

## Atomic Theory—Inside the Invisible

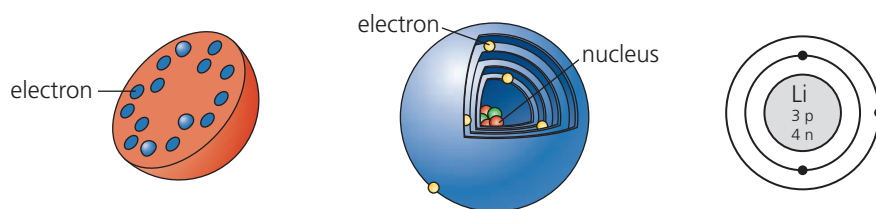
### Key Ideas

#### Matter is made of atoms.

- Each element has its own kind of atom.
- Atoms of different elements combine to form compounds.

#### The atomic theory of matter has changed with new discoveries.

- The discovery of the electron led to Thomson’s “raisin-bun” model of the atom.
- Rutherford’s discovery of the nucleus required a new model, one with most of the mass concentrated in a small space at the centre of the atom.
- Bohr’s model of the atom explained the behaviour of electrons in orbit around the nucleus.



#### Elements can be classified and ordered according to their properties.

- Metal elements are on the left side of the Periodic Table.
- Non-metal elements are on the right side of the Periodic Table.
- Metalloid elements fall on a zigzag line between the metal and non-metal elements.
- The Periodic Table arranges elements in vertical columns, or chemical groups, with similar properties.

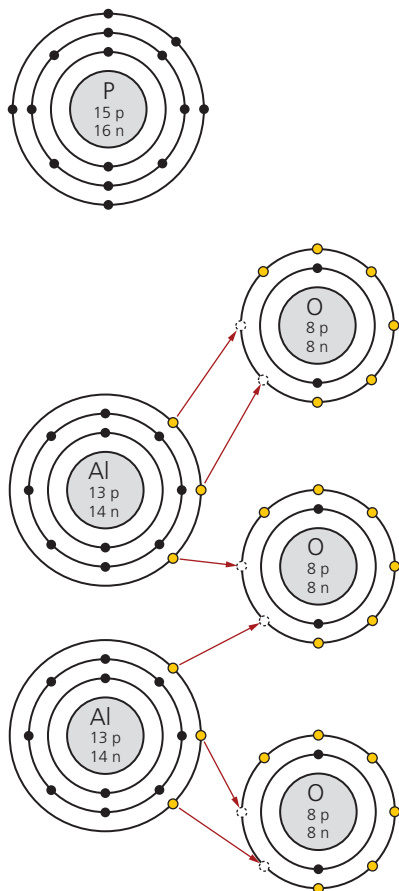
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

### Vocabulary

- atom, p. 204
- electron, p. 206
- nucleus, p. 207
- protons, p. 207
- neutrons, p. 207
- subatomic particles, p. 207
- emission spectrum, p. 209
- shells, p. 209
- atomic number, p. 211
- mass number, p. 211
- ion, p. 211
- negative ion, p. 211
- positive ion, p. 211
- ion charge, p. 211
- atomic mass, p. 215
- Bohr diagrams, p. 218
- ionic compound, p. 221
- electron transfer, p. 221
- ionic bond, p. 221
- molecules, p. 221

## Atoms have a structure that determines their chemical and physical properties.

- Atoms are made up of subatomic particles: protons, neutrons, and electrons.
- Protons have a positive charge, have the same mass as neutrons, and are in the nucleus.
- Neutrons have no charge, have the same mass as protons, and are in the nucleus.
- Electrons have a negative charge, have  $\frac{1}{1800}$  the mass of a proton, and orbit the nucleus at specific locations, or shells.
- For the first 20 elements, the first three orbits can contain a maximum of two, eight, and eight electrons.
- Bohr diagrams can help you visualize the structure of atoms and ions.
- Atoms form ions by either acquiring electrons (non-metals) or losing electrons (metals) so that their outer shell is full.
- Ionic compounds are formed when metal and non-metal atoms transfer electrons to become positive and negative ions. The ions are attracted to each other by the electric force.



