CHAPTER 4 SOLUTIONS MANUAL

The Structure of the Atom

Section 4.1 Early Ideas About Matter

pages 102–105

Section 4.1 Assessment

page 105

1. Contrast the methods used by the Greek philosophers and Dalton to study the atom.

Greek philosophers could not conduct experiments to verify their hypothesis, whereas Dalton could make careful measurements.

2. Define *atom* using your own words.

An atom is the smallest component of an element that exhibits all of the characteristic properties of that element.

3. Summarize Dalton's atomic theory.

Matter is composed of small particles called atoms that are indivisible. Atoms of an element are identical in size, mass, and chemical properties. Atoms of a specific element are different from atoms of another element. Different atoms combine in simple whole-number ratios to form compound. In a chemical reaction, atoms are separated, combined, or rearranged.

4. Explain how Dalton's theory of the atom and the conservation of mass are related.

Dalton explained that atoms are not created or destroyed in chemical reactions, but only rearranged.

5. Apply Six atoms of Element A combine with 8 atoms of Element B to produce six compound particles. How many atoms of Elements A and B does each particle contain? Are all atoms used to form compounds?

Each compound contains 1 atom A and 1 atom B. 2 atoms of element B are not used.

6. Design a concept map that compares and contrasts the atomic theories proposed by Democritus and John Dalton.

Concept maps will vary, but should reflect the following summary. Both believed: matter composed of extremely small particles called atoms; all atoms of a given element are identical, but differ from the atoms of other elements; atoms could not be created, divided, or destroyed; apparent changes in matter result from changes in the groupings of atoms. Democritus further believed that matter is composed of empty space through which atoms move, that different kinds of atoms come in different sizes and shapes, and that the differing properties of atoms are due to the size, shape, and movement of the atoms. Dalton further specified that different atoms combine in simple whole number ratios to form compounds.

Section 4.2 Defining the Atom

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Section 4.2 Assessment

page 114

7. Describe the structure of a typical atom. Identify where each subatomic particle is located.

A typical atom consists of a central, small, dense nucleus containing protons and neutrons. The nucleus is surrounded by a cloud of negatively charged electrons.

8. Compare and contrast Thomson's plum pudding atomic model with Rutherford's nuclear atomic model.

Thomson's plum pudding model describes atoms as spherical particles with uniformly distributed positive charge in which individual, negatively charged, electrons are located in fixed positions. In contrast, Rutherford's model states that an atom is mostly empty space, with a small, dense, central nucleus containing all of an atom's positive charge and most of its mass. The negatively charged electrons move through the empty space and are held in the atom by their attraction to the positively charged nucleus.

9. Evaluate the experiments that led to the conclusion that electrons are negatively charged particles found in all matter.

The deflection toward positively charged plates demonstrated the negatively charged nature of electrons; the fact that changing the type of electrode or the type of gas used in the cathode ray tube did not affect the ray produced led to the conclusion that electrons are present in all matter.

10. Compare the relative charge and mass of each of the subatomic particles.

Particle	Relative charge	Relative mass
Electron	−1	1/1840
Proton	+1	1
Neutron	0	~1

11. Calculate What is the difference expressed in kilograms between the mass of a proton and the mass of an electron?

1.673×10^{-24} g − 9.11×10^{-28} g = 1.672×10^{-24} g × 1 kg/1000 g = 1.672×10^{-27} kg

Section 4.3 How Atoms Differ

pages 115–121

Practice Problems

pages 116–121

12. How many protons and electrons are in each atom?

a. radon, 86 protons and 86 electrons

b. magnesium, 12 protons and 12 electrons

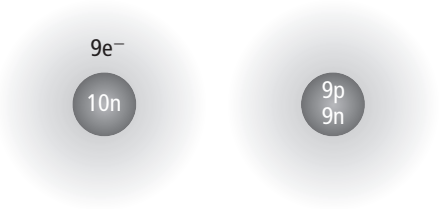
13. An atom of an element contains 66 electrons. Which element is it?

dysprosium

14. An atom of an element contains 14 protons. Which element is it?

silicon

15. Challenge Do the atoms shown in the figure to the right have the same atomic number?



Yes. 9

16. Determine the number of protons, electrons, and neutrons for isotopes b through f. in the table above. Name each isotope, and write its symbol.

	Protons and Electrons	Neutrons	Isotope	Symbol
b.	20	26	calcium-46	$^{46}_{20}Ca$
c.	8	9	oxygen-17	$^{17}_{8}O$
d.	26	31	iron-57	$^{57}_{26}Fe$
e.	30	34	zinc-64	$^{64}_{30}Zn$
f.	80	124	mercury-204	$^{204}_{80}Hg$

17. Challenge An atom has a mass number of 55. Its number of neutrons is the sum of its atomic number and 5. How many protons, neutrons, and electrons does this atom have? What is the identity of this atom?

