

The Structure of the Atom

Reviewing Vocabulary

Match each definition in Column A with the term in Column B.

Column A

Column B

- | | |
|--|----------------------------------|
| _____ 1. Radiation deflected toward the positively charged plate | a. atom |
| _____ 2. Atoms with the same number of protons but different numbers of neutrons | b. nucleus |
| _____ 3. High-energy radiation that has no charge and no mass | c. atomic mass |
| _____ 4. The smallest particle of an element that retains the properties of that element | d. isotopes |
| _____ 5. The weighted average mass of an element's isotopes | e. gamma ray |
| _____ 6. The center-most part of an atom where the protons and neutrons are contained | f. alpha radiation |
| _____ 7. Radiation deflected toward the negatively charged plate | g. beta radiation |
| _____ 8. The rays and particles emitted by radioactive material | h. atomic mass unit |
| _____ 9. Equal to 1/12 the mass of a carbon-12 atom | i. radiation |
| _____ 10. Ray of radiation traveling from the cathode to the anode | j. Dalton's atomic theory |
| _____ 11. Process (not requiring energy) by which unstable nuclei lose energy | k. cathode ray |
| _____ 12. States that all matter is composed of atoms | l. radioactivity |
| _____ 13. Process whereby some substances spontaneously emit radiation | m. radioactive decay |

Compare and contrast each pair of related terms.

- 14.** mass number, atomic number

- 15.** nuclear reaction, nuclear equation

Understanding Main Ideas (Part A)

Use the periodic table to identify each element described below.

1. atomic number 65 _____
2. 78 protons _____
3. 44 protons and 44 electrons _____
4. atomic number 24 _____
5. 21 protons _____
6. atomic number 55 _____

In the space at the left, write *true* if the statement is true; if the statement is false, change the italicized term to make it true.

- _____ 7. An atom's nucleus contains its protons and *electrons*.
- _____ 8. *Neutrons* have no electrical charge.
- _____ 9. *Beta* particles have a charge of 2+.
- _____ 10. An alpha particle consists of two protons and two *electrons*.

Complete the table below.

Isotope	Symbolic Notation	Number of Protons	Number of Electrons	Number of Neutrons
11. Hydrogen-1		1	1	0
12.	${}^3_1\text{H}$			
13.		8		10
14. Copper-65				36
15.	${}^{235}_{92}\text{U}$			

Understanding Main Ideas (Part B)

For each description in Column A, write the letter of the matching symbol in Column B.

Column A

- _____ 1. Isotope in which the number of neutrons is six more than the isotope's atomic number
- _____ 2. Copper-63
- _____ 3. Copper with seven neutrons more than its atomic number
- _____ 4. Isotope that has one neutron more than its number of protons
- _____ 5. Carbon with equal numbers of neutrons, protons, and electrons
- _____ 6. Carbon with two more neutrons than its number of protons
- _____ 7. Chromium with two more neutrons than its number of protons
- _____ 8. Isotope in which the difference between the neutrons and number of protons is 4

Column B

- a. $^{17}_8\text{O}$
- b. $^{63}_{29}\text{Cu}$
- c. $^{12}_6\text{C}$
- d. $^{50}_{24}\text{Cr}$
- e. $^{14}_6\text{C}$
- f. $^{65}_{29}\text{Cu}$
- g. $^{52}_{24}\text{Cr}$
- h. $^{54}_{24}\text{Cr}$

Answer the following questions.

9. Calculate the atomic mass of gallium (Ga). Gallium has two isotopes: ^{69}Ga and ^{71}Ga . ^{69}Ga has a relative abundance of 60.12% and an atomic mass of 68.9257 amu. ^{71}Ga has a relative abundance of 39.88% and an atomic mass of 70.9249 amu. Show all your work.

10. Calculate the atomic mass of the element X. Then use the periodic table to identify the element. Show all your work.

Isotope	Mass (amu)	Percent Abundance
^{27}X	27.977	92.23
^{28}X	28.976	4.67
^{29}X	29.974	3.10

Thinking Critically

Antimony (Sb) has two stable isotopes. ^{121}Sb has a mass of 120.90 amu. ^{123}Sb has a mass of 122.90 amu.

1. What is antimony's atomic mass? Use the periodic table.

2. Write an equation to describe the relationship between the percent abundance of ^{121}Sb and the percent abundance of ^{123}Sb . Assume that no other isotopes exist.

3. Write an equation that you can use to calculate the percent abundance of each isotope.

4. Calculate the percent abundance for each isotope of antimony. Show all your work.

Applying Scientific Methods

Data Table I is a chemist's record of data about six isotopes.

Data Table I

Isotope	Number of Protons	Number of Electrons	Number of Neutrons	Mass (amu)
Isotope 1	24	24	26	49.946
Isotope 2	24	24	28	51.941
Isotope 3	26	26	30	55.999
Isotope 4	24	24	29	52.941
Isotope 5	24	24	30	53.939
Isotope 6	26	26	31	56.969

1. Which of the isotopes listed are the same element? Explain your reasoning.

2. Explain why the mass of each isotope is not a whole number.

Upon further research, the chemist determined the percent abundance of each isotope. These are listed in Data Table II below.

