

The BIG Idea **Properties of Matter** Atoms of different elements combine to form compounds by gaining, losing, or sharing electrons.

1 Elements and Atoms

Key Concepts

- Elements are the building blocks of matter because all matter is composed of one element or a combination of two or more elements.
- Atomic theory grew as a series of models that developed from experimental evidence. As more evidence was collected, the theory and models were revised.

Key Terms

- matter • element • compound • mixture
- atom • scientific theory • model
- electrons • nucleus • protons • energy level
- neutrons

2 Atoms, Bonding, and the Periodic Table

Key Concepts

- The number of valence electrons in an atom of an element determines many properties of that element, including the ways in which the atom can bond with other atoms.
- The properties of elements change in a regular way across a period in the periodic table.

Key Terms

- valence electrons • electron dot diagram
- chemical bond • symbol • atomic number
- period • group • family • noble gas
- halogen • alkali metal



3 Ionic Bonds

Key Concepts

- When an atom loses an electron, it becomes a positive ion. When an atom gains an electron, it becomes a negative ion.
- Ionic bonds form as a result of the attraction between positive and negative ions.
- When ionic compounds form, the charges on the ions balance out.
- Ionic compounds are hard, brittle crystals that have high melting points and conduct electricity when dissolved in water.

Key Terms

- ion • polyatomic ion • ionic bond
- ionic compound • chemical formula
- subscript • crystal

4 Covalent Bonds

Key Concepts

- The force that holds atoms together in a covalent bond is the attraction of each atom's nucleus for the shared pair of electrons.
- Molecular compounds have low melting and boiling points and do not conduct electricity.
- In polar covalent bonds, the bonded atoms have slight electrical charges.

Key Terms

- covalent bond • molecule • double bond
- triple bond • molecular compound
- polar bond • nonpolar bond

5 Bonding in Metals

Key Concepts

- A metal consists of positively charged metal ions in a "sea" of valence electrons.
- Solid metals conduct heat and electricity, can change shape easily, and have luster.

Key Terms

- metallic bond ductile
- alloy malleable

Organizing Information

Comparing and Contrasting

Copy the graphic organizer about chemical bonds onto a separate sheet of paper. Then complete it. (For more on Comparing and Contrasting, see the Skills Handbook.)

Types of Chemical Bonds

Feature	Ionic Bond	Polar Covalent Bond	Nonpolar Covalent Bond	Metallic Bond
How Bond Forms	a. ?	Unequal sharing of electrons	b. ?	c. ?
Charge on Bonded Atoms?	Yes; positive or negative	d. ?	e. ?	Yes; positive
Example	f. ?	g. ?	O ₂ molecule	h. ?

Reviewing Key Terms

Choose the letter of the best answer.

- All compounds are made up of two or more
 - elements.
 - electrons.
 - nuclei.
 - mixtures.
- The nucleus of an atom has a positive charge because the nucleus contains
 - electrons.
 - protons.
 - mass.
 - neutrons.
- On the periodic table, elements with the same number of valence electrons are in the same
 - square.
 - period.
 - block.
 - group.
- When an atom loses or gains electrons, it becomes a(n)
 - ion.
 - formula.
 - crystal.
 - subscript.
- A covalent bond in which electrons are shared unequally is a
 - double bond.
 - triple bond.
 - polar bond.
 - nonpolar bond.
- Because it can be pounded into thin sheets, copper is said to be
 - an alloy.
 - conductive.
 - ductile.
 - malleable.

If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.

- In the modern atomic model, most of the volume of an atom is occupied by its nucleus.
- The atomic number of an element is the number of protons in the nucleus of an atom.
- A polyatomic ion is made up of more than one atom.
- An alloy is a mixture of elements that has the properties of a metal.

Writing in Science

Travel Brochure Pretend you have just visited a city modeled on the periodic table. Write a travelogue about how the "city" is organized. Be sure to describe some of the elements you visited and how they are related to their neighbors.



Atoms and Bonding
Video Preview
Video Field Trip
▶ Video Assessment

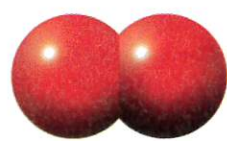
Review and Assessment

Checking Concepts

- What discoveries did Rutherford make about the atom from his team's experiments?
- Which element is less reactive, an element whose atoms have seven valence electrons or an element whose atoms have eight valence electrons? Explain.
- Why do ionic compounds generally have high melting points?
- The formula of sulfuric acid is H_2SO_4 . How many atoms of hydrogen, sulfur, and oxygen are in one molecule of sulfuric acid?
- Why is the covalent bond between two atoms of the same element a nonpolar bond?
- Explain how metallic bonding causes metals to conduct electricity.

Thinking Critically

- Applying Concepts** Your friend tells you that she has a theory that eating cabbage will make hair grow faster. How does your friend's use of the word theory differ from a scientist's use of the word?
- Making Generalizations** What information does the organization of the periodic table tell you about atoms and the bonds they form?
- Classifying** Classify each molecule below as either a polar molecule or a nonpolar molecule. Explain your reasoning.