25 protons, 25 electrons, 30 neutrons. manganese

18. Boron (B) has two naturally occurring isotopes: boron-10 (abundance = 19.8%, mass = 10.013 amu), boron-11 (abundance = 80.2%, mass = 11.009 amu). Calculate the atomic mass of boron.

B-10 10.013 amu × 0.198 = 1.98 amu

B-11 11.009 amu × 0.802 = 8.83 amu

Atomic mass 1.98 amu + 8.83 amu = 10.81 amu

19. Challenge Nitrogen has two naturally occurring isotopes, N-14 and N-15. Its atomic mass is 14.007. Which isotope is more abundant? Explain your answer.

N-14 is more abundant because the atomic mass is closer to 14 than 15.

Section 4.3 Assessment

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20. Explain how the type of an atom is defined.

by the atomic number

21. Recall Which subatomic particle identifies an atom as that of a particular element?

the proton

22. Explain how the existence of isotopes is related to the fact that atomic masses are not whole numbers.

Atomic masses aren't whole numbers because they represent weighted averages of the masses of the isotopes of an element.

23. Calculate Copper has two isotopes: Cu-63 (abundance = 69.2%, mass = 62.930 amu) and Cu-65 (abundance = 30.8%, mass = 64.928 amu). Calculate the atomic mass of copper.

Cu-63 62.930 amu × 0.692 = 43.5 amu

Cu-65 64.928 amu × 0.308 = 20.0 amu

Atomic mass 43.5 amu + 20.0 amu = 63.5 amu

24. Calculate Three magnesium isotopes have atomic masses and relative abundances of 23.985 amu (79.99%), 24.986 amu (10.00%), and 25.982 (11.01%). Calculate the atomic mass of magnesium.

Mg-24 23.985 amu × 0.7999 = 19.19 amu

Mg-25 24.986 amu × 0.1000 = 2.497 amu

Mg-26 25.982 amu × 0.1101 = 2.861 amu

Atomic mass 19.19 + 2.497 + 2.861 amu = 24.55 amu (24.31 amu)

Section 4.4 Unstable Nuclei and Radioactive Decay

pages 122–124

Section 4.4 Assessment

page 124

25. Explain how unstable atoms gain stability.

They undergo a series of radioactive decays until they reach a stable element.

26. State what quantities are conserved when balancing a nuclear reaction.

mass number and atomic number

27. Classify each of the following as a chemical reaction, a nuclear reaction, or neither.

a. Thorium emits a beta particle.

nuclear

b. Two atoms share electrons to form a bond.

chemical

c. A sample of pure sulfur emits heat energy as it slowly cools.

neither

d. A piece of iron rusts.

Chemical

28. Calculate How much heavier is an alpha particle than an electron?

6.65×10^{-27} kg − 9.11×10^{-31} kg = 6.65×10^{-27} kg

29. Create a table showing how each type of radiation affects the atomic number and the mass number of an atom.

Particle	Atomic number	Mass Number
α	−2	−4
β	+1	no change
γ	no change	no change

Chapter 4 Assessment

pages 128–131

Section 4.1

Mastering Concepts

30. Who originally proposed the concept that matter was composed of tiny indivisible, particles?

Democritus

31. Whose work is credited with being the beginning of modern atomic theory?

John Dalton

32. Distinguish between Democritus's ideas and Dalton's atomic theory.

Democritus's ideas	Dalton's atomic theory
Atoms move through empty space composed of matter.	Matter is composed of small particles called atoms.
Different kinds of atoms have different sizes and shapes.	Atoms of a given element are identical having the same size, mass and chemical properties.
The movement, size and shape of different atoms result in unique properties of matter.	Different atoms combine in simple whole number ratios to form compounds.
Atoms are indivisible, solid, homogenous and indestructible.	Atoms cannot be created, destroyed or divided into smaller particles.
Observed changes in matter, result from changes in the groupings of atoms and not from changes in the atoms themselves.	In a chemical reaction, atoms are separated, rearranged or combined.

33. Ideas and Scientific Methods Was Democritus's proposal of the existence of atoms based on scientific methods or ideas? Explain.

Ideas. He had no experimental evidence.

34. Explain why Democritus was unable to experimentally verify his ideas.

He had no scientific instruments to research matter at the atomic level.

35. What was Aristotle's main objection to the atomic theory?

He did not believe that atoms could move through empty space.

36. State the main points of Dalton's atomic theory using your own words. Which parts of Dalton's theory were later found to be in error? Explain why.

Atoms are not indivisible and all atoms of an element are not identical.

37. Conservation of Mass Explain how Dalton's atomic theory offered a convincing explanation of the observation that mass is conserved in chemical reactions.

Mass is conserved because atoms cannot be created, divided, or destroyed. Chemical reactions involve only the separation, combination, and rearrangement of atoms.

