

Study Guide

Key Concepts



4.1 Defining the Atom

- Democritus believed that atoms were indivisible and indestructible.
- By using experimental methods, Dalton transformed Democritus's ideas on atoms into a scientific theory.
- Scientists can observe individual atoms by using instruments such as scanning tunneling microscopes.



4.2 Structure of the Nuclear Atom

- Three types of subatomic particles are electrons, protons, and neutrons.
- In the nuclear atom, the protons and neutrons are located in the nucleus. The electrons are distributed around the nucleus and occupy almost all the volume of the atom.



4.3 Distinguishing Among Atoms

- Elements are different because they have different numbers of protons.
- The number of neutrons in an atom is the difference between the mass number and atomic number.
- Because isotopes of an element have different numbers of neutrons, they also have different mass numbers.
- To calculate the atomic mass of an element, multiply the mass of each isotope by its natural percent abundance (expressed as a decimal), and then add the products.
- The periodic table lets you easily compare the properties of one element (or a group of elements) to another element (or group of elements).

Vocabulary

- | | | |
|-----------------------------------|-----------------------------------|---------------------------|
| • atom (p. 101) | • Dalton's atomic theory (p. 102) | • neutron (p. 106) |
| • atomic mass (p. 115) | • electron (p. 104) | • nucleus (p. 107) |
| • atomic mass unit (amu) (p. 114) | • group (p. 118) | • period (p. 118) |
| • atomic number (p. 110) | • isotopes (p. 112) | • periodic table (p. 118) |
| • cathode ray (p. 104) | • mass number (p. 111) | • proton (p. 106) |

Key Equation

- $\text{number of neutrons} = \text{mass number} - \text{atomic number}$

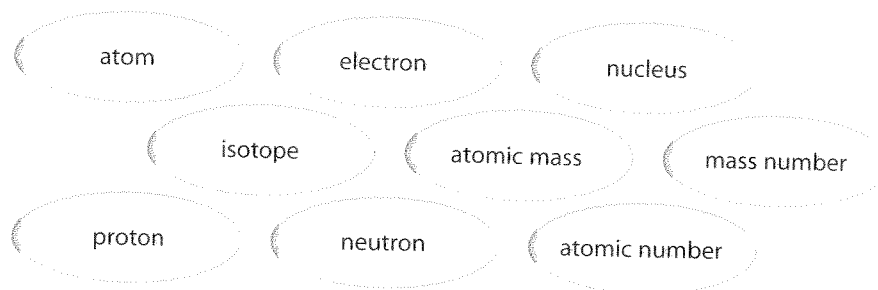
Organizing Information

Use these terms to construct a concept map that organizes the main ideas of this chapter.



Concept Map 4 Solve the Concept map with the help of an interactive guided tutorial.

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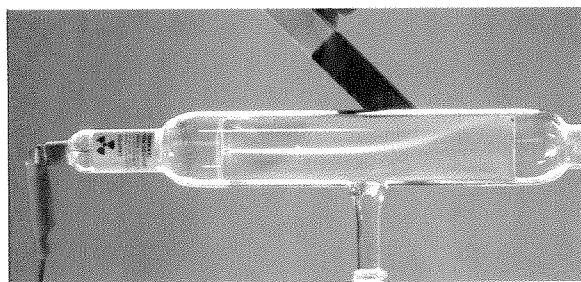
Reviewing Content

4.1 Defining the Atom

34. What is an atom?
35. What were the limitations of Democritus's ideas about atoms?
36. With which of these statements would John Dalton have agreed in the early 1800s? For each, explain why or why not.
- Atoms are the smallest particles of matter.
 - The mass of an iron atom is different from the mass of a copper atom.
 - Every atom of silver is identical to every other atom of silver.
 - A compound is composed of atoms of two or more different elements.
37. Use Dalton's atomic theory to describe how atoms interact during a chemical reaction.

4.2 Structure of the Nuclear Atom

38. What experimental evidence did Thomson have for each statement?
- Electrons have a negative charge.
 - Atoms of all elements contain electrons.



39. Would you expect two electrons to attract or repel each other?
40. How do the charge and mass of a neutron compare to the charge and mass of a proton?
41. Why does it make sense that if an atom loses electrons, it is left with a positive charge?
42. Describe the location of the electrons in Thomson's "plum pudding" model of the atom.
43. How did the results of Rutherford's gold-foil experiment differ from his expectations?
44. What is the charge, positive or negative, of the nucleus of every atom?
45. In the Rutherford atomic model, which sub-atomic particles are located in the nucleus?

