3.26 Atomic Structure and the Development of the Model: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 In 1904, before the nucleus had been discovered, J.J. Thomson proposed the 'plum pudding' model of the atom.

(a) Describe the plum pudding model of the atom. **(2)**

(b) Give one way in which the plum pudding model is different from the nuclear model of the atom accepted today. **(2)**

(Total for Question 1 is 4 marks)

2 A neutral atom of magnesium-24 has 12 protons, 12 neutrons and 12 electrons. A neutral atom of fluorine-19 has 9 protons, 10 neutrons and 9 electrons.

(a) A magnesium atom loses 2 electrons to form a magnesium ion. State the number of protons, the number of neutrons and the number of electrons in this ion, and its overall charge. **(3)**

(b) A fluorine atom gains 1 electron to form a fluoride ion. State the number of electrons in this ion and its overall charge. **(2)**

(Total for Question 2 is 5 marks)

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3 The table shows the approximate atomic radius of three elements.

Element	Number of protons	Atomic radius (m)
Hydrogen	1	5.3×10^{-11}
Carbon	6	7.0×10^{-11}
Uranium	92	1.75×10^{-10}

(a) State the order of magnitude of the radius, in metres, that is common to all three atoms. **(1)**

(b) Uranium atoms contain far more protons, neutrons and electrons than hydrogen atoms. Use the data in the table to explain what this suggests about the size of atoms in general. **(2)**

(Total for Question 3 is 3 marks)

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4 Describe how and why scientists' ideas about the structure of the atom have changed since the start of the 20th century. Your answer should refer to the contributions of at least three scientists.

(Total for Question 4 is 6 marks)

5 The table gives the atomic number and mass number of a sodium atom and a sodium ion.

Species	Atomic number	Mass number	Protons	Neutrons	Electrons
Sodium atom (Na)	11	23	...	...	...
Sodium ion (Na^+)	11	23	...	...	...

(a) Complete the row for the sodium atom (Na). **(3)**

(b) Complete the row for the sodium ion (Na^+), which has lost one electron. **(3)**

(Total for Question 5 is 6 marks)

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Mark scheme · 3.26 Atomic Structure and the Development of the Model: 30-minute Pack

Question 1

(a) a ball (sphere) of positive charge, spread evenly throughout the atom, oe **B1**

(a) negative electrons are embedded/spread through the positive charge, like plums in a pudding, oe **B1**

(a) Answer: A ball of positive charge, spread evenly throughout the atom, with negative electrons embedded through it.

(b) correctly describes one feature of the plum pudding model, e.g. positive charge is spread throughout the whole atom **B1**

(b) correctly contrasts this with the corresponding feature of the nuclear model, e.g. the nuclear model has a small, dense, positively charged nucleus at the centre, with electrons in shells around it; accept any other valid, correctly contrasted difference **B1**

(b) Answer: E.g. in the plum pudding model, positive charge is spread through the whole atom; in the nuclear model, it is concentrated in a small, dense nucleus at the centre.

Question 2

(a) protons = 12, neutrons = 12 (both unchanged) **B1**

(a) electrons = 10 (12 - 2) **B1**

(a) overall charge = 2+ (Mg^{2+}), because there are 2 more protons than electrons, oe **B1**

(a) Answer: Protons = 12, neutrons = 12, electrons = 10, overall charge = 2+ (Mg^{2+}).

(b) electrons = 10 (9 + 1) **B1**

(b) overall charge = 1- (F^-), because there is 1 more electron than protons, oe **B1**

(b) Answer: Electrons = 10, overall charge = 1- (F^-).

Question 3

(a) 10^{-10} m (1 x 10^{-10} m), oe **B1**

(a) Answer: 10^{-10} m (about 1 x 10^{-10} m).

(b) despite having very different numbers of particles (e.g. 1 proton compared with 92 protons), all three atoms have a radius of the same order of magnitude, oe **B1**

(b) this suggests that (nearly) all atoms are approximately the same tiny size, regardless of which element they are, oe **B1**

(b) Answer: Although the number of particles varies hugely between elements, atomic radius stays roughly the same order of magnitude, so almost all atoms are approximately the same tiny size.

Question 4

Level 3 A detailed, coherent description is given of how the atomic model changed over time, correctly sequencing the contributions of at least three scientists and linking each change to the evidence or reasoning that caused it. The answer is well organised throughout, using correct scientific vocabulary. **5-6**

Level 2 A description is given of how the atomic model changed, referring to the contributions of at least two scientists, with some links made between evidence and the resulting changes to the model. The answer has some structure, with occasional lapses in scientific vocabulary. **3-4**

Level 1 Simple, isolated statements are made about one or two scientists or changes to the atomic model, with little or no linking between the evidence and the changes made. The answer lacks clear structure. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- J.J. Thomson discovered the electron and proposed the plum pudding model: an atom is a ball of positive charge with negative electrons embedded/scattered throughout it.
- Ernest Rutherford, with Hans Geiger and Ernest Marsden, carried out the alpha particle scattering experiment, firing alpha particles at thin gold foil.
- Most alpha particles passed straight through the foil, showing that atoms are mostly empty space.
- A small number of alpha particles were deflected through large angles, and a very small number bounced almost straight back.
- This showed that most of the mass and all of the positive charge of an atom must be concentrated in a tiny, dense region: the nucleus.
- The plum pudding model could not explain this large-angle scattering, so it was rejected in favour of Rutherford's nuclear model.
- Niels Bohr adapted the nuclear model, proposing that electrons orbit the nucleus at specific fixed distances, called shells or energy levels, rather than at any distance.
- Bohr's theoretical calculations agreed with experimental observations, which made the nuclear model more widely accepted by scientists.
- In 1932, James Chadwick provided evidence for a neutral particle in the nucleus, the neutron, explaining why atoms of the same element (same number of protons) can have different masses (isotopes).
- This led to the currently accepted model of the atom: a small, dense, positively charged nucleus containing protons and neutrons, surrounded by electrons arranged in shells/energy levels.

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Question 5

(a) protons = 11 **B1**

(a) neutrons = 12 (23 - 11) **B1**

(a) electrons = 11 (equal to protons, since the atom is neutral) **B1**

(a) Answer: Protons = 11, neutrons = 12, electrons = 11.

(b) protons = 11 (unchanged) **B1**

(b) neutrons = 12 (unchanged) **B1**

(b) electrons = 10 (11 - 1) **B1**

(b) Answer: Protons = 11, neutrons = 12, electrons = 10.

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