38. Define matter and give two everyday examples.

Matter is anything that occupies space and has mass. For example: desk, chair.

Section 4.2

Mastering Concepts

39. What particles are found in the nucleus of an atom? What is the charge of the nucleus?

protons and neutrons; positive charge equal to the number of protons

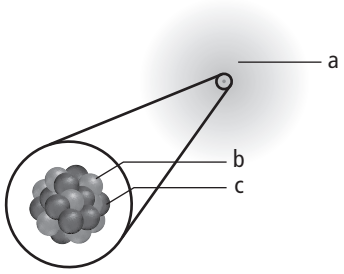
40. How was the overall charge distributed in the plum pudding model?

Evenly through a sphere.

41. How did the charge distribution in the plum pudding model affect alpha particles passing through an atom?

Alpha particles would only be slightly deflected.

42. Label the subatomic particles shown in **Figure 4.22.**



a. electron cloud

b. protons

c. neutron

43. Arrange the following subatomic particles in order of increasing mass: neutron, electron and proton

electron < proton = neutron

44. Explain why atoms are electrically neutral.

The number of positively charged protons equals the number of negatively charged electrons.

45. What is the charge of the nucleus of element 89?

89+

46. Which subatomic particles account for most of an atom's mass?

protons and neutrons

47. If you had a balance that could determine the mass of a proton, how many electrons would you need to weigh on the same balance to measure the same mass as that of a single proton?

1836

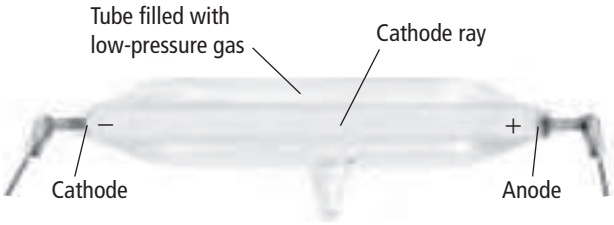
48. Cathode-Ray Tubes Which subatomic particle was discovered by researchers working with cathode ray tubes?

the electron

49. What experimental results led to the conclusion that electrons were part of all forms of matter?

changing the type of electrode or the type of gas did not affect the ray produced.

50. Cathode Ray Use the elements labeled in **Figure 4.23** to explain the direction of a cathode ray inside a cathode-ray tube. (4.2)



A cathode ray is composed of a stream of electrons that originate at the cathode and flow through the tube to the anode. Because the electrons have a negative charge, they are attracted to the anode, which has a positive charge.

51. Briefly explain how Rutherford discovered the nucleus.

Rutherford aimed a beam of alpha particles at a thin foil of gold. He expected most of the alpha particles to pass through the gold atoms, confirming the plum pudding model. However, a few particles were deflected at very large angles, which led to the discovery of the positively charged nucleus.

52. Particle deflection What caused the deflection of the alpha particles in Rutherford's gold foil experiment?

The α particles were deflected by the positively charged gold nuclei.

53. Charge of Cathode Rays How was an electric field used to determine the charge of a cathode ray?

The cathode ray was attracted to the positive end of the magnet implying that the cathode ray is negative.

54. Explain what keeps the electrons confined in the space surrounding the nucleus.

attraction to the positively charged nucleus

55. What is the approximate size of an atom?

It is in the range of 10^{-10} m.

56. Visualizing atoms What technique can be used to visualize individual atoms?

Scanning tunneling microscope (STM) can be used to visualize individual atoms.

57. What are the strengths and weaknesses of Rutherford's nuclear model of the atom?

Strengths: Rutherford's model explained the results of the gold-foil experiment and why an atom is electrically neutral. Weaknesses: The model could not account for the total mass of an atom or the arrangement of the electrons.

Section 4.3

Mastering Concepts

58. How do isotopes of a given element differ? How are they similar?

differ: number of neutrons, masses; similar: chemical properties, number of protons and electrons

59. How is an atom's atomic number related to its number of protons? To its number of electrons?

They are all equal.

60. How is the mass number related to the number of protons and neutrons an atom has?

mass number = number of p + number of n

61. How can you determine the number of neutrons in an atom if its mass number and its atomic number are known.

number of n^0 = mass number − atomic number

62. What do the superscript and subscript in the notation $^{40}_{19}K$ represent?

The superscript represents the mass number (40) and the subscript represents the atomic number (19).

63. Standard Units Define the atomic mass unit. What were the benefits of developing the atomic mass unit as a standard unit of mass?

amu = 1/12 of the mass of a C-12 atom; Scientists defined the atomic mass unit as a relative standard that was closer in size to atomic and subatomic masses.

64. Isotopes Are the following elements isotopes of each other? Explain.

$$^{24}_{12}Mg,\ ^{25}_{12}Mg,\ ^{26}_{12}Mg$$

Yes. Isotopes are atoms of the same element with different atomic mass but the same number of protons.