4.3 Distinguishing Among Atoms

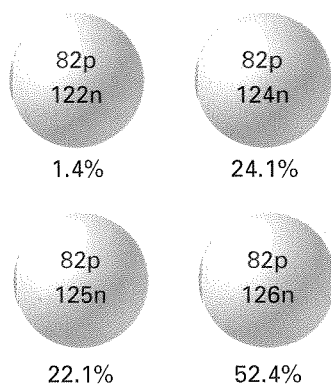
46. Why is an atom electrically neutral?
47. What does the atomic number of each atom represent?
48. How many protons are in the nuclei of the following atoms?
- phosphorus
 - molybdenum
 - aluminum
 - cadmium
 - chromium
 - lead
49. What is the difference between the mass number and the atomic number of an atom?
50. Complete the following table by referring to Figure 4.11 on page 118.

Atomic number	Mass number	Number of protons	Number of neutrons	Symbol of element
9	(a)	(b)	10	(c)
(d)	(e)	14	15	(f)
(g)	47	(h)	25	(i)
(j)	55	25	(k)	(l)

51. Name two ways that isotopes of an element differ.
52. How can there be more than 1000 different atoms when there are only about 100 different elements?
53. What data must you know about the isotopes of an element to calculate the atomic mass of the element?
54. How is an average mass different from a weighted average mass?
55. What is the atomic mass of an element?
56. How are the elements arranged in the modern periodic table?
57. Look up the word *periodic* in the dictionary. Propose a reason for the naming of the periodic table.

Understanding Concepts

58. Characterize the size of an atom.
59. Compare the size and density of an atom with its nucleus.
60. Imagine you are standing on the top of a boron-11 nucleus. Describe the numbers and kinds of subatomic particles you would see looking down into the nucleus, and those you would see looking out from the nucleus.
61. What parts of Dalton's atomic theory no longer agree with the current picture of the atom?
62. Millikan measured the quantity of charge carried by an electron. How did he then calculate the mass of an electron?
63. How is the number of electrons in an atom of a given element related to the atomic number of that element?
64. How is the atomic mass of an element calculated from isotope data?
65. The four isotopes of lead are shown below, each with its percent by mass abundance and the composition of its nucleus. Using these data, calculate the approximate atomic mass of lead.



66. Dalton's atomic theory was not correct in every detail. Should this be taken as a criticism of Dalton as a scientist? Explain.

67. Why are atoms considered the basic building blocks of matter even though smaller particles, such as protons and electrons, exist?
68. The following table shows some of the data collected by Rutherford and his colleagues during their gold-foil experiment.

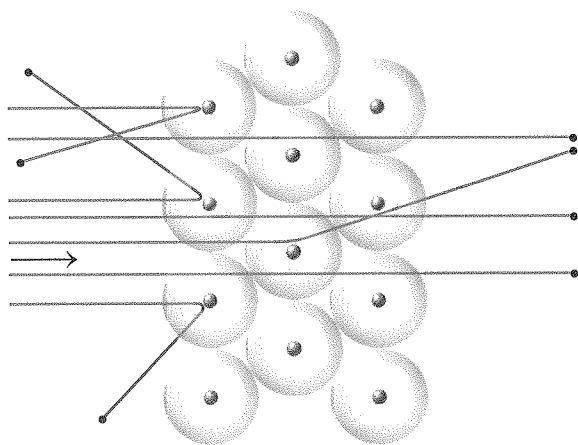


Angle of deflection (degrees)	Number of deflections
5	8,289,000
10	502,570
15	120,570
30	7800
45	1435
60	477
75	211
>105	198

- a. What percentage of the alpha particle deflections were 5° or less?
- b. What percentage of the deflections were 15° or less?
- c. What percentage of the deflections were 60° or greater?
69. Using the data for nitrogen listed in Table 4.3, calculate the weighted average atomic mass of nitrogen. Show your work.
70. What characteristics of cathode rays led Thomson to conclude that the rays consisted of negatively charged particles?
71. If you know the atomic number and mass number of an atom of an element, how can you determine the number of protons, neutrons, and electrons in that atom?
72. What makes isotopes of the same element chemically alike?
73. In the periodic table, what happens to the pattern of properties within a period when you move from one period to the next?

Critical Thinking

74. The diagram below shows gold atoms being bombarded with fast-moving alpha particles.



- The large yellow spheres represent gold atoms. What do the small gray spheres represent?
 - List at least two characteristics of the small gray spheres.
 - Which subatomic particle cannot be found in the area represented by the gray spheres?
75. How could you modify Rutherford's experimental procedure to determine the relative sizes of different nuclei?
76. Rutherford's atomic theory proposed a dense nucleus surrounded by very small electrons. This implies that atoms are composed mainly of empty space. If all matter is mainly empty space, why is it impossible to walk through walls or pass your hand through your desk?
77. This chapter illustrates the scientific method in action. What happens when new experimental results cannot be explained by the existing theory?
78. Do you think there are more elements left to be discovered? Explain your answer.
79. The law of conservation of mass was introduced in Chapter 2. Use Dalton's atomic theory to explain this law.

