

Compounds, Ions, and Molecules

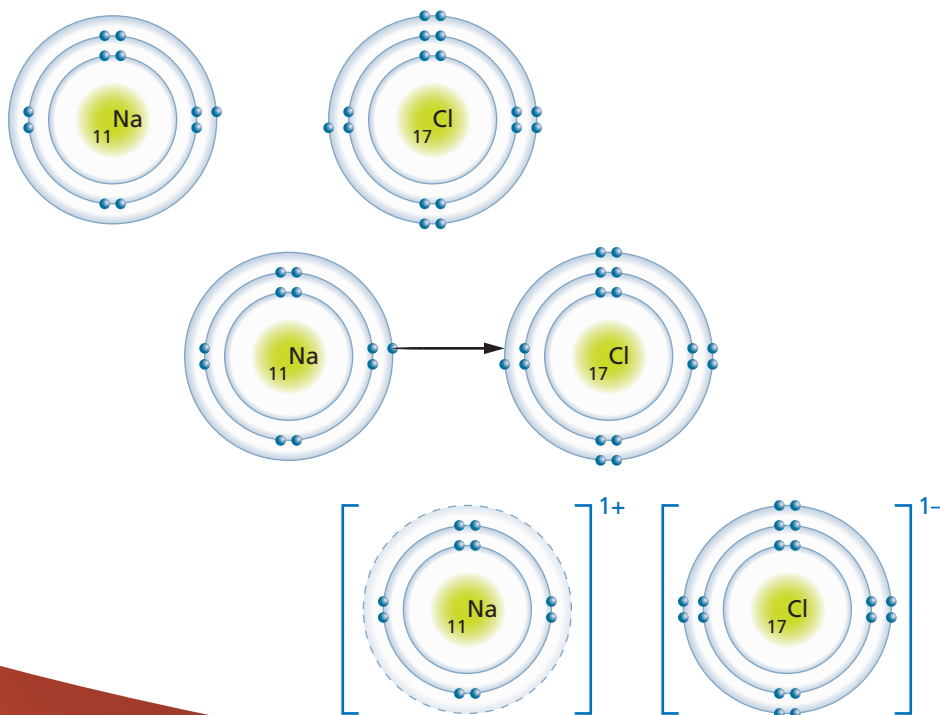
Key Ideas

Compounds result when elements bond together in fixed proportions.

- The simplest form of matter is an element. The smallest particle of an element is an atom.
- A compound is made up of two or more elements chemically bonded in fixed proportions.
- Each compound has properties that are different from the elements that they are made from.

Bohr diagrams can illustrate how ions form.

- Bohr diagrams show how electrons are arranged in shells.
- Only the valence electrons in the valence shell are involved when atoms join together.
- Atoms tend to acquire the same number of valence electrons as their nearest noble gas. Noble gases have complete valence shells.
- When atoms gain or lose electrons, they become negatively or positively charged and are called ions.
- An atom and an ion of the same element have completely different properties. The symbol for an ion includes the charge, for example, Na^+ or O^{2-} . The symbol for an atom is written as Na or O.

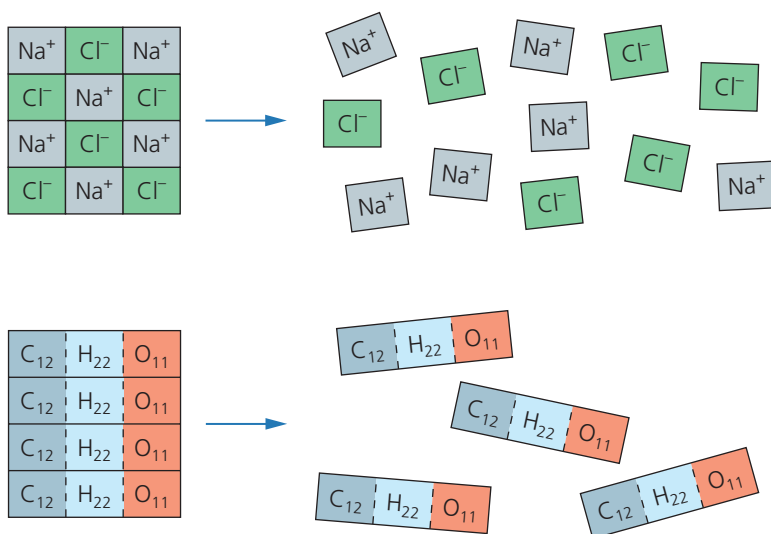


Vocabulary

- bond, p. 170
- valence shell, p. 170
- valence electrons, p. 170
- ion, p. 171
- chemical bonds, p. 176
- ionic compounds, p. 176
- ionic bonding, p. 176
- covalent or molecular compounds, p. 177
- covalent bonding, p. 177
- molecule, p. 178
- diatomic molecule, p. 178
- phase or state, p. 180
- chemical formula, p. 183
- ion charge balance, p. 183
- multivalent, p. 187
- polyatomic ion, p. 189

Bonding can involve electron transfer (ionic) or electron sharing (covalent).

- A chemical bond is a force that holds atoms together to form compounds.
- There are two general types of chemical bonds: ionic and covalent.
- Ionic bonds involve a transfer of electrons between atoms. Ionic bonding forms ionic compounds. The smallest particle of an ionic compound is an ion. Ionic compounds separate into ions when dissolved in water so they conduct electricity.
- Covalent bonds involve a sharing of electrons between atoms. Covalent bonds form molecular compounds. The smallest part of a molecular compound is a molecule. Molecular compounds do not separate into ions when dissolved in water, so they are poor conductors of electricity.