65. Does the existence of isotopes contradict part of Dalton's original atomic theory? Explain.

Yes; not all atoms of an element are identical in mass.

Mastering Problems

66. How many protons and electrons are contained in an atom of element 44?

44 protons, 44 electrons

67. Carbon A carbon atom has a mass number of 12 and an atomic number of 6. How many neutrons does it have?

12 − 6 = 6 neutrons

68. Mercury An isotope of mercury has 80 protons and 120 neutrons. What is the mass number of this isotope?

80 + 120 = 200, mass number

69. Xenon An isotope of xenon has an atomic number of 54 and contains 77 neutrons. What is the xenon isotope's mass number?

54 + 77 = 131, mass number

70. If an atom has 18 electrons, how many protons does it have?

18 protons

71. Sulfur Show that the atomic mass of the element sulfur is 32.065 amu.

S = (31.972 amu)(0.9502) + (32.971 amu)(0.0075) + (33.968 amu) (0.0421) + (35.967 amu) (0.0002) = 32.065

72. Fill in the blanks in **Table 4.6:**

Chlorine and Zirconium				
Element	**Cl**	**Cl**	**Zr**	**Zr**
Atomic number	17	**17**	40	**40**
Mass number	35	37	**90**	92
Protons	**17**	**17**	**40**	40
Neutrons	**18**	**20**	50	**52**
Electrons	**17**	17	**40**	**40**

73. How many electrons, protons, and neutrons are contained in each atom?

Symbol	Electrons	Protons	Neutrons
$^{132}_{55}Cs$	**55**	**55**	**77**
$^{59}_{27}Co$	**27**	**27**	**32**
$^{163}_{69}Tm$	**69**	**69**	**94**
$^{70}_{30}Zn$	**30**	**30**	**40**

74. How many electrons, protons, and neutrons are contained in each atom?

Symbol	Electrons	Protons	Neutrons
Ga-69	**31**	**31**	**33**
F-23	**9**	**9**	**14**
Ti-48	**22**	**22**	**26**
Ta-181	**73**	**73**	**108**

75. For each chemical symbol, determine the number of protons and electrons an atom of the element contains.

a. V

b. Mn

c. Ir

d. S

	Protons	Electrons
a.	**23**	**23**
b.	**25**	**25**
c.	**77**	**77**
d.	**16**	**16**

76. Gallium, which has an atomic mass of 69.723 amu, has two naturally occurring isotopes, Ga-69 and Ga-71. Which isotope occurs in greater abundance? Explain.

Ga-69 must be more abundant because the atomic mass of gallium is closer to the mass Ga-69 than the mass of Ga-71.

77. Atomic Mass of Silver Silver has two isotopes: $^{107}_{47}Ag$ which has a mass of 106.905 amu and a percent abundance of 52.00%, and $^{109}_{47}Ag$ which has a mass of 108.905 amu and a percent abundance of 48.00%. What is the atomic mass of silver?

106.905 amu × 0.5200 = 55.59

108.905 amu × 0.4800 = 52.27

107.86 amu

78. Data for chromium's four naturally occuring isotopes is provided in the **Table 4.7.** Calculate chromium's atomic mass.

Cr-50 0.0435 × 49.946 amu = 2.17

Cr-52 0.8379 × 51.941 amu = 43.52

Cr-53 0.0950 × 52.941 amu = 5.03

Cr-54 0.0236 × 53.939 amu = 1.27

51.99 amu

Section 4.4

Mastering Concepts

79. What is radioactive decay?

Radioactive decay occurs when unstable nuclei spontaneously (occurs without input of energy) lose energy by emitting radiation.

80. Why are some atoms radioactive?

The stability of atoms depends on their neutron-to-proton ratio. When this ratio is either too large or too small the nucleus of an atom becomes unstable causing an atom to be radioactive.

81. Discuss how radioactive atoms gain stability.

An atom gains stability by emitting radiation or a particle that changes the neutron-to-proton ratio.

82. Define alpha particle, beta particle and gamma rays.

alpha particle is a helium atom with a 2+ charge

beta particle is an electron

gamma rays is high energy radiation

83. Write the symbols used to denote alpha, beta, and gamma radiation and give their mass and charge.

Particle	Symbol	Mass (amu)	Charge
alpha	^4_2He	4	+2
beta	β	1/1840	−1
gamma	γ	0	0

84. What type of reaction involves changes in the nucleus of an atom?

nuclear reaction

85. Radioactive Emissions What change in mass number occurs when a radioactive atom emits an alpha particle? A beta particle? A gamma particle?

α, mass number decreases by 4; β, no change in mass number; γ, no change in mass number

86. What is the primary factor determining whether a nucleus is stable or unstable?

the neutron-to-proton ratio

87. Explain how energy loss and nuclear stability are related to radioactive decay.

Radioactivity results when unstable nuclei emit energy in order to gain stability.

