Atoms on Trial

Compare atomic models through the evidence they explain

PHS.2.1 "Research and develop models (e.g., 3-D models, online simulations, or ball and stick) to investigate both modern and historical theories of atomic structure. Compare models and contributions of Dalton, Thomson, Rutherford, Bohr..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB As you read, number the five atomic models in the order they were proposed. Underline one observation that challenged an earlier model, and circle one feature that changed in a later model.

Five Ways to Picture an Atom

1. A museum case holds five models of the same atom. Dalton pictured atoms as solid, indivisible spheres; atoms of different elements had different properties. Thomson's cathode-ray experiments revealed negatively charged electrons inside atoms, so his model embedded electrons in a spread-out positive charge. Then Rutherford's team fired alpha particles at thin gold foil. Most passed through, but a few turned sharply back. Rutherford proposed a tiny, dense, positively charged nucleus with electrons outside it. A solid sphere or a diffuse positive charge could not explain those large deflections. Each model changed when evidence challenged an earlier picture.

2. Rutherford's nuclear model left a puzzle: why does hydrogen emit only certain colors of light? Bohr proposed that its electron could occupy only certain energy levels. A jump between levels releases or absorbs a particular amount of energy, matching hydrogen's pattern of colors. Later experiments called for a different description. Modern atomic theory treats an electron as a quantum object, not a bead traveling around the nucleus on a fixed circular track. Orbitals describe regions where an electron is likely to be found. The modern model retains a nucleus but replaces Bohr's prescribed paths with probability distributions.

3. A physical model can make these differences easier to investigate. For example, a class might use a marble for a nucleus and a loop of wire to represent an allowed path in one historical model. They could compare predictions with a published hydrogen emission spectrum. Yet a wire loop might falsely suggest that an electron always travels like a tiny planet. A cloud of closely spaced pencil dots can instead suggest a region of higher detection probability, though it cannot show every quantum property. When researching a model, record the observation it explains and one feature that the model leaves out.

2 ANSWER WITH EVIDENCE

Use the passage

1. How did Thomson's model change Dalton's picture of the atom, and what evidence led to the change?

2. Why did the gold-foil results support Rutherford's model over Thomson's model?

3. What did Bohr add to Rutherford's nuclear model to explain hydrogen's pattern of light?

4. How does the modern model keep one feature of Rutherford's model while changing Bohr's description of the electron?

3 YOUR TURN

Your own words

Imagine a detector records many positions of a hydrogen electron, including positions between two allowed rings in a Bohr model. In two panels, sketch and label how Bohr's model and the modern model would represent the electron; below the panels, explain which model can account for the detector results and one limit of your sketches.

ANSWER KEY

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HIGH SCHOOL · PHS.2.1

PART 1 · READ AND MARK

As you read, number the five atomic models in the order they were proposed. Underline one observation that challenged an earlier model, and circle one feature that changed in a later model. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	How did Thomson's model change Dalton's picture of the atom, and what evidence led to the change?	**Thomson added electrons within a spread-out positive charge instead of treating the atom as an indivisible solid sphere. His cathode-ray experiments revealed electrons.**
2	Why did the gold-foil results support Rutherford's model over Thomson's model?	**A few alpha particles turned sharply back, supporting Rutherford's tiny, dense, positive nucleus rather than Thomson's spread-out positive charge.**
3	What did Bohr add to Rutherford's nuclear model to explain hydrogen's pattern of light?	**Bohr proposed specific electron energy levels. Jumps between levels release or absorb particular amounts of energy, accounting for hydrogen's specific colors.**
4	How does the modern model keep one feature of Rutherford's model while changing Bohr's description of the electron?	**It retains a nucleus but describes electron locations with probability distributions rather than Bohr's prescribed paths.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Bohr panel: Draw a positive nucleus and two labeled allowed rings, with one electron on one ring. Modern panel: Draw a positive nucleus and a shaded probability region that includes positions between the former rings. The modern model can account for detections between the rings because its electron locations are not confined to Bohr's allowed paths. Neither sketch shows every quantum property of an electron.

Accept different sketch styles if the Bohr panel confines its electron to an allowed path and the modern panel shows a region of possible locations. The explanation should connect between-ring detections to the modern model and name a reasonable limitation of the sketches.