Data Table II

Isotope	Percent Abundance
Isotope 1	4.35
Isotope 2	83.80
Isotope 3	81.32
Isotope 4	9.50
Isotope 5	2.35
Isotope 6	18.68

Applying Scientific Methods, *continued*

3. Assume that Isotope 1 is an isotope of element X and that all the isotopes of X are listed in Data Table II. Determine the atomic mass of X . Show all your work.

4. Which isotope of X is most abundant? Least abundant?

5. Which isotope of X has the greatest effect on the atomic mass of X ? Explain why.

6. If the chemist later discovered the following isotope, what could you conclude?

Isotope	Number of Protons	Number of Electrons	Number of Neutrons	Mass (amu)
Isotope 7	24	24	31	54.939

Electrons in Atoms

Reviewing Vocabulary

Match the definition in Column A with the term in Column B.

Column A

- _____ 1. The set of frequencies of the electromagnetic waves emitted by the atoms of an element
- _____ 2. The minimum amount of energy that can be lost or gained by an atom
- _____ 3. A form of energy that exhibits wavelike behavior as it travels through space
- _____ 4. A three-dimensional region around the nucleus of an atom that describes an electron's probable location
- _____ 5. The shortest distance between equivalent points on a continuous wave
- _____ 6. The lowest allowable energy state of an atom
- _____ 7. A particle of electromagnetic radiation with no mass that carries a quantum of energy
- _____ 8. The emission of electrons from a metal's surface when light of a certain frequency shines on it
- _____ 9. A figure indicating the relative sizes and energies of atomic orbitals

Column B

- a. wavelength
- b. photoelectric effect
- c. photon
- d. quantum
- e. atomic orbital
- f. atomic emission spectrum
- g. principal quantum number
- h. ground state
- i. electromagnetic radiation

Describe how each pair is related.

10. frequency, amplitude

11. valence electron, electron-dot structure

12. principal energy levels, energy sublevels

Understanding Main Ideas (Part A)

Match the equation in Column A with its description in Column B.

Column A

Column B

- | | |
|--|---|
| <p>_____ 1. $E = h\nu$</p> <p>_____ 2. $c = \lambda\nu$</p> <p>_____ 3. $\lambda = h/mv$</p> <p>_____ 4. $\Delta E = E_{\text{higher-energy orbit}} - E_{\text{lower-energy orbit}}$</p> | <p>a. Relates the wavelength, frequency, and speed of an electromagnetic wave</p> <p>b. Describes the energy change of an electron undergoing an orbit transition</p> <p>c. Energy relationship developed by Planck</p> <p>d. de Broglie's equation</p> |
|--|---|

Complete the table.

Principal Quantum Number, n	Types of Orbitals	Number of Orbitals Related to Principal Energy Level
5. 1	s	
6.		
7. 3		9
8. 4		

Write the orbital diagram and complete electron configuration for each atom.

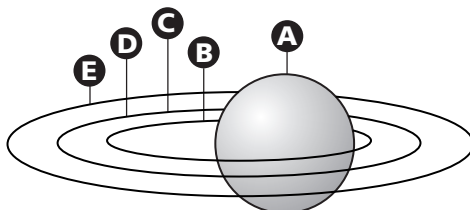
9. nitrogen

10. fluorine

11. sodium

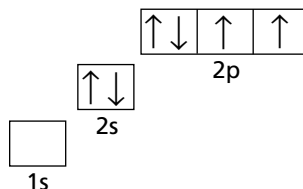
Understanding Main Ideas (Part B)

Circle the letter of the choice that best completes the statement or answers the question. Use the following figure to answer questions 1 and 2.



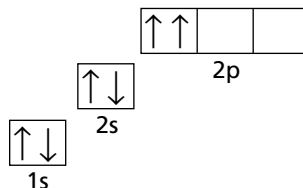
1. According to Bohr's atomic model, which letter(s) in the figure represents a place where an electron cannot be?
 - a. A
 - b. B, C and E
 - c. A and D
 - d. D
2. According to the quantum mechanical model of the atom, point E in the figure represents a
 - a. point where an electron cannot be.
 - b. position where an electron probably is.
 - c. position where an electron must be.
 - d. point beyond which no electron can go.

3. What can you conclude from the figure on the right?



- a. Hund's rule has been violated.
- b. The Pauli exclusion principle has been violated.
- c. The Aufbau principle has been violated.
- d. This is a valid orbital diagram.

4. What can you conclude from the figure on the right?



- a. Hund's rule has been violated.
- b. The Pauli exclusion principle has been violated.
- c. The Aufbau principle has been violated.
- d. This is a valid orbital diagram.

5. Which of the following can you conclude based on the de Broglie equation?

- a. Waves behave like particles.
- b. Most particles are electrons.
- c. All matter has an associated wavelength.
- d. All matter behaves like particles.