88. Explain what must occur before a radioactive atom ceases to undergo further radioactive decay.

A stable, nonradioactive atom must be formed.

89. Boron-10 emits alpha particles and cesium-137 emits beta particles. Write balanced nuclear reactions for each radioactive decay.

$$^{10}_{5}B \rightarrow {}^{6}_{3}Li + {}^{4}_{2}He$$

$$^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + {}^{0}_{-1}e$$

Mixed Review

90. Determine what is wrong with Dalton's theory and provide the revised version of the atomic structure.

Atoms are indivisible and atoms of the same element can have different mass. An atomic structure consists of subatomic particles: electrons, protons and neutrons.

91. Cathode-Ray Tube Describe a cathode ray tube and how it operates.

A cathode ray tube has a metal electrode at each end and is filled with a gas at low pressure. One electrode is connected to the negative terminal of a battery (cathode), and the other is connected to the positive terminal (anode). When current flows, negatively charged particles called electrons are emitted from the cathode and travel through the tube to the anode.

92. Subatomic Particles Explain how J. J. Thomson's determination of the charge-to-mass ratio of the electron led to the conclusion that atoms were composed of subatomic particles.

Thomson showed that the electron's mass was much less than the mass of a hydrogen atom, the lightest atom. This showed that there were smaller, subatomic particles. Atoms are divisible.

93. Gold Foil Experiment How did the actual results of Rutherford's gold foil experiment differ from the results he expected?

Rutherford expected the α particles to be slightly deflected when they passed through a gold foil. Instead, he found that some were deflected at very large angles.

94. If a nucleus contains 12 protons, how many electrons are in the neutral atom. Explain.

12 electrons. The protons are the only charged particles in the nucleus. To balance their positive charge, there must be the same number of electrons as protons.

95. An atom's nucleus has 92 protons and the atom's mass number is 235. How many neutrons are in the nucleus? What is the name of the atom?

There are 143 neutrons. Uranium.

96. Complete **Table 4.8.**

Isotope	Atomic number	Mass number	p^+	n^0	e^-
S-32	16	32	16	16	16
Ca-44	20	44	20	24	20
Zn-64	30	64	30	34	30
F-19	9	19	9	10	9
Na-23	11	23	11	12	11

97. Approximately how many times greater is the diameter of an atom than the diameter of its nucleus? Knowing that most of an atom's mass is contained in the nucleus, what can you conclude about the density of the nucleus?

An atom's diameter is about 10,000 times the diameter of its nucleus. Consequently, the density of the nucleus must be enormous.

98. Is the charge of a nucleus positive, negative, or zero? The charge of an atom?

The nucleus is positively charged, whereas the atom is neutral.

99. Why are electrons in a cathode ray tube deflected by electric fields?

Because they are charged particles, and charged particles are affected by the electrostatic forces of attraction and repulsion from electric fields.

100. What was Henry Moseley's contribution to our understanding of the atom?

Moseley discovered that each element contains a unique positive charge (or number of protons) in its nucleus. Thus, the number of protons in an atom's nucleus uniquely identifies it as an atom of a particular element.

101. What is the mass number of potassium-39? What is the isotope's charge?

mass number = 39; charge = 0

102. Boron-10 and boron-11 are the naturally occurring isotopes of elemental boron. If boron has an atomic mass of 10.81 amu, which isotope occurs in greater abundance?

B-11 must occur in greater abundance because the atomic weight of bromine is much closer to the mass of B-11 than to the mass of B-10.

103. Semiconductors Silicon is very important to the semiconductor manufacturing industry. The three naturally occurring isotopes of silicon are silicon-28, silicon-29, and silicon-30. Write the symbol for each.

$^{28}_{14}Si$, $^{29}_{14}Si$, $^{30}_{14}Si$

104. Titanium Use **Table 4.9** to calculate the atomic mass of titanium.

Isotope	Atomic mass (amu)	Relative abundance (%)
Ti-46	45.953	8.00
Ti-47	46.952	7.30
Ti-48	47.948	73.80
Ti-49	48.948	5.50
Ti-50	49.945	5.40

45.953 amu × 0.0800 = 3.68

46.952 amu × 0.0730 = 3.43

47.948 amu × 0.7380 = 35.39

48.948 amu × 0.0550 = 2.69

49.945 amu × 0.0540 = 2.70

47.89 amu

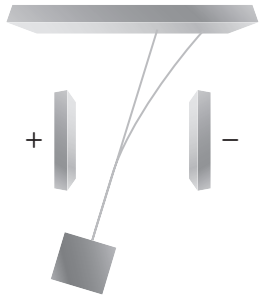
105. Describe how each type of radiation affects an atom's atomic number and mass number.