Rules for writing chemical formulas and for naming ionic compounds are based on ion charge balances.

- The chemical formulas for ionic compounds can be predicted by balancing ion charges.
- The chemical names are derived from the ion names.
- Ionic compounds can be classified into binary, ionic with multivalent elements, and ionic with polyatomic ions.

Rules for writing chemical formulas and for naming molecular compounds are based on a prefix system.

- The chemical formulas for molecular compounds are derived from their chemical names (and vice versa) based on a prefix system, for example, mono, di, and tri.

Many of these questions are in the style of the Science 10 Provincial Exam. The following icons indicate an exam-style question and its cognitive level.

K Knowledge **U** Understanding and Application **HMP** Higher Mental Processes

Review Key Ideas and Vocabulary

- K** 1. Which of the following describes compounds?
- They have atoms as their smallest particles.
 - They can be easily separated by physical methods.
 - They cannot be broken down into simpler substances.
 - They are composed of two or more elements in fixed proportions.
- K** 2. Atoms form compounds through interactions of which of the following?
- nuclei
 - protons
 - neutrons
 - electrons
- K** 3. What are the valence electrons in an atom?
- the total number of electrons
 - the electrons in the outermost shell
 - the electrons that always occupy the first shell
 - the number of electrons that equal the protons
- K** 4. Which of the following is an example of an ion?
- O
 - O^{2-}
 - O_2
 - 2O
- K** 5. Which of the following is the smallest particle of an element?
- ion
 - atom
 - molecule
 - compound
6. What is the main difference between ionic bonding and covalent bonding?
- K** 7. Which of the following is the smallest particle of a covalently bonded compound?
- ion
 - atom
 - element
 - molecule

- K** 8. How do ions form?

I	Atoms gain or lose protons.
II	Atoms gain or lose neutrons.
III	Atoms gain or lose electrons.

- I only
 - II only
 - III only
 - I and III
- K** 9. Why is a crystal of an ionic compound held together so strongly?
- Ionic bonds are a result of electron transfer.
 - Similar ions are strongly attracted to each other.
 - Crystals have a definite shape that results from ionic bonds.
 - Each ion is equally attracted to all adjacent oppositely charged ions.
10. Compare the melting points for ionic compounds and molecular compounds. Explain why they are different.
11. What is the concept used in determining the fixed proportions of elements in ionic compounds?
12. What are the names of the following?
- Ca^{2+}
 - K
 - K^+
 - S^{2-}
 - SO_4^{2-}
 - NH_4^+

Use What You've Learned

- U** 13. How do positive ions form?
- Atoms gain protons.
 - Atoms lose protons.
 - Atoms gain electrons.
 - Atoms lose electrons.
14. Draw Bohr diagrams for atoms of lithium, beryllium, magnesium, phosphorus, fluorine, and argon.
15. Draw Bohr diagrams for the ions of sulfur, potassium, aluminum, and nitrogen.
16. Can an atom turn into an ion on its own? Explain.

17. Indicate the nearest noble gases for each of the following atoms. Secondly, state the number of electrons that each atom will gain or lose. Thirdly, write the symbol for the ion that will form.
- H
 - N
 - Li
 - S
 - Al
 - Cl
 - O
 - Ca

u 18. What is the chemical formula for barium nitrate?

- Ba_3N_2
- BaNO_3
- $\text{Ba}(\text{NO}_3)_2$
- $\text{Ba}(\text{NO}_2)_2$

19. For each of the following compounds, classify it as ionic or molecular and write its chemical formula.

- barium nitrate
- ammonium sulfate
- lead(II) chloride
- aluminum sulfide
- carbon disulfide

20. For each of the following compounds, classify it as ionic or molecular and write its chemical name.

- KCl
- $(\text{NH}_4)_3\text{N}$
- P_3Br_6
- Cr_2O_3
- $\text{Mg}_3(\text{PO}_4)_2$

21. For each of the following compounds, classify it as ionic or molecular and write the chemical name or formula.

- NaBr
- magnesium sulfate
- NBr_3
- lead(IV) oxide
- $\text{Ca}(\text{MnO}_4)_2$

Think Critically

22. Oppositely charged ions are held together by electrostatic forces. What other opposite forces in nature hold objects together?
23. At a molecular level, why is it unlikely to find a single isolated unit such as KBr? Use a sketch to support your answer.
24. Write out and number your own set of rules that explain how to correctly write chemical formulas for ionic compounds given the chemical name.
25. Write out and number your own set of rules that explain how to correctly write chemical formulas for molecular compounds given the chemical name.
- HMP** 26. Which of the following correctly list a compound with its formula and compound type?

	Name	Formula	Type
I	carbon dioxide	CO_2	molecular
II	lithium sulfate	LiSO_4	polyatomic ionic
III	potassium chloride	KCl	binary ionic
IV	manganese(II) sulfate	Mn_2SO_4	multivalent ionic

- I and III only
- II and III only
- III and IV only
- I, II, and III only

27. Suppose you are asked to predict the chemical formula for the covalent compound that results when nitrogen atoms combine with oxygen atoms. Conduct an Internet search to determine if a formula for nitrogen oxide exists and write a brief paragraph to report what you learn.

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Reflect on Your Learning

28. Why do you think that chemistry is often referred to as the “central science”? Give some examples to support your reasoning.

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