## Review Key Ideas and Vocabulary

- Four solid substances are examined. The substance most likely to be a metalloid is
  - shiny, conductive, and bendable
  - shiny, conductive, and brittle
  - dull, non-conductive, and brittle
  - dull, non-conductive, and bendable
- An element is a gas at room temperature. It is likely to be a
  - metal
  - metalloid
  - non-metal
  - compound
- For the first 20 elements, the maximum numbers of electrons that can occupy the first three electron shells are
  - 8, 8, and 8
  - 2, 2, and 8
  - 8, 18, and 18
  - 2, 8, and 8
- In the modern Periodic Table, the upper right is where you can find the
  - non-metals
  - metals
  - transition metals
  - alkali metals
- The nucleus of an atom
  - makes up one-third of the mass
  - makes up almost all of the mass
  - takes up most of the diameter
  - holds all of the negative charge
- How many electrons are in the outer shell of the atoms of the elements in the second and third rows of the Periodic Table?
  - How many electrons are in the outer shell of an atom in the second row of the Periodic Table once it has become an ion?
- What does the atomic number of an element represent?
- What tells you the total number of protons and neutrons in the nucleus of an atom?
- Which scientist first described the nucleus as a dense inner core containing all the positive charges in an atom?

- List three types of information about elements that you can expect to find in the Periodic Table.
- Explain why Thomson's atomic model is sometimes called the "chocolate-chip cookie" model.
- What are the ion charges of each of the following elements?
  - oxygen
  - chlorine
  - sodium
  - nitrogen
  - neon
- An ion has a charge of  $3^-$  because
  - there are 3 electrons missing
  - there are electrons in three shells
  - there are 3 extra electrons
  - there are 3 missing protons

## Use What You've Learned

- Draw Bohr diagrams for sodium, magnesium, aluminum, silicon, oxygen, and neon.
- Draw Bohr diagrams for the ions of nitrogen, boron, and potassium.
- How many electrons will occupy the outer shell of an element in the third row of Group 15 (15th column) of the Periodic Table?
- For each of the four Bohr diagrams shown below (Figures 1 to 4), determine
  - the atomic number
  - the element name
  - the number of electrons
  - the number of neutrons
  - the atomic mass
  - whether the diagram represents an atom or an ion

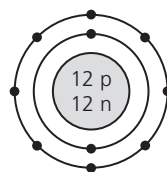


Figure 1

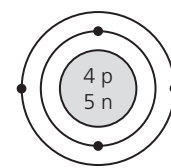


Figure 2

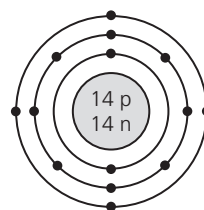


Figure 3

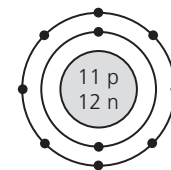



Figure 4

18. Describe the process in which a metal atom in Group 2 becomes an ion. What charge does the ion have?
19. Describe the process in which a non-metal atom in Group 17 becomes an ion. What charge does the ion have?
20. How do the properties of aluminum and copper atoms differ from the properties of their ions?
21. Zinc and iodine react to form ions. Zinc has an ion charge of  $2+$ , and iodine has an ion charge of  $1-$ . Determine how many ions of iodine form for each zinc ion.
22. When the compound magnesium nitride is formed, there are three magnesium ions for every two nitrogen ions in the compound. Explain why.
23. Describe how Bohr's theory of the atom explains the emission spectra of elements.
24. The electrons in the outer shell of an atom are sometimes referred to as valence electrons. Using print and electronic resources, research the meaning of the word "valence." Write a paragraph to summarize your research.

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### Think Critically

25. "Energy levels" is another term used for the electron shells in the Bohr theory. Explain why this is an acceptable term.
  26. Conduct research to learn about the limitations of Bohr's atomic theory. Summarize your results in a brief presentation.
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27. Could a flame test be used to identify any element? Explain.

28. Which element do you think would be more reactive, bromine or selenium (Figure 5)? Explain.



(a)



(b)

**Figure 5** (a) Bromine (b) Selenium

29. Describe four objects that you could find in a hardware store or a toy store and use as models for the atomic theories of Dalton, Thomson, Rutherford, and Bohr. Briefly describe how each model would demonstrate the key ideas of the theories.
30. You have discovered a new substance that may or may not be an element. Write five questions you can ask to help you determine whether the substance is an element and, if it is a new element, where it should be placed in the Periodic Table.

### Reflect on Your Learning

31. Do you believe Bohr's model describes the actual positions of the electrons in an atom if it were possible to see them? Why or why not?
32. Write a short paragraph to describe a situation in your life when you changed your idea or viewpoint of the situation after learning more information about it. Which ideas did you find most difficult to change? Which ideas were easiest to change? Why?

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