**Rutherford and Bohr describe atomic structure**

(adapted from PBS: A Science Odyssey – People and Discoveries; http://www.pbs.org/wgbh/aso/databank/entries/dp13at.html, http://en.wikibooks.org/wiki/High\_School\_Chemistry/The\_Bohr\_Model, and http://www.ck12.org/user:YWJyb3duQGJnY3MuazEyLmluLnVz/section/The-Bohr-Model-of-the-Atom/)



Photo: Niels Bohr's research notes for his new atomic theory

In 1911, Niels Bohr earned his PhD in Denmark with a dissertation on the electron theory of metals. Right afterwards, he went to England to study with J.J. Thomson, who had discovered the electron in 1897. Most physicists in the early years of the twentieth century were engrossed by the electron, such a new and fascinating discovery. Few concerned themselves much with the work of Max Planck or Albert Einstein. Thomson wasn't that interested in these new ideas, but Bohr had an open mind. Bohr soon went to visit Ernest Rutherford (a former student of Thomson's) in another part of England, where Rutherford had made a brand-new discovery about the atom.

Rutherford's find came from a very strange experience. Everyone at that time imagined the atom as a "plum pudding." That is, it was roughly the same consistency throughout, with negatively-charged electrons scattered about in it like raisins in a pudding. As part of an experiment with x-rays in 1909, Rutherford was shooting a beam of alpha particles (or alpha rays, emitted by the radioactive element radium) at a sheet of gold foil only 1/3000 of an inch thick, and tracing the particles' paths. Most of the particles went right through the foil, which would be expected if the atoms in the gold were like a plum pudding. But every now and then, a particle bounced back as though it had hit something solid. After tracing many particles and examining the patterns, Rutherford deduced that the atom must have nearly all its mass, and positive charge, in a central nucleus about 10,000 times smaller than the atom itself. All of the negative charge was held in the electrons, which must orbit the dense nucleus like planets around the sun.

In 1912 Bohr joined Rutherford. He realized that Rutherford's model wasn't quite right. By all rules of classical physics, it should be very unstable. For one thing, the orbiting electrons should give off energy and eventually spiral down into the nucleus, making the atom collapse. Or the electrons could be knocked out of position if a charged particle passed by. Bohr used the atomic spectra of hydrogen to explain the stability of most atoms. He noted that atoms only emitted light at specific energies.



 (purple) (blue) (teal) (red)

Based on this, Bohr was able to mathematically produce a set of energy levels for the hydrogen atom and suggested the revolutionary idea that electrons "jump" between energy levels (orbits) in a quantum fashion, that is, without ever existing in an in-between state. Thus when an atom absorbs or gives off energy (as in light or heat), the electron jumps to higher or lower orbits. Bohr published these ideas in 1913 to mixed reaction. Many people still hadn't accepted the idea of quanta, or they found other flaws in the theory because Bohr had based it on very simple atoms. But there was good evidence he was right: the electrons in his model lined up with the regular patterns (spectral series) of light emitted by real hydrogen atoms.

1. Read the entire text and circle any words you think are hard or important.

2. For paragraph 1, write the main idea in 1 or 2 sentences:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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3. For paragraph 2, write the main idea in 1 or 2 sentences:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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4. For paragraph 3, write the main idea in 1 or 2 sentences:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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5. For paragraph 4, write the main idea in 1 or 2 sentences:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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6. How is paragraph 1 related to paragraph 2?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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7. How is paragraph 2 related to paragraph 3?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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8. What evidence did Rutherford use to develop the idea of a nucleus?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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9. Refer back to specific paragraphs in the text to describe the evidence that Bohr used to explain his idea of electron orbits.

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10. How did scientists’ ideas about the atom change from 1897 to 1913?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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