CHAPTER REVIEW

The Development of a New Atomic Model

SECTION 1 REVIEW

1. a. List five examples of electromagnetic radiation.
b. What is the speed of all forms of electromagnetic radiation in a vacuum?

2. Prepare a two-column table. List the properties of light that can best be explained by the wave theory in one column. List those best explained by the particle theory in the second column. You may want to consult a physics textbook for reference.

3. What are the frequency and wavelength ranges of visible light?

4. List the colors of light in the visible spectrum in order of increasing frequency.

5. In the early twentieth century, what two experiments involving light and matter could not be explained by the wave theory of light?

6. a. How are the wavelength and frequency of electromagnetic radiation related?
b. How are the energy and frequency of electromagnetic radiation related?
c. How are the energy and wavelength of electromagnetic radiation related?

7. Which theory of light—the wave or particle theory—best explains the following phenomena?
a. the interference of light
b. the photoelectric effect
c. the emission of electromagnetic radiation by an excited atom

8. Distinguish between the ground state and an excited state of an atom.

9. According to Bohr's model of the hydrogen atom, how is hydrogen's emission spectrum produced?

PRACTICE PROBLEMS

10. Determine the frequency of light whose wavelength is 4.257×10^{-7} cm.

11. Determine the energy in joules of a photon whose frequency is 3.55×10^{17} Hz.

12. Using the two equations $E = h\nu$ and $c = \lambda\nu$, derive an equation expressing E in terms of h, c, and λ.

13. How long would it take a radio wave whose frequency is 7.25×10^{5} Hz to travel from Mars to Earth if the distance between the two planets is approximately 8.00×10^{7} km?

14. Cobalt-60 is an artificial radioisotope that is produced in a nuclear reactor and is used as a gamma-ray source in the treatment of certain types of cancer. If the wavelength of the gamma radiation from a cobalt-60 source is 1.00×10^{-3} nm, calculate the energy of a photon of this radiation.

The Quantum Model of the Atom

SECTION 2 REVIEW

15. Describe two major shortcomings of Bohr's model of the atom.

16. a. What is the principal quantum number?
b. How is it symbolized?
c. What are shells?
d. How does n relate to the number of electrons allowed per main energy level?

17. a. What information is given by the angular momentum quantum number?
b. What are sublevels, or subshells?

18. For each of the following values of n, indicate the numbers and types of sublevels possible for that main energy level. (Hint: See **Table 2.**)
a. $n = 1$
b. $n = 2$
c. $n = 3$
d. $n = 4$
e. $n = 7$ (number only)

19. a. What information is given by the magnetic quantum number?
b. How many orbital orientations are possible in each of the *s*, *p*, *d*, and *f* sublevels?
c. Explain and illustrate the notation for distinguishing between the different *p* orbitals in a sublevel.

20. a. What is the relationship between n and the total number of orbitals in a main energy level?
b. How many total orbitals are contained in the third main energy level? in the fifth?

21. a. What information is given by the spin quantum number?
b. What are the possible values for this quantum number?

22. How many electrons could be contained in the following main energy levels with n equal to the number provided?
a. 1
b. 3
c. 4
d. 6
e. 7

PRACTICE PROBLEMS

23. Sketch the shape of an s orbital and a p orbital.

24. How does a $2s$ orbital differ from a $1s$ orbital?

25. How do a $2p_x$ and a $2p_y$ orbital differ?

Electron Configurations

SECTION 3 REVIEW

26. a. In your own words, state the Aufbau principle.
b. Explain the meaning of this principle in terms of an atom with many electrons.

27. a. In your own words, state Hund's rule.
b. What is the basis for this rule?

28. a. In your own words, state the Pauli exclusion principle.
b. What is the significance of the spin quantum number?

29. a. What is meant by the highest occupied energy level in an atom?
b. What are inner-shell electrons?

