no charge, which are neutrons. [2]

SECTION B · Standard, 3 to 5 marks

B1 PNE-Q2

B1 $^{39}K^{+}$ has 19 protons, from the atomic number, and 39 - 19 = 20 neutrons. **B1** $^{39}K^{+}$ has 18 electrons, one fewer than its protons because the charge is +1. **B1** $^{127}I^{-}$ has 53 protons and 127 - 53 = 74 neutrons. **B1** $^{127}I^{-}$ has 54 electrons, one more than its protons because the charge is -1. [4]

B2 PNE-Q5

B1 isotopes are atoms of the same element, with the same number of protons. **B1** they have different numbers of neutrons; reject 'different mass' alone. **B1** the two isotopes have the same number of electrons, in the same arrangement or electron configuration. **B1** chemical reactions involve the electrons, not the nucleus, so the isotopes react in the same way. [4]

B3 PNE-Q8

B1 a beam of alpha particles was fired at a very thin sheet of gold foil. **B1** the alpha particles were detected where they struck a zinc sulfide screen placed around the foil. **B1** most of the alpha particles passed straight through the foil, undeflected or deflected by a small angle. **B1** a very small number were deflected through large angles, some by more than 90° back towards the source. [4]

B4 PNE-Q9

B1 most alpha particles passed straight through, so most of the atom is empty space. **B1** a few were deflected through large angles, so they were repelled by a small region of concentrated positive charge holding most of the mass. **B1** large deflections were very rare, so this nucleus is very small compared with the whole atom. **B1** in the plum pudding model the positive charge is spread through the atom, which could not turn an alpha particle through a large angle. [4]

B5 PNE-Q13

B1 all three have 17 protons. **B1** ^{35}Cl and $^{35}Cl^{-}$ have 18 neutrons, while ^{37}Cl has 20. **B1** ^{35}Cl and ^{37}Cl have 17 electrons, while $^{35}Cl^{-}$ has 18. **B1** $^{35}Cl^{-}$ differs from ^{35}Cl only in having one more electron, and ^{37}Cl differs from ^{35}Cl only in its nucleus. [4]

B6 PNE-Q14

B1 it is sulfur, because it has 16 protons. **B1** its mass number is 16 + 18 = 34. **B1** its charge is 2−, because it has two more electrons than protons. **B1** the symbol is $^{34}S^{2-}$; allow $^{34}_{16}S^{2-}$. [4]

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B7 PNE-Q16 [4]

B1 isotopes are defined by the same number of protons and a different number of neutrons; the definition says nothing about radioactivity. **B1** many isotopes are stable, such as chlorine-35, chlorine-37 and carbon-12. **B1** some isotopes are radioactive, such as tritium and carbon-14, so the claim is true of some isotopes only. **B1** the claim is therefore false as a definition: the ordinary atoms of an element are themselves isotopes.

B8 PNE-Q19 [4]

B1 electrons are negative and protons positive, so electrons are attracted to the positive plate and protons to the negative plate. **B1** the angle of deflection is proportional to charge ÷ mass. **B1** the charges are equal in size but the electron's mass is 1840 times smaller, so it is deflected about 1840 times as much. **B1** a neutron has no charge, so the field exerts no force on it and the beam passes straight through.

B9 PNE-Q1 [3]

B1 a proton has a relative mass of 1 and a relative charge of +1. **B1** a neutron has a relative mass of 1 and a relative charge of 0. **B1** an electron has a relative mass of 1/1840 and a relative charge of -1; allow a relative mass of 0.0005 or 'negligible'.

B10 PNE-Q4 [3]

M1 the relative mass of the atom is 1 + 1/1840 = 1.000543. **M1** percentage = (1/1840) ÷ 1.000543 × 100. **A1** 0.0543% to three significant figures; allow 0.0543% from dividing by 1.

B11 PNE-Q7 [3]

B1 a deuterium nucleus holds a proton and a neutron, while a ^{1}H nucleus is a single proton. **B1** a D_2O molecule has a relative mass of 20 against 18 for H_2O, while the molecules take up almost the same volume, so the density is higher. **B1** deuterium has the same number of electrons in the same arrangement as ^{1}H, and reactions depend on electrons, so the reactions are the same.

B12 PNE-Q10 [3]

B1 heated hydrogen gives out light at only certain exact wavelengths, not a continuous spectrum. **B1** each wavelength corresponds to a fixed amount of energy, given out when an electron drops to a lower level. **B1** the electron can therefore have only certain energies, which means it occupies fixed energy levels.

B13 PNE-Q12 [3]

B1 $^{37}Cl_2$ molecules have a relative mass of 74, greater than the mean of about 71 for natural chlorine. **B1** at the same temperature the molecules have the same mean kinetic energy, so the heavier molecules move more slowly and diffuse more slowly. **B1** the electrons are the same in number and arrangement, so the chemical reactions are unchanged.

B14 PNE-Q21 [3]

M1 charge ÷ mass is 2 ÷ 4 = 0.5 for $^{4}He^{2+}$ and 1 ÷ 1 = 1 for $^{1}H^{+}$. **M1** angle = 3.0° × 0.5 ÷ 1. **A1** 1.5°, to two significant figures, towards the negative plate, the same direction as the $^{1}H^{+}$ beam.

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SECTION C · Long, 6 marks or more

C1 PNE-Q17

Indicative content [6]

B1 Dalton's atoms were solid, indivisible spheres, which explained fixed combining ratios but not particles coming out of atoms. **B1** Thomson found that cathode rays are negative particles far lighter than any atom, so atoms contain electrons. **B1** atoms are neutral, so Thomson proposed the plum pudding model: electrons dotted through a sphere of spread-out positive charge. **B1** in the gold foil experiment most alpha particles passed straight through, but a few were deflected through more than 90°. **B1** Rutherford concluded that the positive charge and nearly all the mass are in a tiny, dense nucleus, with the atom mostly empty space. **B1** the line spectrum of hydrogen showed that its electron has only certain energies, so Bohr placed electrons in fixed energy levels.

Levels

Level 3 (5–6 marks) every step from Dalton to Bohr is present with the evidence that forced each change: cathode rays and the electron, the plum pudding model, the alpha scattering results and the nucleus, and the hydrogen line spectrum and energy levels; the order is right and each model is linked to its evidence.

Level 2 (3–4 marks) three or four models appear in order with evidence for most of the changes; one link is asserted rather than argued, such as a nucleus with no reason drawn from the few alpha particles that bounced back.

Level 1 (1–2 marks) two or three models are listed, often with alpha scattering said to have revealed the electron, and no evidence for why each model changed.

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