α, atomic number decreases by 2, mass number decreases by 4; β, atomic number increases by 1, mass number unchanged; γ, atomic number and mass number are unchanged

106. Magnesium constitutes about 2% of Earth's crust and has 3 naturally occurring isotopes. Suppose you analyze a mineral and determine that it contains the three isotopes in the following proportions Mg-24 (abundance = 79%), Mg-25 (abundance = 10%), and Mg-26 (abundance = 11%). If your friend analyzes a different mineral containing magnesium, do you expect him to obtain the same relative abundance of magnesium? Explain.

Yes. The isotopic abundance of an element is the same no matter where the element comes from.

107. Radiation Identify the two types of radiation shown in the **Figure 4.24.** Explain your reasoning.



The deflected beam is alpha radiation because it is deflected toward the negatively charged plate. The undeflected beam must be neutral γ gamma radiation.

Think Critically

108. Formulate How were scientific methods used to determine the model of the atom? Why is the model considered a theory?

Experiments (cathode ray, gold foil) were performed to explain observations (deflection of cathode ray, deflection of alpha particles) and test hypotheses (structure of the atom). It is a theory because it is supported by experiments, but is still subject to modifications are more data become available.

109. Discuss What experiment led to the dispute of the J.J. Thomson's plum pudding atomic model? Justify your answer.

Rutherford's thin gold foil experiment. His experimental results were inconsistent with the plum pudding atomic model.

110. Apply Which is greater, the number of compounds or the number of elements? The number of elements or the number of isotopes? Explain.

The number of compounds is greater than the number of elements because compounds are combinations of elements and the elements can be combined in many ways. The number of isotopes is greater than the number of elements because each element has only one type of atom but may have more than one isotope.

111. Analyze An element has three naturally occurring isotopes. What other information must you know in order to calculate the element's atomic mass?

You also need to know the mass and percent abundance of each isotope.

112. Apply If atoms are primarily composed of empty space, why can't you pass your hand through a solid object?

Atoms are extremely small and very close together in comparison to our hand. Atoms in a solid object are bonded together by electrical forces—bonds that are not easily broken.

113. Formulate Sketch a modern atomic model of a typical atom and identify where each type of subatomic particle would be located.

Sketches should look similar to Figure 4.14 on page 114.

114. Apply Indium has two naturally occurring isotopes and an atomic mass of 114.818 amu. In-113 has a mass of 112.904 amu and an abundance of 4.20%. What is the identity and percent abundance of indium's other isotope?

The other isotope is In-115. Its percent abundance is 95.7%.

115. Infer Sulfur's average atomic mass is very close to the whole number 32. Chlorine's average atomic mass is 35.453, which is not a whole number. Suggest a possible reason for this difference.

Sulfur has an isotope with a very high abundance. Chlorine has more than one isotope with a large percent abundance.

Challenge Problem

116. Magnesium Isotopes Compute the mass number, X, of the third isotope of magnesium given that the abundances of the natural occurring isotopes are 79.0%, 10% and 11% for $^{24}_{12}Mg$, $^{25}_{12}Mg$, $^{X}_{12}Mg$, respectively. The relative atomic mass of magnesium is 24.305 amu.

24.305 amu = (24 amu)(.790) + (25 amu)(0.10) + (*X* amu)(0.11)

***X* = 26 amu**

Cumulative Review

117. How is a qualitative observation different from a quantitative observation? Give an example of each. *(Chapter 1)*

A qualitative observation does not involve measurement (water is hot). A quantitative observation involves measurement (the water is 42°C).

118. A 1.0-cm^3 block of gold can be flattened to a thin sheet that averages 3.0×10^{-8} cm thick. What is the area (in cm^2) of the flattened gold sheet? *(Chapter 2)*

area = volume/height = 1.0 cm^3/3.0 $\times$ 10^{-8} cm = 3.3 $\times$ 10^7 cm^2

119. A piece of paper has an area of 603 cm^2. How many sheets of paper would the sheet of gold mentioned in problem 118 cover? *(Chapter 2)*

$$3.3 \times 10^7 \text{ cm}^2 \times \frac{1 \text{ sheet}}{603 \text{ cm}^2} = 55{,}000 \text{ sheets}$$

120. Classify each mixture as heterogeneous or homogeneous. *(Chapter 3)*

a. salt water

homogeneous

b. vegetable soup

heterogeneous

c. 14-K gold

homogeneous

d. concrete

heterogeneous

121. Determine whether each change is physical or chemical? *(Chapter 3)*

a. water boils

physical change

b. a match burns

chemical change

c. sugar dissolves in water

physical change

d. sodium reacts with water

chemical change

e. ice cream melts

physical change

Additional Assessment

122. Television and Computer Screens Describe how cathode rays are used to generate the television and computer monitor images.

The back of a computer monitor screen or television screen is coated with a phosphorescent material that glows when a beam of electrons strikes on it. Phosphorescent means that the material emits a light of a different color.

