Edgenuity

Warm-Up | The Modern Atomic Theory

Birth of the Atomic Theory

Dalton's Atomic Theory (1808):

- Elements are composed of extremely small, indivisible particles called atoms.
- All atoms of an element are identical, and are different from the atoms of any other element.
- Atoms combine in whole number ratios to form compounds.
- Chemical reactions involve the separation, combination, or rearrangement of atoms, but not the creation or destruction of atoms.

Lesson Objectives

By the end of this lesson, you should be able to:

- Describe the experimental basis for Einstein's explanation of the photoelectric effect.
- Explain Bohr's model of the atom and how it accounts for the existence of spectral lines.
- Describe the modern (electron cloud) model of the atom.

Science Practice: Compare Dalton's atomic model with the current quantum model of the atom.

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Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

C	electron cloud model	A. an electromagnetic radiation spectrum in which wavelengths of light emitted by a substance show up as brightly colored lines on a black background
A	emission spectrum	B. the process in which matter emits electrons as the result of absorbing light
B	photoelectric effect	C. the modern model of atomic structure in which protons and neutrons make up the very dense, tiny nucleus, and electrons surround the nucleus in clouds of probable locations

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Lesson Question

How was the modern understanding of the atom developed?

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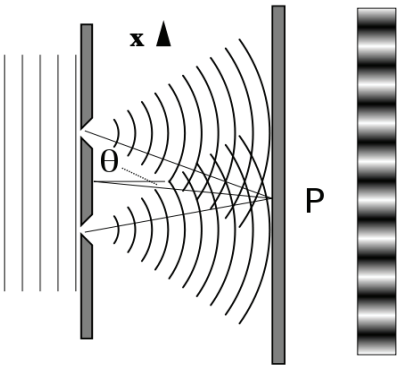
Theories of Light

Theories of light:

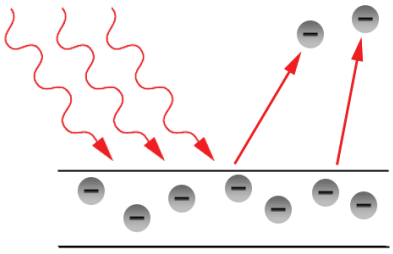
- Newton (1704): [Light] is made up of particles.
  - Corpuscular theory accepted until the 1800s
- Young (early 1800s): Light behaves as a [wave].
  - [Diffraction] in double-slit experiment demonstrated



Light Causes Emissions

Data began to contradict the wave theory in the 1800s.

- Hertz (1887): Light shining on metal produces emissions.
  - Known as the [photoelectric effect]
- Thomson: Particles emitted are electrons.
- Energy of electrons depends on frequency, not [intensity].
  - Ultraviolet light = more electrons than [visible] light



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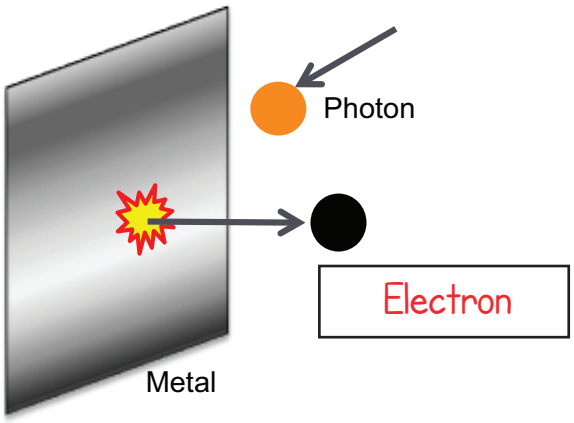
Einstein and the Photoelectric Effect

Einstein's explanation of the photoelectric effect:

- Einstein: Light is a [particle] (quantum).
  - Energy of particles is [quantized] (Planck).
- [Energy] of quantum is given by $E = hv$.
  - E = energy
  - h = Planck's constant
  - v = frequency



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Discrete Lines

Johannes Rydberg carried out studies on the emission spectra of heated [metals].