30. Determine the highest occupied energy level in the following elements:
a. He
b. Be
c. Al
d. Ca
e. Sn

31. Write the orbital notation for the following elements. (Hint: See Sample Problem A.)
a. P
b. B
c. Na
d. O

32. Write the electron-configuration notation for the element whose atoms contain the following number of electrons:
a. 3
b. 6
c. 8
d. 13

33. Given that the electron configuration for oxygen is $1s^2 2s^2 2p^4$, answer the following questions:
a. How many electrons are in each oxygen atom?
b. What is the atomic number of this element?
c. Write the orbital notation for oxygen's electron configuration.
d. How many unpaired electrons does oxygen have?
e. What is the highest occupied energy level?
f. How many inner-shell electrons does the atom contain?
g. In which orbital(s) are these inner-shell electrons located?

34. a. What are the noble gases?
b. What is a noble-gas configuration?
c. How does noble-gas notation simplify writing an atom's electron configuration?

35. Write the noble-gas notation for the electron configuration of each of the elements below. (Hint: See Sample Problem B.)
a. Cl
b. Ca
c. Se

36. a. What information is given by the noble-gas notation $[Ne]3s^2$?
b. What element does this represent?

37. Write both the complete electron-configuration notation and the noble-gas notation for each of the elements below. (Hint: See Sample Problem C.)
a. Na
b. Sr
c. P

38. Identify each of the following atoms on the basis of its electron configuration:
a. $1s^2 2s^2 2p^1$
b. $1s^2 2s^2 2p^5$
c. $[Ne]3s^2$
d. $[Ne]3s^2 3p^2$
e. $[Ne]3s^2 3p^5$
f. $[Ar]4s^1$
g. $[Ar]3d^6 4s^2$

PRACTICE PROBLEMS

39. List the order in which orbitals generally fill, from the 1*s* to the 7*p* orbital.

40. Write the noble-gas notation for the electron configurations of each of the following elements:
a. As
b. Pb
c. Lr
d. Hg
e. Sn
f. Xe
g. La

41. How do the electron configurations of chromium and copper contradict the Aufbau principle?

MIXED REVIEW

42. a. Which has a longer wavelength: green light or yellow light?
b. Which has a higher frequency: an X ray or a microwave?
c. Which travels at a greater speed: ultraviolet light or infrared light?

43. Write both the complete electron-configuration and noble-gas notation for each of the following:
a. Ar b. Br c. Al

44. Given the speed of light as 3.00×10^8 m/s, calculate the wavelength of the electromagnetic radiation whose frequency is 7.500×10^{12} Hz.

45. a. What is the electromagnetic spectrum?
b. What units can be used to express wavelength?
c. What unit is used to express frequencies of electromagnetic waves?

46. Given that the electron configuration for phosphorus is $1s^2 2s^2 2p^6 3s^2 3p^3$, answer the following questions:
a. How many electrons are in each atom?
b. What is the atomic number of this element?
c. Write the orbital notation for this element.
d. How many unpaired electrons does an atom of phosphorus have?
e. What is its highest occupied energy level?
f. How many inner-shell electrons does the atom contain?
g. In which orbital(s) are these inner-shell electrons located?

47. What is the frequency of a radio wave whose energy is 1.55×10^{-24} J per photon?

48. Write the noble-gas notation for the electron configurations of each of the following elements:
a. Hf
b. Sc
c. Fe
d. At
e. Ac
f. Zn

49. Describe the major similarities and differences between Schrödinger's model of the atom and the model proposed by Bohr.

50. When sodium is heated, a yellow spectral line whose energy is 3.37×10^{-19} J per photon is produced.
a. What is the frequency of this light?
b. What is the wavelength of this light?

51. a. What is an orbital?
b. Describe an orbital in terms of an electron cloud.

CRITICAL THINKING

52. **Inferring Relationships** In the emission spectrum of hydrogen shown in **Figure 5,** each colored line is produced by the emission of photons with specific energies. Substances also produce absorption spectra when electromagnetic radiation passes through them. Certain wavelengths are absorbed. Using the diagram below, predict what the wavelengths of the absorption lines will be when white light (all of the colors of the visible spectrum) is passed through hydrogen gas.

Hydrogen absorption spectrum