Worksheet 1 - Atomic Models and Evidence

Trimester school assessment - IB-style chemistry practice

Suggested time: 45 minutes **Total marks:** 40 **HL:** Includes one HL evidence/model-limitations question.

Learning focus

- Describe how atomic models changed from Dalton to Thomson, Rutherford and Bohr.
- Use evidence from alpha-particle scattering to justify the nuclear model.
- Evaluate models as simplified representations with limitations.

Section A - Multiple choice

Q1. Which statement is most closely associated with Dalton's early atomic model?

A Atoms contain a tiny dense nucleus.
B Atoms are indivisible particles of each element.
C Electrons occupy quantized energy levels.
D Atoms contain neutrons that stabilize the nucleus.

Q2. Cathode-ray experiments provided evidence for the existence of:

A protons
B neutrons
C electrons
D isotopes

Q3. In Rutherford's gold foil experiment, most alpha particles passed through the foil because:

A the atom is mostly empty space
B alpha particles are negatively charged
C gold atoms have no nucleus
D electrons have a very large mass

Q4. A small number of alpha particles were deflected through large angles. This observation suggested that:

A electrons are arranged in shells
B positive charge is spread evenly throughout the atom
C the nucleus is small, dense and positively charged
D neutrons have a negative charge

Q5. Which model first placed negatively charged electrons inside a region of positive charge?

A Dalton model
B Thomson plum pudding model
C Rutherford nuclear model
D Bohr model

Q6. Why is a scientific model useful even when it is not a perfect description of reality?

A It avoids the need for evidence.
B It can explain and predict observations within limits.
C It never needs to be changed.
D It replaces experimental data.

Section B - Short answer

Q7. State two ideas from Dalton's atomic theory that are still useful in school chemistry. **[2]**

Q8. Explain why Thomson concluded that electrons were present in all atoms, not only in one metal. **[2]**

Q9. Describe two ways Rutherford's model differed from Thomson's model. **[3]**

Q10. The nuclear radius is about 1 x 10^-15 m and the atomic radius is about 1 x 10^-10 m. Calculate approximately how many times larger the atomic radius is than the nuclear radius. **[2]**

Section C - Data response/case study

A student repeats a simplified alpha-particle scattering experiment using a thin metal foil. The observations are summarized below.

Observation	Relative frequency
Passes straight through	Very high

Observation	Relative frequency
Slightly deflected	Low
Deflected by more than 90 degrees	Very low
Returns backwards	Extremely low

Q11. Use the data to infer the distribution of mass and positive charge in the atom. **[4]**

Q12. Explain why the result was unexpected if Thomson's model had been correct. **[3]**

Q13. Suggest one limitation of using a simple diagram of a nucleus with electrons orbiting like planets. **[2]**

Section D - Extended response and HL extension

Q14. Compare Dalton's, Thomson's and Rutherford's models of the atom. In your answer, refer to the evidence that caused the model to change. **[8]**

Q15. HL: Rutherford's scattering equation assumed that electrostatic repulsion was the only important force during scattering. Suggest why this assumption may fail for very high-energy alpha particles. **[4]**

Answer key and marking guidance

Award marks for chemically correct ideas. Accept alternative wording when the same scientific meaning is clear. For extended responses, use the marking guidance as a best-fit rubric.

Q1-6. B, C, A, C, B, B. MC: 1 mark each.

Q7. Any two: matter is made of atoms; atoms of the same element have the same chemical identity; atoms of different elements differ; atoms combine in simple whole-number ratios; atoms are conserved in chemical reactions. [2]

Q8. The negative particles produced were the same regardless of the metal/electrode used [1], so they were inferred to be a common part of all atoms [1].

Q9. Rutherford: atom is mostly empty space [1], positive charge/mass concentrated in a tiny nucleus [1], electrons are outside the nucleus rather than embedded in a positive matrix [1].

Q10. Ratio = 10^-10 / 10^-15 = 10^5, so the atomic radius is about 100 000 times larger. [2]

Q11. Most particles pass through, so most of the atom is empty space [1]. Rare large deflections show that positive charge is concentrated in a very small region [1]. Because alpha particles are massive and positive, a large deflection requires repulsion from a dense positive nucleus [1]. Most mass must be concentrated in that nucleus [1].

Q12. In Thomson's model positive charge is spread out, so alpha particles should experience many weak interactions and no rare strong backward deflections. Award up to [3] for linking the observation to the failure of diffuse positive charge.

Q13. Any valid limitation: electrons are not classical planets; the model does not show orbitals/probability; it can imply fixed paths; it ignores wave behavior; scale is unrealistic. [2]

Q14. Best-fit [8]: Dalton as indivisible solid spheres and fixed combining ratios [2]; Thomson from cathode rays/electrons and plum pudding model [2]; Rutherford from gold foil/alpha scattering and nuclear model [2]; clear comparison and model-change/evidence argument [2].

Q15. HL: High-energy alpha particles may approach the nucleus closely enough for the strong nuclear force/nuclear interactions to become significant [2]. The assumption of a point-like nucleus or purely Coulomb repulsion may no longer describe the path accurately [1]. Very close collisions can therefore deviate from Rutherford predictions [1].