30. Each elliptical shape represents a polar molecule or a dipole. The oppositely charged ends of the dipoles attract each other with electrostatic forces. This type of attraction is called a dipole-dipole force.

Chapter 3 Atomic Models and Properties of Atoms

Answers to Learning Check Questions

(Student textbook page 168)

1. Thomson's discovery of the electron in 1897 invalidated Dalton's atomic theory.
2. Alpha particles would have passed straight through the foil with minimal or no deflection from encounters or collisions with nearby electrons. There would be no deflection caused by the positive charge because Thomson's model postulates a uniform, positive charge spread throughout the atom.
3. Some radioactive elements emit positively charged alpha particles. Rutherford studied them and then used the alpha particles to bombard thin foils including gold foils. This led to the model in which all of the positive charge and most of the atom's mass were confined to a very small region at the centre of the atom, which Rutherford called the nucleus.
4. Diagrams should be based on Figures 3.3 and 3.6. Both models are spherical and include electrons and the positive charge. In Thomson's model, the positive charge is spread throughout the sphere and electrons are embedded in the sphere like raisins in a muffin. In Rutherford's model, the positive charge is found in a tiny, extremely dense nucleus and the electrons orbit the nucleus like planets.
5. Scientists tend to name their models, or other discoveries, after something that is common to their own everyday lives. Rutherford's model is sometimes called the planetary model.
6. In Thomson's model, negative charges were scattered evenly throughout a large positively charged mass. The alpha particles were highly energetic and would not be expected to be deflected very much by such atoms.

(Student textbook page 183)

7. In a hydrogen atom, orbital energy depends only on n. For example, electrons in $2s$ and $2p$ have the same energy. In multi-electron atoms, orbitals in different sublevels have different energies associated with them, even if they have the same value of n. For example, $2s$ and $2p$ are associated with different energies.
8. **a.** $2s$, $2p$, $3s$, $3p$
   b. $3p$, $4s$, $3d$, $4p$
   c. $5s$, $4d$, $5p$, $6s$, $4f$, $5d$, $6p$, $5f$
9. An orbital is "full" when it contains two electrons.
10. Method one: There are five possible orbitals for $n = 1$ and $n = 2$: one $1s$ orbital, one $2s$ orbital, and three $2p$ orbitals. Each of these can contain a maximum of two electrons. Therefore, 10 electrons can occupy all possible orbitals with $n = 1$ and $n = 2$. Method two: Using the formula $2n^2$, $n = 1$ can contain two electrons and $n = 2$ can contain eight electrons, for a total of 10.
11. No. Two arrows pointing in the same direction would indicate that two electrons in the same orbital have the same spin quantum number. This violates the statement made in the Pauli exclusion principle that no two electrons can have the same four quantum numbers.
12. **a.** $\boxed{}$ **b.** $\boxed{\uparrow}$ **c.** $\boxed{\uparrow\downarrow}$

(Student textbook page 187)

13. Orbitals fill in order of increasing energy. At energy levels above $n = 3$, the different sublevels overlap. As a result, the $5s$ orbital has a lower energy than the $4d$ orbitals.
14. boron: $1s^22s^22p^1$; $[He]2s^22p^1$
    neon: $1s^22s^22p^6$; $[He]2s^22p^6$
15. $1s^22s^22p^63s^23p^4$
16. $\underset{3s}{\boxed{\uparrow\downarrow}}\ \underset{3p}{\boxed{\uparrow}\boxed{\uparrow}\boxed{}}$
17. **a.** sodium: $1s^22s^22p^63s^1$
    b. vanadium: $1s^22s^22p^63s^23p^64s^23d^3$
18. titanium: $[Ar]4s^23d^2$

Answers to Caption Questions

Figure 3.3 (Student textbook page 165): These descriptions act as models for real structures that are complex or incapable of being seen. Each part of the model is related to a part of the real structure (for example, raisins represent electrons), so that it is easier to visualize the whole structure and its component parts.
Figure 3.16 (Student textbook page 182): $4s$ is higher since it has the higher principal quantum number (even though it is filled before the $3d$).