2.12 Atomic Structure and the History of the Atom: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A sample of magnesium contains three isotopes: magnesium-24 (79% abundance), magnesium-25 (10% abundance) and magnesium-26 (11% abundance).

(a) Calculate the relative atomic mass of this sample of magnesium. Give your answer to 1 decimal place. Show your working. **(3)**

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(Total for Question 1 is 3 marks)

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2 Daniel used a mass spectrometer to analyse a sample of a pure element with atomic number 10. The results are shown below: isotope with mass number 20 has a relative abundance of 90%; isotope with mass number 22 has a relative abundance of 10%.

Isotope mass number	Relative abundance (%)
20	90
22	10

(a) Calculate the number of neutrons in the isotope with mass number 22. **(1)**

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(b) Calculate the relative atomic mass of this sample of the element. Give your answer to 3 significant figures. **(3)**

.....

(c) Use the atomic number given to name this element. **(1)**

(Total for Question 2 is 5 marks)

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3 Higher tier only. Boron has a relative atomic mass of 10.8 and occurs naturally as two isotopes, boron-10 and boron-11.

(a) Calculate the percentage abundance of each isotope. Show your working clearly. **(4)**

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(Total for Question 3 is 4 marks)

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4 Atoms are made up of three types of subatomic particle: protons, neutrons and electrons.

Particle	Relative charge	Relative mass
Proton	?	?
Neutron	?	?
Electron	?	?

(a) Complete the 'Relative charge' column of the table to show the relative charge of the proton, the neutron and the electron. **(3)**

(b) Complete the 'Relative mass' column of the table to show the relative mass of the proton, the neutron and the electron. **(3)**

(Total for Question 4 is 6 marks)

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5 Two atoms, X and Y, are isotopes of the same element.

(a) Define the term 'isotope'. **(2)**

(b) Explain why isotopes of the same element have the same chemical properties but can have different physical properties, such as mass. **(2)**

(Total for Question 5 is 4 marks)

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6 Electrons are arranged in shells around the nucleus of an atom.

(a) For atoms of the first 20 elements, state the maximum number of electrons that occupy each of the first three electron shells, starting with the shell closest to the nucleus. **(3)**

(b) An atom of silicon has 14 electrons. Write the electronic structure of this atom. **(2)**

(Total for Question 6 is 5 marks)

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7 In 1897, J. J. Thomson discovered that atoms contain smaller, negatively charged particles called electrons.

(a) Describe the 'plum pudding model' of the atom that Thomson proposed. **(2)**

(b) State why the discovery of the electron meant that Dalton's model of the atom could no longer be correct. **(1)**

(Total for Question 7 is 3 marks)

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8 Complete the nuclear notation and calculate the number of protons, neutrons and electrons for the species shown.

(a) Write the nuclear notation for the isotope with 26 protons and 30 neutrons (use A over Z notation, e.g. A over Z X). **(2)**

(b) An ion is shown as 35 over 17 X with charge -1. Calculate the numbers of protons, neutrons and electrons. **(2)**

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(c) A neutral atom of element Y has mass number 23 and proton number 11. Give its symbol and electron configuration. **(2)**

(Total for Question 8 is 6 marks)

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9 In the α particle scattering experiment, a beam of α particles (which are positively charged) was directed at a thin sheet of gold foil.

(a) Most of the α particles passed straight through the gold foil with little or no deflection. Explain what this observation suggests about the structure of the atom. **(2)**

(b) A small number of α particles were deflected through more than 90 degrees, with a very small number bouncing almost straight back. Explain what this observation suggests about the structure of the atom. **(2)**

(c) Explain why these results led scientists to reject the plum pudding model in favour of a new nuclear model. **(2)**

(Total for Question 9 is 6 marks)

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10 A class practical investigates the scattering of α particles by thin metal foils. The student measures the number of α particles detected at various angles for a gold foil and a thin aluminium foil. The data collected (counts per minute) are: gold foil at 0 degrees 1200 cpm, at 10 degrees 180 cpm, at 30 degrees 24 cpm; aluminium foil at 0 degrees 1180 cpm, at 10 degrees 60 cpm, at 30 degrees 6 cpm. Use these data to answer the following.

(a) Calculate the percentage of detected α particles scattered at 30 degrees for each foil relative to counts at 0 degrees. Give answers to 2 significant figures. **(3)**

(b) Explain, using the data, what these results show about the nuclear structure of gold compared with aluminium. Refer to scattering at large angles. **(3)**

(Total for Question 10 is 6 marks)

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Mark scheme · 2.12 Atomic Structure and the History of the Atom: 1-hour Pack

Question 1

(a) (24 x 79) + (25 x 10) + (26 x 11), oe, = 2432 seen **M1**

(a) divides the total by 100 oe **M1**

(a) 24.3 cao (accept 24.32 correctly rounded to 24.3) **A1**

(a) Answer: 24.3

Question 2

(a) 12 cao (22 - 10) **B1**

(a) Answer: 12

(b) (20 x 90) + (22 x 10), oe, = 2020 seen **M1**

(b) divides the total by 100 oe **M1**

(b) 20.2 cao **A1**

(b) Answer: 20.2

(c) neon cao **B1**

(c) Answer: Neon

Question 3

(a) sets up an equation using x for the percentage of boron-10, e.g. (10x + 11(100 - x)) / 100 = 10.8 oe **M1**

