# 2.12 Atomic Structure and the History of the Atom: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

## The Changing Model of the Atom

*Original text written for Revision Library.*

For much of the nineteenth century, scientists pictured the atom as a tiny, solid sphere that could not be divided, created or destroyed, an idea first proposed by John Dalton in the early 1800s. This changed in 1897, when J. J. Thomson's experiments with cathode rays revealed the existence of tiny, negatively charged particles far smaller than a whole atom. Since atoms are electrically neutral overall, Thomson proposed the 'plum pudding model': a sphere of positive charge with negative electrons embedded throughout it, rather like fruit in a pudding. In the early 1900s, Ernest Rutherford directed an experiment in which Hans Geiger and Ernest Marsden fired alpha particles at a thin sheet of gold foil. Most particles passed straight through, but a small number bounced back through large angles. This was not what the plum pudding model predicted, and it led Rutherford to propose a new nuclear model: a tiny, dense, positively charged nucleus surrounded by mostly empty space. Niels Bohr then refined this model further, suggesting that electrons occupy fixed shells at set distances from the nucleus, corresponding to different energy levels. His calculations matched experimental observations closely. Finally, in 1932, James Chadwick provided evidence for the neutron, a particle with no charge found alongside protons in the nucleus, completing the model of the atom used today.

**1** Write the electron arrangement (shell notation) for the following neutral atoms.

**(a)** Oxygen, atomic number 8. **(1)**

**(b)** Magnesium, atomic number 12. **(1)**

**(c)** Chlorine, atomic number 17. **(1)**

**(Total for Question 1 is 3 marks)**


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**2** This question is about the particles that make up an atom.

**(a)** Which subatomic particle has a relative charge of 0 (no charge)? **(1)**

- ☐ A) Proton
- ☐ B) Neutron
- ☐ C) Electron
- ☐ D) Nucleus

**(b)** Name the central region of an atom that contains the protons and neutrons. **(1)**

**(c)** Name the particles that move around outside the nucleus. **(1)**

**(Total for Question 2 is 3 marks)**

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**3** Describe how the scientific model of the atom changed over time, from Dalton's model to Bohr's model. In your answer, refer to the experimental evidence that caused scientists to change their ideas at each stage.

**(Total for Question 3 is 6 marks)**


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**4** Priya carried out a flame test as part of the required practical 'Identification of ions by chemical and flame tests', to help identify the metal ion in an unknown compound.

**(a)** State two safety precautions Priya should take when carrying out this practical. **(2)**

**(b)** Priya cleaned the nichrome wire loop with dilute hydrochloric acid before dipping it into each new compound. Explain why this step is necessary. **(2)**

**(c)** Explain, in terms of electronic structure, why heating a metal compound in a flame produces light of a characteristic colour. **(5)**

**(d)** Priya observed a lilac flame, but her teacher pointed out that a lilac colour can be difficult to see if it is masked by a strong yellow-orange colour caused by sodium contamination. Suggest one improvement to the method that would make the lilac colour easier to observe. **(2)**

**(e)** Suggest why it is good practice to repeat each flame test at least twice, using a fresh sample of the compound each time. **(2)**

**(Total for Question 4 is 13 marks)**


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# Mark scheme · 2.12 Atomic Structure and the History of the Atom: 30-minute Pack

## Question 1

(a) 2,6 cao **B1**

**(a) Answer: 2,6**

(b) 2,8,2 cao **B1**

**(b) Answer: 2,8,2**

(c) 2,8,7 cao **B1**

**(c) Answer: 2,8,7**

## Question 2

(a) B (neutron) **B1**

**(a) Answer: B (neutron)**

(b) nucleus **B1**

**(b) Answer: Nucleus**

(c) electrons **B1**

**(c) Answer: Electrons**

## Question 3

**Level 3** A detailed and logically structured description of how the atomic model changed over time, correctly linking each new model to the experimental evidence that caused scientists to accept it. The account is presented in a clear chronological sequence covering Dalton, Thomson, Rutherford and Bohr. **5-6**

**Level 2** Accurate description of at least two atomic models, with some correct reference to the experimental evidence linked to a change in model. The account has some logical structure but may lack detail or full chronological order. **3-4**

**Level 1** Basic, isolated statements about one or two atomic models, with little or no reference to experimental evidence. The account may not be in chronological order. **1-2**

**Level 0** No relevant content. **0**

**Indicative content:**

- Dalton described atoms as solid spheres that could not be divided, created or destroyed, with different spheres for different elements.
- Thomson's discovery of the electron (using cathode ray tubes) showed atoms contain smaller, negatively charged particles, leading to the plum pudding model: a sphere of positive charge with electrons embedded in it.
- Rutherford, Geiger and Marsden's alpha particle scattering experiment showed most alpha particles passed straight through gold foil, meaning the atom is mostly empty space, but a small number were deflected through large angles, meaning a small, dense, positively charged nucleus is present.
- These results did not match the predictions of the plum pudding model, so the plum pudding model was replaced by the nuclear model.
- Bohr proposed that electrons orbit the nucleus in fixed shells at specific distances (energy levels); his calculations agreed with experimental observations.
- Chadwick provided evidence for the existence of the neutron in 1932, explaining the difference between atomic number and mass number and refining the nuclear model further.

## Question 4

(a) wear eye protection/safety goggles oe **B1**

(a) any other sensible precaution, e.g. tie back long hair, use a heatproof mat, do not touch the hot wire loop (any one) oe **B1**

**(a) Answer: Any two of: wear eye protection, tie back long hair, use a heatproof mat, do not touch the hot wire loop**

(b) the acid removes/dissolves any residue of the previous compound from the wire loop oe **B1**

(b) this prevents contamination, which could produce a false flame colour for the next sample tested oe **B1**

**(b) Answer: Cleaning removes any residue from the previous test, preventing contamination that could give a false colour result**

(c) electrons in the metal atom/ion absorb energy from the flame oe **B1**

(c) electrons move to a higher energy level/shell (become excited) oe **B1**

(c) electrons are unstable at the higher level and fall back down to a lower shell oe **B1**

(c) energy is released as light of a fixed/specific frequency (colour) as the electron falls back down oe **B1**

(c) this frequency/colour differs between elements because the energy gaps between their shells differ, giving each element its own characteristic flame colour oe **B1**

**(c) Answer: Electrons absorb energy and move to a higher shell; when they fall back down they release energy as light of a specific colour, which differs for each element**

(d) view the flame through blue cobalt glass oe **B1**

(d) this filters out/absorbs the yellow-orange light from sodium, making the lilac colour easier to see oe **B1**

**(d) Answer: View the flame through blue cobalt glass to filter out the yellow-orange sodium light**

(e) to check that the same colour is seen each time oe **B1**

(e) this improves the reliability of the result / reduces the risk of an anomalous result caused by contamination oe **B1**

**(e) Answer: Repeating the test improves reliability by checking the result is consistent and not due to a contamination anomaly**


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