Early Models Worksheet

1. 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.

2. (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.

3. 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.

4. The main achievement of the Rutherford model was the advancement of atomic theory to include the nucleus. The main problem was explaining the region occupied by the electrons. According to existing theory, electrons should spiral into the nucleus as they lose energy by emitting electromagnetic radiation.

6. 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.

7. 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).

8. 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."

9. The photoelectric effect is the emission of electrons from the surface of a substance when electromagnetic (light) energy strikes the surface. The experiment requires a light source that can be varied in intensity (brightness) and also in frequency (wavelength/colour); and equipment to measure the (photo)electron flow rate (current) and relative electron energy (voltage).

10. Quantum is Planck's term for a small, discrete, indivisible quantity. Photon is Einstein's term for a discrete quantity, or quantum, of light.

11. Bohr's solution to the problem with the Rutherford model was to assume that classical ideas of energy did not hold inside the atom, and that electron energies were quantized in special energy states called stationary states.

12. The important new idea used by Bohr was the quantum theory of light, together with the experimental evidence of line spectra.

14. Bohr's theory was considered a success because it explained the known emission spectral lines for hydrogen, and predicted sucessfully some lines in the infrared light spectrum. Bohr's theory also provided a better understanding of the arrangement of elements in the periodic table.

15. Element 118, based on the periodic law and the Bohr theory of the atom, should be in group 18, making it a noble gas (unreactive chemically) with a full valence electron level (18 electrons in the seventh level), with a very high density for a gas, around 14 ± 3 g/L, and melting and boiling points of around –20 ± 20°C.