123. The Standard Model The Standard Model of particle physics describes all of the known building blocks of matter. Research the particles included in the Standard Model. Write a short report describing the known particles and those thought to exist but not detected experimentally.

Answers should include:

Known particles: protons, neutrons, electrons, quarks, pions

Not detected yet: Higgs boson

124. STM Individual atoms can be seen using a sophisticated device known as a scanning tunneling microscope. Write a short report on how the scanning tunneling microscope works and create a gallery of scanning tunneling microscope images from sources such as books, magazines, and the Internet.

A point moves across a sample and the electron in the point interact with the electrons surrounding the superficial atoms in the sample. This interaction is recorded electronically.

Document-Based Questions

Zirconium is a lustrous, gray-white metal. Because of its high resistance to corrosion and its low cross section for neutron absorption, it is often used in nuclear reactors. It can also be processed to produce gems that look like diamonds and are used in jewelry.

Table 4.10 shows the relative abundances of zirconium isotopes.

Data obtained from: Lide, David R., ed. 20 05. *CRC Handbook of. Chemistry and physics*. Boca Raton: CRC Press.

Relative Abundances of Zirconium Isotopes

Element	Relative Abundance
Zirconium-90	51.4
Zirconium-91	11.2
Zirconium-92	17.2
Zirconium-94	17.4
Zirconium-95	2.8

125. What is the mass number of each zirconium isotope?

See table below.

126. Compute the number of protons and neutrons for each of the Zirconium isotopes.

See table below.

Element	Mass	Relative Abundance	Number of Neutrons	Number of Protons
Zirconium-90	**89.905**	51.45	**50**	**40**
Zirconium-91	**90.906**	11.22	**51**	**40**
Zirconium-92	**91.905**	17.15	**52**	**40**
Zirconium-94	**93.906**	17.38	**54**	**40**
Zirconium-96	**95.908**	2.80	**56**	**40**

127. Does the number or protons or neutrons remain the same for all isotopes? Explain.

Protons. Isotopes are atoms of the same element with different mass numbers.

128. Based on the relative abundances of each isotope, predict to which isotope's mass the average atomic mass of zirconium is going to be closest.

zirconium-90

129. Calculate the relative atomic mass of Zirconium.

Atomic mass of Zr = [(89.905)*(0.5145) + (90.906)*(0.1122) + (91.905)*(0.1715) + (93.906)*(0.1738) + (95.908)*(0.0280)] amu

Atomic mass = 91.22 amu

Standardized Test Practice

pages 132–133

1. Which describes an atom of plutonium?

a. It can be divided into smaller particles that retain all the properties of plutonium.
b. It cannot be divided into smaller particles that retain all the properties of plutonium.
c. It does not possess all the properties of a larger quantity of plutonium.
d. It has an atomic number of 244.

b

2. Neptunium's only naturally occurring isotope, $^{237}_{93}Np$, decays by emitting one alpha particle, one beta particle, and one gamma ray. What is the new atom formed from this decay?

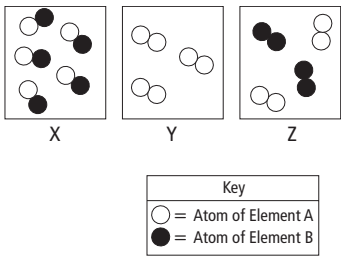
a. $^{233}_{92}U$
b. $^{241}_{93}Np$
c. $^{233}_{90}Th$
d. $^{241}_{92}U$

a

3. Which type of matter has a definite composition throughout and is made of more than one type of element?

a. heterogeneous mixture
b. homogeneous mixture
c. element
d. compound

d



4. Which diagram shows a mixture?

a. X
b. Y
c. Z
d. both X and Z

c

5. The Moon is approximately 384,400 km from Earth. What is this value in scientific notation?

a. 384.4×10^3 km
b. 3.844×10^5 km
c. 3.844×10^{-5} km
d. 3.844×10^{-2} km

b

6. Why does an atom have no new electric charge?

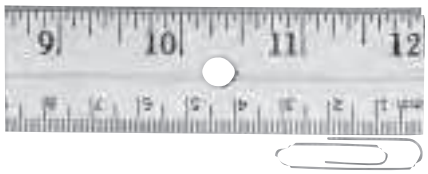
a. Its subatomic particles carry no electric charges.
b. The positively charged protons cancel out the negatively charged neutrons.
c. The positively charged neutrons cancel out the negatively charged electrons.
d. The positively charged protons cancel out the negatively charged electrons.

