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5 ELECTRONS IN ATOMS

SECTION 5.1 MODELS OF THE ATOM (pages 127–132)

This section summarizes the development of atomic theory. It also explains the significance of quantized energies of electrons as they relate to the quantum mechanical model of the atom.

▶ The Development of Atomic Models (pages 127–128)

1. Complete the table about atomic models and the scientists who developed them.

Scientist	Model of Atom
Dalton	
Thomson	
Rutherford	
Bohr	

2. Is the following sentence true or false? The electrons in an atom can exist between energy levels. _____

▶ The Bohr Model (pages 128–129)

3. What is a small, discrete unit of energy called?

_____

4. Circle the letter of the term that completes the sentence correctly. A quantum of energy is the amount of energy required to

a. move an electron from its present energy level to the next lower one

b. maintain an electron in its present energy level

c. move an electron from its present energy level to the next higher one

5. In general, the higher the electron is on the energy ladder, the _____ it is from the nucleus.

▶ The Quantum Mechanical Model (page 130)

6. What is the difference between the previous models of the atom and the modern quantum mechanical model? _____

_____

_____

7. Is the following sentence true or false? The quantum mechanical model of the atom estimates the probability of finding an electron in a certain position.

_____

▶ Atomic Orbitals (pages 131–132)

8. Circle the letter of the term that correctly answers this question. Which name describes the major energy levels of electrons?

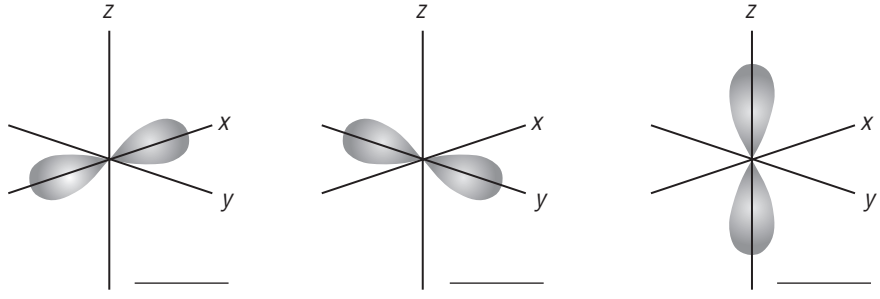
a. atomic orbitals **b.** quantum mechanical numbers

c. quantas **d.** principal quantum numbers (n)

9. Principal energy levels are assigned values in order of _____ energy: $n = 1, 2, 3, 4$, and so forth.

10. In the quantum mechanical model the regions where electrons are likely to be found are called _____ and are denoted by _____ .

11. Match each diagram below with the name of its p orbital, the p_x, p_y, or p_z.



p orbitals

12. Use the diagram above. Describe how the p_x, p_y, and p_z orbitals are similar.

_____

13. Describe how the p_x, p_y, and p_z orbitals are different. _____

_____

14. Circle the letter of the formula for the maximum number of electrons that can occupy a principal energy level. Use n for the principal quantum number.

a. $2n^2$ **b.** n^2 **c.** $2n$ **d.** n

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SECTION 5.2 ELECTRON ARRANGEMENT IN ATOMS (pages 133–136)

This section shows you how to apply the aufbau principle, the Pauli exclusion principle, and Hund's rule to help you write the electron configurations of elements. It also explains why the electron configurations for some elements differ from those assigned using the aufbau principle.

▶ Electron Configurations (pages 133–135)

1. The ways in which electrons are arranged around the nuclei of atoms are called _____ .

Match the name of the rule used to find the electron configurations of atoms with the rule itself.

_____ **2.** aufbau principle

_____ **3.** Pauli exclusion principle

_____ **4.** Hund's rule

a. When electrons occupy orbitals of equal energy, one electron enters each orbital until all the orbitals contain one electron with parallel spins.

b. Electrons enter orbitals of lowest energy first.

c. An atomic orbital may describe at most two electrons.

5. Look at the aufbau diagram, Figure 5.7 on page 133. Which atomic orbital is of higher energy, a 4*f* or a 5*p* orbital? _____

6. Fill in the electron configurations for the elements given in the table. Use the orbital filling diagrams to complete the table.

Electron Configurations for Some Selected Elements

Element	Orbital filling 1*s*	2*s*	2p_x	2p_y	2p_z	3*s*	Electron configuration
	↑						$1s^1$
He	↑↓						
	↑↓	↑					$1s^2 2s^1$
C	↑↓	↑↓	↑	↑			
	↑↓	↑↓	↑	↑	↑		$1s^2 2s^2 2p^3$
O	↑↓	↑↓	↑↓	↑	↑		
	↑↓	↑↓	↑↓	↑↓	↑		$1s^2 2s^2 2p^5$
Ne	↑↓	↑↓	↑↓	↑↓	↑↓		
	↑↓	↑↓	↑↓	↑↓	↑↓	↑	$1s^2 2s^2 2p^6 3s^1$

7. In the shorthand method for writing an electron configuration, what does a superscript stand for?

_____

8. In the shorthand method for writing an electron configuration, what does the sum of the superscripts equal?

_____

▶ Exceptional Electron Configurations (page 136)

9. Is the following sentence true or false? The aufbau principle works for every element in the periodic table. _____

10. Filled energy sublevels are more _____ than partially filled sublevels.

11. Half-filled levels are not as stable as _____ levels, but are more stable than other configurations.

Reading Skill Practice

Outlining can help you understand and remember what you have read. Prepare an outline of Section 5.2, *Electron Arrangement in Atoms.* Begin your outline by copying the headings from the textbook. Under each heading, write the main idea. Then list the details that support, or back up, the main idea. Do your work on a separate sheet of paper.

