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

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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

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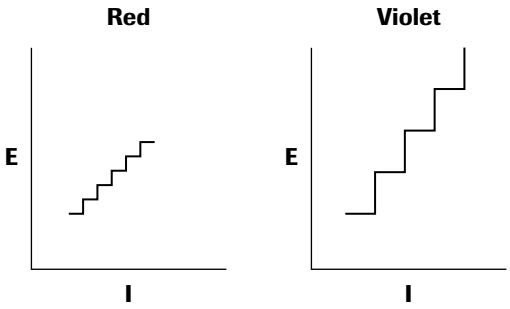
Understanding Concepts

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

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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.”