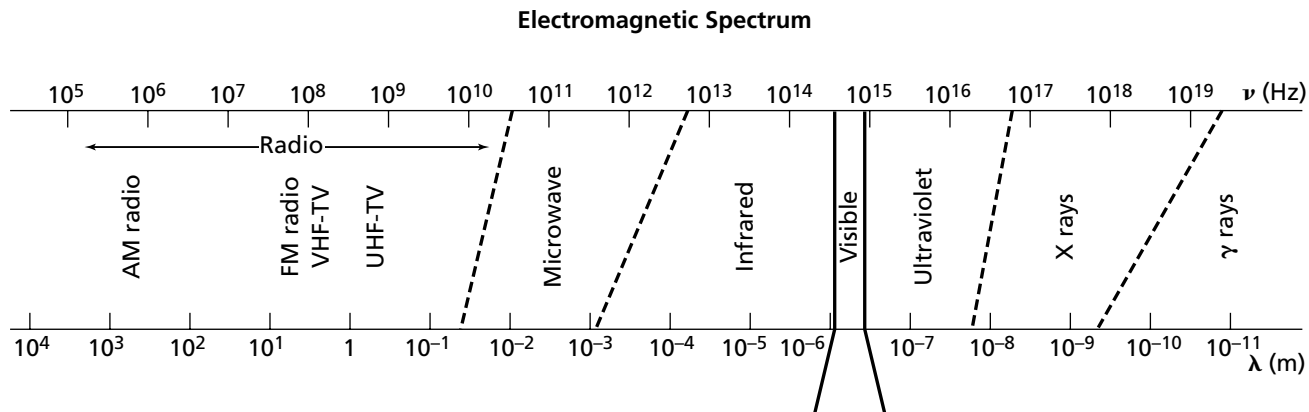
6. Which of the following best describes the Heisenberg uncertainty principle?

- a. Light behaves like a particle and like a wave.
- b. The shorter the wavelength, the higher the frequency.
- c. It is impossible to know both the velocity and the position of a particle at the same time.
- d. You can measure an object without disturbing it.

Thinking Critically

Answer the following questions.

- A radio station has a frequency of 103.7 MHz. (1 MHz = 10^6 s^{-1}) What is the wavelength of the radiation emitted by the station? Indicate where this wavelength falls on the electromagnetic spectrum shown below.



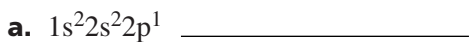
- Look at the electromagnetic spectrum again. Are the microwaves used to cook food higher or lower in frequency than radio waves? Are microwaves longer or shorter in wavelength than radio waves?

- Write the orbital diagram of aluminum.

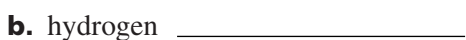
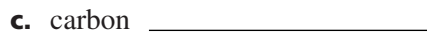
- Write the complete electron configuration and the noble-gas notation for aluminum.

- Write the noble-gas notation for iodine. _____

- Identify each atom.

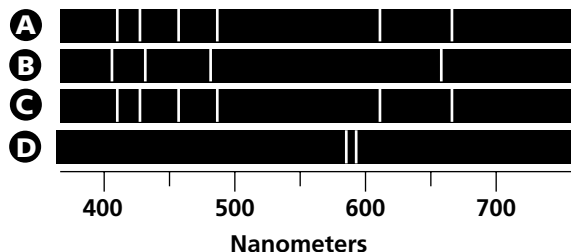


- Write electron-dot structures for the following atoms.



Applying Scientific Methods

A chemist isolated four samples, A, B, C, and D. She obtained the following atomic emission spectra of the samples.



1. Examine each sample's atomic emission spectra. Assume that each sample represents a single element. What can you conclude by looking at the spectra? Do the samples represent the same element or different elements?

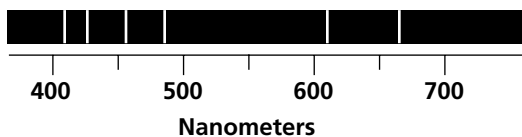
2. Which part of the electromagnetic spectrum do the atomic emission spectra show?

3. Would the atomic emission spectrum for each sample change if you repeated the procedure? Explain your answer

4. What does each line in an atomic emission spectrum represent?

Applying Scientific Methods, *continued*

5. You find the following atomic emission spectrum for hydrogen in your textbook. Compare this spectrum to the spectra of the samples that the chemist obtained. What can you conclude? Explain your answer.



6. Which, if any, of the atomic emission spectra can the Bohr model explain? Explain your answer.

7. According to Bohr's model, how many times were photons emitted from the excited atoms in each sample to produce its atomic emission spectrum?

A _____

B _____

C _____

D _____

8. The difference between successive energy levels becomes smaller as n becomes larger. Explain how hydrogen's emission spectrum demonstrates this statement.

9. Assume that instead of measuring the photons *emitted* by each sample, the chemist measured the photons *absorbed* by each sample. What would the absorption spectra look like? Explain your answer.