Concept Challenge

80. Diamond and graphite are both composed of carbon atoms. The density of diamond is 3.52 g/cm^3 . The density of graphite is 2.25 g/cm^3 . In 1955, scientists successfully made diamond from graphite. Using the relative densities, imagine what happens at the atomic level when this change occurs. Then suggest how this synthesis may have been accomplished.
81. Lithium has two naturally occurring isotopes. Lithium-6 has an atomic mass of 6.015 amu; lithium-7 has an atomic mass of 7.016 amu. The atomic mass of lithium is 6.941 amu. What is the percentage of naturally occurring lithium-7?
82. When the masses of the particles that make up an atom are added together, the sum is always larger than the actual mass of the atom. The missing mass, called the mass defect, represents the matter converted into energy when the nucleus was formed from its component protons and neutrons. Calculate the mass defect of a chlorine-35 atom by using the data in Table 4.1. The actual mass of a chlorine-35 atom is $5.81 \times 10^{-23} \text{ g}$.

Cumulative Review

83. How does the goal of pure chemistry compare with that of applied chemistry? (*Chapter 1*)
84. How does a scientific law differ from a scientific theory? (*Chapter 1*)
85. Classify each as an element, a compound, or a mixture. (*Chapter 2*)
- | | |
|--------------|--------------|
| a. sulfur | b. salad oil |
| c. newspaper | d. orange |
86. Oxygen and hydrogen react explosively to form water. In one reaction, 6 g of hydrogen combines with oxygen to form 54 g of water. How much oxygen was used? (*Chapter 2*)
87. An aquarium measures $54.0 \text{ cm} \times 31.10 \text{ m} \times 380.0 \text{ cm}$. How many cubic centimeters of water will this aquarium hold? (*Chapter 3*)
88. What is the mass of 4.42 cm^3 of platinum? The density of platinum is 22.5 g/cm^3 . (*Chapter 3*)

Standardized Test Prep

Test-Taking Tip

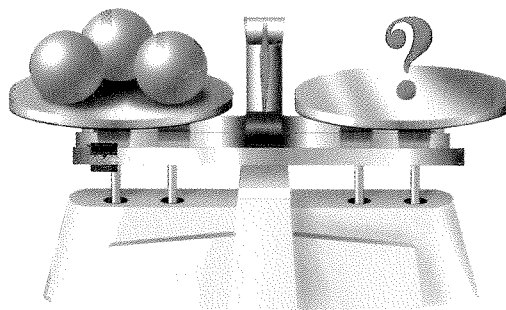
Connectors Sometimes two phrases in a true/false question are connected by a word such as *because* or *therefore*. These words imply a relationship between one part of the sentence and another. Statements that include such words can be false even if both parts of the statement are true by themselves.

Select the choice that best answers each question or completes each statement.

1. An atom composed of 16 protons, 16 electrons, and 16 neutrons is
a. ${}^{48}_{16}\text{S}$ b. ${}^{16}_{32}\text{Ge}$ c. ${}^{32}_{16}\text{S}$ d. ${}^{16}_{32}\text{S}$
2. Which list contains elements that fall within the same group on the periodic table?
a. He, Ar, Xe b. O, F, Ne
c. K, Rb, Ba d. H, He, Li
3. Which of these descriptions is *incorrect*?
a. proton: positive charge, in nucleus, mass of ≈ 1 amu
b. electron: negative charge, mass of ≈ 0 amu, in nucleus
c. neutron: mass of ≈ 1 amu, no charge
4. Thallium has two isotopes, thallium-203 and thallium-205. Thallium's atomic number is 81 and its atomic mass is 204.38 amu. Which statement about the thallium isotopes is true?
a. There is more thallium-203 in nature.
b. Atoms of both isotopes have 81 protons.
c. Thallium-205 atoms have fewer neutrons.
d. The most common atom of thallium has a mass of 204.38 amu.

Use the art to answer Question 5.

5. How many nitrogen-14 atoms (${}^{14}\text{N}$) would you need to place on the right pan to balance the three calcium-42 atoms (${}^{42}\text{Ca}$) on the left pan of the "atomic balance" below? Describe the method you used to determine your answer, including any calculations.



6. Which of the following statements about the periodic table are correct?
I. Elements are arranged in order of increasing atomic mass.
II. A period is a horizontal row.
III. The properties of the elements within a period vary from element to element.
a. I only
b. I and II only
c. I, II, and III
d. I and III only
e. II and III only

For each question below there are two statements. Decide whether each statement is true or false. Then decide whether Statement II is a correct explanation for Statement I.

Statement I

7. Every aluminum-27 atom has 27 protons and 27 electrons.
8. Isotopes of an element have different atomic masses.
9. An electron is repelled by a negatively charged particle.

Statement II

- BECAUSE The mass number of aluminum-27 is 27.
- BECAUSE The nuclei of an element's isotopes contain different numbers of protons.
- BECAUSE An electron has a negative charge.