SECTION 5.3 PHYSICS AND THE QUANTUM MECHANICAL MODEL (pages 138–146)

This section explains how to calculate the wavelength, frequency, or energy of light, given two of these values. It also explains the origin of the atomic emission spectrum of an element.

▶ Light (pages 138–140)

1. Match each term describing waves to its definition.

_____	amplitude	**a.** the distance between two crests
_____	wavelength	**b.** the wave's height from the origin to the crest
_____	frequency	**c.** the number of wave cycles to pass a given point per unit of time

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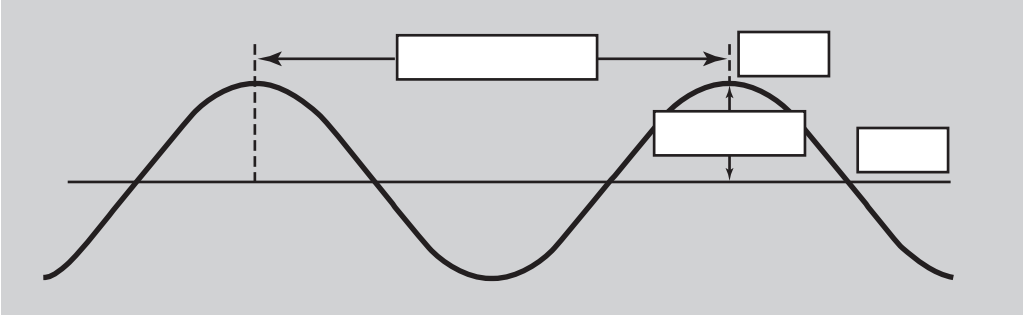
2. The units of frequency are usually cycles per second. The SI unit of cycles per second is called a(n) _____ .

3. Label the parts of a wave in this drawing. Label the wavelength, the amplitude, the crest, and the origin.



4. The product of wavelength and frequency always equals a(n) _____ , the speed of light.

5. Is the following sentence true or false? The wavelength and frequency of all waves are inversely proportional to each other. _____

6. Light consists of electromagnetic waves. What kinds of visible and invisible radiation are included in the electromagnetic spectrum?

_____

_____

_____

7. When sunlight passes through a prism, the different wavelengths separate into a(n) _____ of colors.

8. Put the visible colors in order of frequency.

_____ orange _____ violet

_____ green _____ yellow

_____ blue _____ red

9. Look at Figure 5.10 on page 139. The electromagnetic spectrum consists of radiation over a broad band of wavelengths. What type of radiation has the lowest frequency? The highest frequency?

_____

▶ Atomic Spectra (page 141)

10. What happens when an electric current is passed through the gas or vapor of an element?

_____

11. Passing the light emitted by an element through a prism gives the _____ of the element.

12. Is the following sentence true or false? The emission spectrum of an element can be the same as the emission spectrum of another element.

_____

▶ An Explanation of Atomic Spectra (pages 142–143)

13. What is the lowest possible energy of an electron called? _____

14. Only electrons moving from _____ to _____ energy levels lose energy and emit light.

▶ Quantum Mechanics (pages 381–382)

15. What did Albert Einstein call the quanta of energy that is light?

_____

16. What did de Broglie's equation predict about the behavior of particles?

_____

17. Is the following sentence true or false? The new method of describing the motions of subatomic particles, atoms, and molecules is called quantum mechanics. _____

18. Is the following sentence true or false? de Broglie's conclusions were supported by experimental evidence. _____

19. Does the Heisenberg uncertainty principle apply to cars and airplanes?

_____

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GUIDED PRACTICE PROBLEM

GUIDED PRACTICE PROBLEM 14 (page 140)

14. What is the wavelength of radiation with a frequency of 1.50×10^{13} Hz ($1.50 \times 10^{13}\ s^{-1}$)? Does this radiation have a longer or shorter wavelength than red light?

Analyze

Step 1. What is the equation for the relationship between frequency and wavelength? _____

Step 2. What does *c* represent and what is its value?

_____

Step 3. What is the wavelength of red light in cm?

_____

_____

Solve

Step 4. Solve the equation for the unknown. □ = _____

Step 5. Substitute the known quantities into the equation and solve.

$$\frac{3.00 \times 10^{8}\ \text{m/s}}{\square} = \square$$

Step 6. Compare the answer with the wavelength of red light. Does the given radiation have a wavelength longer or shorter than that of red light?

_____

_____

Evaluate

Step 7. Explain why you think your result makes sense?

_____

_____

_____

Step 8. Are the units in your answer correct? How do you know?

_____