d

7. How many neutrons, protons, and electrons does $^{126}_{52}$Te have?

a. 126 neutrons, 52 protons, and 52 electrons
b. 74 neutrons, 52 protons, and 52 electrons
c. 52 neutrons, 74 protons, and 74 electrons
d. 52 neutrons, 126 protons, and 126 electrons

b



8. Record the length of this paperclip to the appropriate number of significant digits.

a. 31 mm
b. 31.1 mm
c. 30.1 mm
d. 31.15 mm

c

9. Element X has an unstable nucleus due to an overabundance of neutrons. All are likely to occur EXCEPT

a. element X will undergo radioactive decay.
b. element X will eventually become a stable, nonradioactive element.
c. element X will gain more protons to balance the neutrons it possesses.
d. element X will spontaneously lose energy.

b

10. What makes up most of the volume of an atom?

a. protons
b. neutrons
c. electrons
d. empty space

d

11. A 36.41-g sample of calcium carbonate ($CaCO_3$) contains 14.58 g of calcium and 4.36 g of carbon. What is the mass of oxygen contained in the sample? What is the percent by mass of each element in this compound?

mass of oxygen = 36.41 − 14.58 − 4.36 = 17.47 g

40% calcium, 12% carbon, 48% oxygen.

14.58/36.41 = 40.04% calcium

4.36/36.41 = 12.0% carbon

17.47/36.41 = 47.98% oxygen

Characteristics of Naturally Occurring Neon Isotopes			
Isotopes	**Atomic Number**	**Mass(amu)**	**Percent Abundance**
^{20}Ne	10	19.992	90.48
^{21}Ne	10	20.994	0.27
^{22}Ne	10	21.991	9.25

12. For each isotope listed above, write the number of protons, electrons, and neutrons it contains.

^{20}Ne: 10p, 10n, 10e

^{21}Ne: 10p, 11n, 10e

^{22}Ne: 10p, 12n, 10e

13. Using the data in the table above, calculate the average atomic mass of neon.

average atomic mass = (90.48%)(19.992 amu) + (0.27%)(20.994 amu) + (9.25%)(21.991 amu) = 20.180 amu

Extended Response

14. Assume that Element Q has the following three isotopes: ^{248}Q, ^{252}Q, and ^{259}Q. IF the atomic mass of Q is 258.63, which of its isotopes is most abundant. Explain your answer.

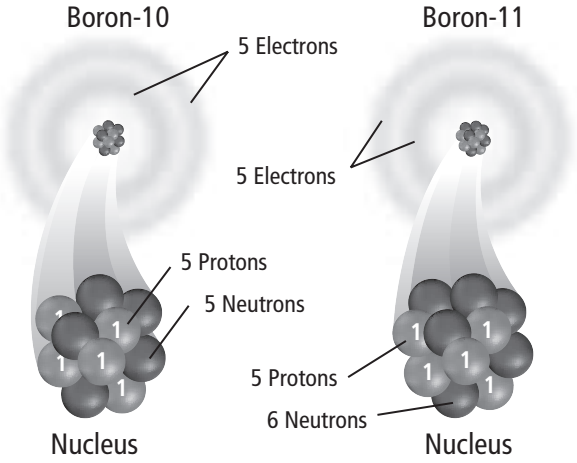
^{259}Q is probably the most abundant isotope because the average atomic mass is close to 259. If a different isotope were more abundant, the average atomic mass would be much lower.

15. Iodine-131 undergoes radioactive decay to form an isotope with 54 protons and 77 neutrons. What type of decay occurs in this isotope? Explain how you can tell.

beta decay; The atomic number changes from 53 (iodine) to 54 (xenon), whereas the mass number does not change at all (131 for iodine, 54 + 77 for xenon).

16. You are given an aluminum cube. Your measurements show that its sides are 2.14 cm and its mass is 25.1 g. Explain how you would find its density. If the density of aluminum is known to be 2.70 g/cm^3, what is your percent error?

Use the formula for volume of a cube (L times W times H), then use the density formula (D = m/v) to solve for density. Volume = (2.14 cm)(2.14 cm)(2.14 cm) = 9.80 cm^3; 25.1 g/9.80 cm^3 = 2.56 g/cm^3 percent error = (2.70 − 2.56)/2.7 = 0.0518 = 5.18% error



17. **T, T, CE**

18. **T, F**

19. **F, T**

20. **T, F**

21. **T, T (although both statements are true, Statement II is NOT a correct explanation of Statement I)**

Statement I		**Statement II**
17. The two atoms of boron pictured above are isotopes	BECAUSE	they have the same number of protons but a different number of neutrons.
18. Most alpha particles shot at a piece of gold foil travel through it	BECAUSE	an atom has a large nucleus compared to its overall size.
19. A beam of neutrons is attracted to the charged plates surrounding it	BECAUSE	neutrons have not charge.
20. Carbon and oxygen can form either CO or CO_2	BECAUSE	carbon and oxygen obey the law of definite composition.
21. A mixture of sand and water is heterogeneous	BECAUSE	Water is a compound formed from hydrogen and oxygen.