Oxygen

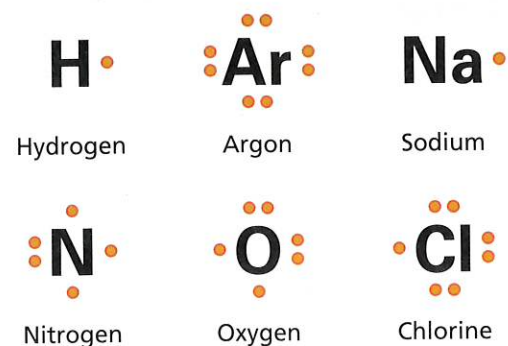


Carbon dioxide

- Relating Cause and Effect** Many molecular compounds with small molecules are gases at room temperature. Water, however, is a liquid. Use what you know about polar and nonpolar molecules to explain this difference. (*Hint: Molecules of a gas are much farther apart than molecules of a liquid.*)

Applying Skills

Use the electron dot diagrams below to answer Questions 21–25.



- Predicting** When nitrogen and hydrogen combine, what will be the ratio of hydrogen atoms to nitrogen atoms in a molecule of the resulting compound? Explain.
- Inferring** Which of these elements can become stable by losing one electron? Explain.
- Drawing Conclusions** Which of these elements is least likely to react with other elements? Explain.
- Interpreting Diagrams** Which of these elements would react with two atoms of sodium to form an ionic compound? Explain.
- Classifying** What type of bond forms when two atoms of nitrogen join to form a nitrogen molecule? When two atoms of oxygen join to form an oxygen molecule?

Lab zone Chapter Project

Performance Assessment Present your models to the class, telling what the parts of each model represent. Explain why you chose particular items to model the atoms and chemical bonds. Which kind of bonds were easier to show? Why? What more would you like to know about bonding that could help improve your models?

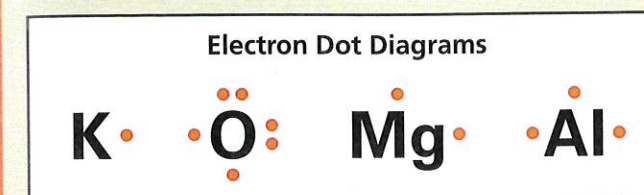
Standardized Test Prep

Test-Taking Tip

Interpreting Diagrams

When answering a question related to a diagram, examine the diagram carefully. Read any titles or labels included. Be sure you understand the meanings of the symbols used. For example, in the diagram below, the dots represent valence electrons. Study the diagram and answer the sample question.

Sample Question



Which element is the most likely to lose two electrons and form an ion with a charge of 2+?

- A potassium (K)
- B oxygen (O)
- C magnesium (Mg)
- D aluminum (Al)

Answer

The correct answer is C. Atoms with low numbers of valence electrons are likely to lose electrons. Potassium, magnesium, and aluminum all have low numbers of valence electrons, but only magnesium will lose two electrons, producing an ion with a 2+ charge.

Choose the letter of the best answer.

Use the electron dot diagrams above to answer Questions 1–3.

- Oxygen has 6 valence electrons, as indicated by the 6 dots around the letter symbol "O." Based on this information, how many covalent bonds could an oxygen atom form?
 - A six
 - B three
 - C two
 - D none

- If a reaction occurs between potassium (K) and oxygen (O), what will be the ratio of potassium ions to oxide ions in the resulting compound, potassium oxide?
 - F 1 : 1
 - G 1 : 2
 - H 2 : 1
 - J 2 : 2

- The element boron (B) is directly above aluminum (Al) on the periodic table. Which statement about boron is true?
 - A Boron is in the same period as aluminum and has two valence electrons.
 - B Boron is in the same group as aluminum and has two valence electrons.
 - C Boron is in the same period as aluminum and has three valence electrons.
 - D Boron is in the same group as aluminum and has three valence electrons.

- The chemical formula for a glucose molecule is $C_6H_{12}O_6$. The subscripts represent the
 - F mass of each element.
 - G number of atoms of each element in a glucose molecule.
 - H total number of bonds made by each atom.
 - J number of valence electrons.

- An ice cube (solid H_2O) and a scoop of table salt (NaCl) are left outside on a warm, sunny day. Which best explains why the ice cube melts and the salt does not?
 - A The attractive forces between molecules of H_2O are much weaker than those between ions in NaCl.
 - B NaCl can dissolve in H_2O .
 - C The mass of the H_2O was less than the mass of the NaCl.
 - D NaCl is white and H_2O is colorless.

Constructed Response

- In a working light bulb, electricity passes through a thin tungsten wire filament that is wound in a coil. Describe two properties that make the metal tungsten a good material for the filament of a light bulb. Indicate how the type of bonding in tungsten contributes to these properties.