

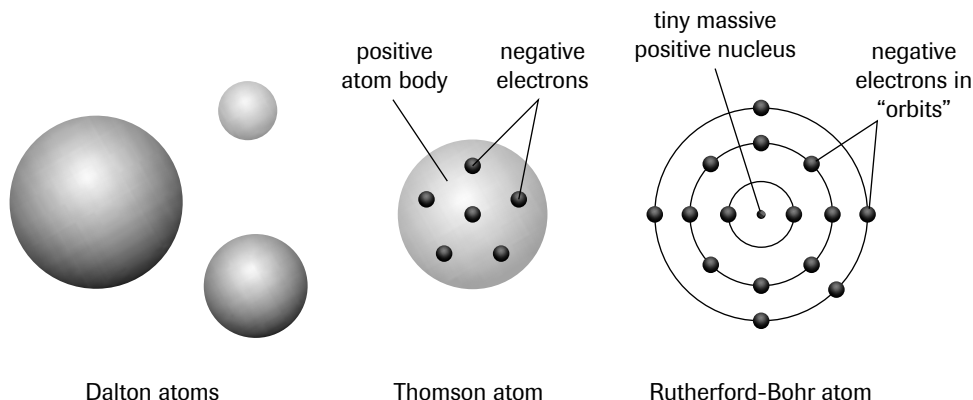
3.1 EARLY HISTORY OF ATOMIC THEORIES

SECTION 3.1 QUESTIONS

(Page 166)

Understanding Concepts

1. Dalton's atom concept was a neutral ball of matter. Thomson's was a ball of positive matter with negative particles embedded in it, and Rutherford's was a tiny, massive, positive nucleus surrounded by "orbiting" electrons.



2. The experimental evidence that led to the Rutherford model was the results of bombarding a thin metal foil with an alpha particle beam. The beam was mostly undeflected, as expected; however, a small but significant number of alpha particles *were* deflected—some, through very large angles.
3. (a) Rutherford inferred that the nucleus was very small (compared to the size of the atom) because very few alpha particles were deflected at all—so the vast majority had to be completely missing whatever in the atom was "solid."
(b) Rutherford inferred that the nucleus was positively charged because the mathematics of the angles of deflection of the alpha particles was consistent with Coulomb's Law of repulsion of similar charges—and alpha particles were known to be positively charged.
4. (a) The experimental evidence used in the discovery of the proton was the study of the behaviour of positive rays in a modified cathode ray tube.
(b) A proton with an electric charge of $1+$ is a small massive subatomic particle found in the atomic nucleus.
5. (a) The experimental evidence used in the discovery of the neutron was the effects of alpha bombardment of materials—and the fact that protons and electrons could not account for all of the observed mass of atoms.
(b) A neutron is a small massive subatomic particle found in the atomic nucleus and has no electric charge.

Applying Inquiry Skills

6. A "black box" is a system that cannot be directly observed and that must be understood by indirect interpretation of evidence. Atomic structure is an example of a concept built from indirect evidence.
7. In ordinary conversation, the word *theory* often means a hypothetical claim, speculation, or guess. In science, the word refers to a comprehensive set of ideas based on general principles that explains a large number of observations.
8. The ultimate authority in scientific work is reproducible evidence from experimentation.

Making Connections

9. News media stories ordinarily refer to atoms only in terms of uses for atomic energy or isotope radioactivity, or publication of new research evidence related to atomic structure theory.
10. (There are many examples students may use. Rutherford did much of his work at McGill University, for instance. Gillespie, LeRoy and Bader, all working in Canada, have each made significant contributions to molecular theory. A typical answer about a Canadian scientist would be something like the following.)

Gerhard Herzberg used advanced spectroscopy to study the geometry and internal energy states of small molecules and free radicals. In the 1950s and 60s, he was Director of Pure Physics at Canada's National Research Council in Ottawa, Ontario. His work, especially the discovery of the spectrum of the CH_2 free radical, led to the 1971 Nobel Prize in Chemistry.

Extensions

11. The phrase “empty space” is misleading. Rutherford stated that almost all of an atom’s volume is empty—in the sense that it contains negligible “solid” matter (material with mass and volume). The 99.9999999 % of the atom’s volume that is free of anything with significant mass is nonetheless “full” of energy—the electric field of the electrons present. Another atom cannot occupy this space because the electrons surrounding the two atoms’ nuclei, repel each other. “Solid,” at an atomic level, means full of negative charge.
12. The composition of a proton, according to the current “standard model” theory, is a triplet—made up of two “up” quarks and one “down” quark. The Canadian scientist who received a share of the Nobel Prize (in 1990) for his empirical work in verifying this hypothesis is Dr. Richard Taylor. Dr. Taylor did his work at Stanford University, using the huge particle accelerator there.

3.2 CASE STUDY: A CANADIAN NUCLEAR SCIENTIST

(Page 168)

1. (There are many possible answers like the Harriet Brooks example given in this section. See Teachers’ Resource—Section 3.2 for sources of information and teaching suggestions.)

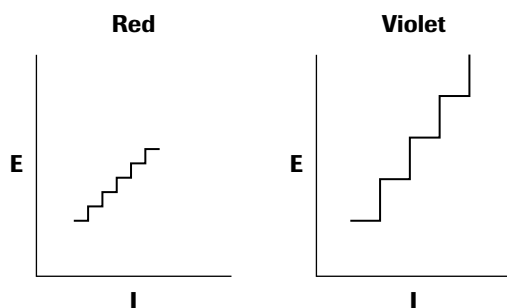
3.3 ORIGINS OF QUANTUM THEORY

PRACTICE

(Page 170)

Understanding Concepts

1. The initial colour of the flame with the air inlet closed is a bright luminous yellow. The final colour—with sufficient air mixed with the gas—is a much less visible blue. The blue flame has a much higher temperature.
2. The colour of the light from a star is directly connected to the temperature of the surface. Bluish stars like Sirius have the highest surface temperatures; and reddish stars like Betelgeuse, the lowest. Our star is yellowish, with an intermediate surface temperature.
- 3.



4. When heated strongly enough, gases produce a light that is observed (when spread out into a spectrum) to be made up of separate bright lines, of specific colours (wavelengths/frequencies).

SECTION 3.3 QUESTIONS

(Page 173)

Understanding Concepts

1. The two most important experimental observations leading to the quantum theory of light were: Max Planck’s observation that electromagnetic radiation emission could only be explained by hypothesizing that such energy release must occur in discrete amounts, or quanta; and Albert Einstein’s observation that the photoelectric effect could be explained by assuming that light energy travels in discrete packages of given energy, which he called “photons.”