Reviewing Content

5

- **22.** could not explain why metals and metal compounds give off characteristic colors when heated, nor could it explain the chemical properties of the elements; electrons
- **23.** that electrons traveled in circular paths around the nucleus
- **24.** In Rutherford's model, negatively charged electrons surround a dense, positively charged nucleus. In Bohr's model, the electrons are assigned to concentric circular orbits of fixed energy.
- **25.** An electron is found 90% of the time inside this boundary.
- **26.** a region in space around the nucleus in which there is a high probability of finding an electron
- **27.** 3
- **28.** The 1s orbital is spherical. The 2*s* orbital is spherical with a diameter larger than that of the 1s orbital. The three 2p orbitals are dumbbell shaped and oriented at right angles to each other.

29.	a.	1	b.	2
	c.	3	d.	4
30.	a.	2	b.	1
	c.	3	d.	6

- **31.** Electrons occupy the lowest possible energy levels. An atomic orbital can hold at most two electrons. One electron occupies each of a set of orbitals with equal energies before any pairing of electrons occurs.
- **32.** a. $1s^22s^22p^63s^23p^3$ b. $1s^22s^22p^63s^2$ c. $1s^22s^22p^5$ d. $1s^22s^22p^63s^23p^6$
- **33.** The *p* orbitals in the third quantum level have three electrons.
- **34.** a. $1s^22s^22p^63s^1$ b. $1s^22s^22p^63s^23p^4$ c. $1s^22s^22p^63s^2$ d. $1s^22s^22p^6$ e. $1s^22s^22p^63s^23p^64s^1$

35. b and **c**

36.	a.	2	b.	6
	c.	2	d.	10
	e.	6	f.	2
	g.	14	h.	6

37. 2*s*, 3*p*, 4*s*, 3*d*

38. a. 8 b. 8 c. 8

39. a.
$$1s^22s^22p^63s^23p^63d^{10}4s^24p^4$$

b. $1s^22s^22p^63s^23p^63d^34s^2$
c. $1s^22s^22p^63s^23p^63d^84s^2$

d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

- **40.** Violet, indigo, blue, green, yellow, orange, red
- **41.** Frequency is the number of wave cycles that pass a given point per unit time. Frequency units are cycles/sec or reciprocal seconds or Hertz. Wavelength and frequency are inversely related.
- **42.** Diagrams should look similar to those in Figure 5.9.
- **43.** Classical physics views energy changes as continuous. In the quantum concept energy changes occur in tiny discrete units called quanta.
- **44.** Both travel at the same speed. Ultraviolet is short wavelength and high frequency; microwave is long wavelength and low frequency.
- **45. a.** v, vi, iv, iii, i, ii **b.** It is the reverse.
- **46.** Students may say that ultraviolet is used for tanning the skin and growing plants, X-rays for taking pictures of the interior of the body, visible for seeing, infrared for warmth, radio waves for communication, and microwaves for cooking.
- **47.** The electron of the hydrogen atom is raised (excited) to a higher energy level.
- **48.** The outermost electron of sodium absorbs photons of wavelength 589 nm as it jumps to a higher energy level.
- 49. visible spectrum, Balmer series

Understanding Concepts

50.	a.	Ar	b.	Ru
	c.	Gd		

- **51.** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$; level 1, 2; level 2, 8; level 3, 18; level 4, 5; The fourth energy level is not filled.
- **52. a.** 2 **b.** 4 **c.** 10 **d.** 3
- **53.** $1s^2 2s^2 2p^3$ nitrogen; 3
- **54.** 2.61×10^4 cm
- **55.** a. 4.36×10^{-5} cm b. visible c. 6.88×10^{14} s⁻¹
- **56.** a. 5.890×10^{-5} cm and 5.896×10^{-5} cm b. 5.090×10^{14} s⁻¹ (Hz) and 5.085×10^{14} s⁻¹ (Hz)
 - **c.** yellow
- **57. a.** Na, sodium
 - **b.** N, nitrogen
 - **c.** Si, silicon
 - **d.** O, oxygen
 - e. K, potassium
 - **f.** Ti, titanium
- **58.** The frequency is inversely proportional to the wavelength, so if the frequency increases by a factor of 1.5, the wavelength will decrease by a factor of 1.5.
- **59.** It is not possible to know both the position and the velocity of a particle at the same time.
- **60.** 2
- **61.** c
- **62.** c
- **63.** a
- **64.** a

Critical Thinking

- **65.** An orbit confines the electron to a fixed circular path around the nucleus; an orbital is a region around the nucleus in which electrons are likely to be found.
- **66.** Answers will vary. Some students may note that radio waves have the lowest energy in the electromagnetic spectrum, and thus would not be energetic enough to cook food. Others may reason that if microwaves cook food faster than infrared radiation, then radio waves would cook food even faster.
- **67.** Answers will vary. The model of the atom is based on the abstract idea of probability.

Light is considered a particle and a wave at the same time. Atoms and light cannot be compared to familiar objects or observations because humans cannot experience atoms or photons directly and because matter and energy behave differently at the atomic level than at the level humans can observe directly.

- **68. a.** Electrons in 2*p* boxes should not be paired—there should be one electron in each.
 - **b.** Magnesium has 12 electrons. Two more electrons need to be added to 3*s*.
- **69. a.** *n* = 1 level
 - **b.** n = 4 level
 - **c.** n = 4 level
 - **d.** n = 1 level
- 70. a. fluorineb. germaniumc. vanadium
- **71. a.** potassium, excited state, valence electron has been promoted from 4*s* to 5*p*
 - **b.** potassium, ground state, correct electron configuration
 - **c.** impossible configuration, 3*p* can hold a maximum of 6 electrons, not 7
- 72. The electrons obey Hund's rule.

Concept Challenge





- **c.** 6.62×10^{-34} joule second.
- d. The slope is Planck's constant.

74. 6.93×10^2 s

75. H: (*n* = 1), 1312kJ/mol); (*n* = 2), 328 kJ

Li⁺:
$$(n = 1)$$
, 1.18×10^4 kJ

76.
$$2.12 \times 10^{-22}$$
 J

Cumulative Review

- **77.** a and b are heterogeneous; c is homogeneous
- **78.** Answers will vary but could include, water is lost as steam and burned meat gives off carbon dioxide.
- **79.** A compound has constant composition; the composition of a mixture can vary.
- 80. a heterogeneous mixture
- **81.** $7.7 \times 10^{-5} \, \mu \mathrm{m}$
- **82.** 18.9 cm⁻³
- 83. the piece of lead
- 84. a. 3.9×10^{-5} kg b. 7.84×10^{-2} L c. 8.30×10^{-2} g d. 9.7×10^{6} ng
- 85. a and b are exact
- **86.** Mass remains the same; weight decreases because gravity on moon is less than gravity on earth.

- **87.** 8.92 g/cm⁻³
- **88.** 154 g, 1.54×10^{-1} kg
- **89. a.** 55 protons, 55 electrons**b.** 47 protons, 46 electrons
 - c. 48 protons, 46 electronsd. 34 protons, 36 electrons
- **90.** Helium gas is less dense than the nitrogen gas and oxygen gas in the air.
- **91.** Accuracy is a measure of how close the value is to the true value; precision is a measure of how close a series of measurements are to one another.
- **92.** a
- **93.** Neon-20 has 10 neutrons; neon-21 has 11 neutrons.
- **94.** The value 35.453 amu is a weighted average. Its calculation is based on the percentage natural abundance of two isotopes, chlorine-35 and chlorine-37.