(a) correctly expands and rearranges, e.g. 10x + 1100 - 11x = 1080, leading to -x = -20 oe **M1**

(a) boron-10 = 20% (ft from a correctly rearranged equation) **A1**

(a) boron-11 = 80% cao (100 minus their boron-10 value) **A1**

(a) Answer: Boron-10 = 20%, boron-11 = 80%

Question 4

(a) proton: +1 (positive) cao **B1**

(a) neutron: 0 (no charge) cao **B1**

(a) electron: -1 (negative) cao **B1**

(a) Answer: Proton +1, neutron 0, electron -1

(b) proton: 1 cao **B1**

(b) neutron: 1 cao **B1**

(b) electron: very small / negligible (accept approximately 1/2000 of a proton) oe **B1**

(b) Answer: Proton 1, neutron 1, electron very small (negligible)

Question 5

(a) atoms of the same element with the same number of protons (same atomic number) oe **B1**

(a) but a different number of neutrons (different mass number) oe **B1**

(a) Answer: Atoms of the same element with the same number of protons but a different number of neutrons

(b) chemical properties are the same because isotopes have the same number of electrons (the same electronic structure), so they react in the same way oe **B1**

(b) physical properties such as mass differ because isotopes have a different number of neutrons, giving a different mass number oe **B1**

(b) Answer: Same chemical properties because they have the same number of electrons/electronic structure; different physical properties (mass) because they have a different number of neutrons

Question 6

(a) 1st shell = 2 cao **B1**

(a) 2nd shell = 8 cao **B1**

(a) 3rd shell = 8 cao **B1**

(a) Answer: 2, 8, 8

(b) first two shells correctly filled, 2, 8 oe **B1**

(b) remaining 4 electrons correctly placed in the third shell, giving 2, 8, 4 cao **B1**

(b) Answer: 2, 8, 4

Question 7

(a) a sphere (or ball/cloud) of positive charge oe **B1**

(a) with negative electrons embedded throughout/within it oe **B1**

(a) Answer: A sphere of positive charge with negative electrons embedded within it

(b) Dalton's model described atoms as solid, indivisible spheres, but the discovery of the electron showed that atoms contain smaller particles, so atoms can be divided oe **B1**

(b) Answer: Atoms were shown to contain smaller particles (electrons), so could not be solid, indivisible spheres as Dalton described

Question 8

(a) writes mass number A = protons + neutrons = 56 **M1**

(a) full notation: 56 over 26 Fe (or Fe-56) cao **A1**

(a) Answer: 56 over 26 Fe (Fe-56)

(b) states protons = 17 and neutrons = 35 - 17 = 18 **M1**

(b) states electrons = 18 (17 + 1) cao **A1**

(b) Answer: Protons 17; Neutrons 18; Electrons 18.

(c) identifies element with Z = 11 as sodium (Na) **M1**

(c) gives correct electron configuration 2,8,1 cao **A1**

(c) Answer: Symbol Na (sodium); electron configuration 2,8,1.

Question 9

(a) most of the atom is empty space oe **B1**

(a) so most α particles were not close enough to any charged region of the atom to be deflected oe **B1**

(a) Answer: Most of the atom is empty space

(b) the atom has a small, dense region containing most of its mass (the nucleus) oe **B1**

(b) this region has a concentrated positive charge, which strongly repels the positively charged α particles oe **B1**

(b) Answer: There is a small, dense, positively charged nucleus at the centre of the atom

(c) the plum pudding model predicted that positive charge (and mass) was spread evenly throughout the atom, so α particles should only ever be deflected by small angles oe **B1**

(c) the large deflections actually observed did not match this prediction, so a new model with a small, dense, charged nucleus was needed to explain the results oe **B1**

(c) Answer: The plum pudding model could not explain the large deflections observed, so it was replaced by the nuclear model

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Question 10

(a) works out ratio 30 deg count / 0 deg count for each foil **M1**

(a) gold: 24/1200 = 0.02 -> 2.0% cao **A1**

(a) aluminium: 6/1180 = 0.00508 -> 0.51% -> 0.51% rounded to 2 s.f. = 0.51% cao **A1**

(a) Answer: Gold: 2.0%; Aluminium: 0.51%.

(b) states that gold shows a higher proportion of large-angle scattering than aluminium (2.0% vs 0.51%) **M1**

(b) links large-angle scattering to encounter with a small, dense, positively charged nucleus **M1**

(b) concludes that gold nuclei cause more large-angle deflections, consistent with higher nuclear charge or larger nucleus, oe **A1**

(b) Answer: Gold produces more large-angle scattering than aluminium, showing more α particles are deflected by close encounters with a small, dense, positively charged nucleus; this suggests gold nuclei produce stronger repulsion (higher nuclear charge or larger nucleus) than aluminium.

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