- [Emission spectrum]: a visible light spectrum in which wavelengths of light emitted by a substance show up as bright, colored lines
- Emission spectra for some metals produced discrete lines, not continuous
- Relationship between [frequency] and energy determined

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The Bohr Atom

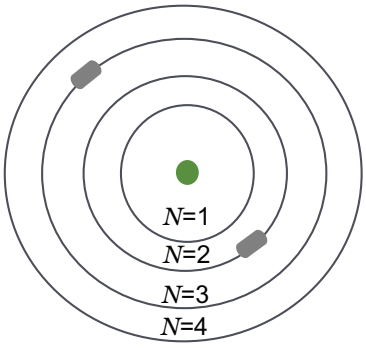
Niels Bohr (1915):

- Defined a new [model] for the atom
- Claimed electrons orbit the nucleus in discrete [paths]
- Created what was called the *planetary model*

The Bohr Model

In the Bohr model of the atom, only certain energy levels are permitted for the electrons.

- [Electrons] exist in specific orbits.
- They cannot exist in other locations.
- Each orbit has a specific [energy] level.
- Higher [orbits] have higher energies.



According to the Bohr model, an electron cannot have any possible energy. Its energy is determined by its orbit.

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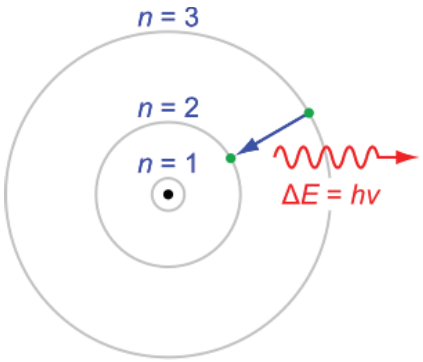
Changing Energy Levels

- Electrons can absorb energy and transition to a [higher] energy level.
- The energy is emitted when the electron drops back to its original [level].
- Each [element] has unique energy levels.



Because orbits have specific energies, and electrons must stay in orbits, atoms can absorb or emit only specific frequencies.

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Problems with the Bohr Model

- Some [spectral] lines are brighter than others.
- The model did not work for [helium] and any larger atoms.
- Electrons have a definite radius and momentum.
- The model did not take the [uncertainty] principle into account.

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Electron Cloud Model

The [Bohr] concept was replaced by the **electron cloud model**.

- Electrons in a cloud have probable locations.
- Electron [clouds] have different energy levels.
- The exact position of the electron cannot be known.
- This model is the currently accepted [atomic] model.

Summary | The Modern Atomic Theory

Lesson Question

How was the modern understanding of the atom developed?

Answer

(Sample answer) In the late 20th century, different scientists refined and updated the atomic model. The Bohr model (photoelectric effect) was a refinement of Rutherford model. Then the electron cloud model was developed which addressed the weaknesses of the Bohr model.

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Light and the Photoelectric Effect

- Light has properties of both a [wave] and a particle.
- The photoelectric effect demonstrates that light can behave as a particle.
- The energy of electrons [emitted] during the photoelectric effect is directly related to the energy of the light striking the metal.
- The photoelectric effect suggests that the Rutherford [nuclear] model of the atom is not accurate.

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The Bohr Model

- In the Bohr model, electrons orbit the nucleus in [specific] paths. They cannot exist between these orbits.
- Each orbit has specific energy.
- Electrons transitioning between energy levels [absorb] or emit specific wavelengths of energy that correspond to the energy difference between the levels.
- The Bohr model cannot explain all [observations] about atoms.

The Electron Cloud Model

- The electron cloud model addresses the [weaknesses] in the Bohr model.
- In the electron cloud model, electrons are located in clouds of probability around the nucleus.
- It is impossible to know the [exact] location of an electron within the atom.
- The electron cloud model is the currently accepted [atomic] model.

Summary | The Modern Atomic Theory

Use this space to write any questions or thoughts about this lesson.