

Word Equations

Reaction 1: magnesium + hydrochloric acid \rightarrow magnesium chloride + hydrogen

Reaction 2: magnesium sulphate + sodium carbonate \rightarrow magnesium carbonate + sodium sulphate

Reaction 3: magnesium + copper(II) chloride \rightarrow magnesium chloride + copper

Balanced Chemical Equations

Reaction 1: $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$

Reaction 2: $\text{MgSO}_4\text{(aq)} + \text{Na}_2\text{CO}_3\text{(aq)} \rightarrow \text{MgCO}_3\text{(s)} + \text{Na}_2\text{SO}_4\text{(aq)}$

Reaction 3: $\text{Mg(s)} + \text{CuCl}_2\text{(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{Cu(s)}$

Extend

Ask students to use the Internet to find applications for the magnesium compounds used or produced in these three chemical reactions.

Assess the Activity

As students work on this activity, you can assign marks for participation, recording of data, and clean-up. You might wish to assign marks for a written pre-lab or assign marks for the final Unit Task lab report. You may wish to use the Line Masters listed in the margin to help you assess students' work.

Pages 248–249

UNIT B Review

Key Terms Review

1. Circle a word map that illustrates your understanding of the following terms and how they relate to chemical reactions.

acid
acid base indicator
alkali
balanced chemical equation
base
theory
compound
chemical formula
chemical reaction
combustion reaction
synthesis reaction
decomposition reaction
double displacement reaction
element
ion
ionic compound
law of conservation of mass
matter
molecular compound
neutralization
pH
polyatomic ion
product
pure substance
reaction
salt
single displacement reaction
synthesis reaction
valence shell
word equation

Key Concept Review

1. Write the reactants in the following term.

(a) carbon (b) nickel(II)
(c) oxide (d) titanium(V)
(e) lead(II)

2. Write the name of the following ions.

(a) Mg^{2+} (b) Ag^+
(c) P^{3-} (d) NO_3^-
(e) Al^{3+}

3. What kind of chemical change do metals show?
(a) What kind of chemical change do non-metals show?
(b) What kind of chemical change do ionic compounds show?

4. What is a valence shell?
(a) What is a valence electron?

5. What is the difference between a molecule that is an element and a molecule that is a compound?

6. How many occupied shells are there in a neutral atom?

7. What kinds of elements combine to form ionic compounds?

8. What kinds of elements combine to form molecular compounds?

9. Name the law of conservation of mass.

10. What information does a word equation contain?

11. Where are the reactants and the products located in a chemical equation?

12. How do the properties of ionic and molecular compounds differ?

13. (a) What are synthesis reactions?
(b) What are decomposition reactions?
(c) What are single displacement reactions?
(d) What are double displacement reactions?

14. Chemical reactions can be grouped according to the characteristics of their reactants and products.

15. What is a general chemical equation?

16. What type of chemical reaction is the reaction of a synthesis reaction?

17. What type of chemical reaction is the reaction of a decomposition reaction?

(a) $\text{A} + \text{B} \rightarrow \text{AB}$
(b) $\text{C}_2\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

18. Complete and balance each equation below. The products are all solid ionic compounds.

(a) $\text{Fe} + \text{O}_2 \rightarrow$
(b) $\text{Mg} + \text{Cl}_2 \rightarrow$
(c) $\text{Al} + \text{O}_2 \rightarrow$
(d) $\text{K} + \text{N}_2 \rightarrow$
(e) $\text{Ca} + \text{F}_2 \rightarrow$

19. The change on a carbon ion is 2+. Explain how this diagram might have been used to predict this change.

20. Do ionic compounds form molecules? Explain.

Unit Review



ANSWERS TO QUESTIONS

Key Terms Review

- Students' mind maps will vary but should show how the terms are connected. For example *acid* and *base* will both connect to *pH* with "low" beside *acid* and "high" beside *base*.

Key Concept Review

4

- (a) Cs^+
(b) O^{2-}
(c) Sn^{2+}
(d) Ni^{3+}
(e) Ti^{4+}
- (a) magnesium
(b) fluoride
(c) gold(I)
(d) silver
(e) nitride
- (a) Metal ions have positive charges.
(b) Non-metal ions have negative charges.
- A molecule is a combination of two or more atoms held together by covalent bonds.

6. (a) The valence shell is the outermost shell of an atom.
(b) Electrons in the valence shell are called valence electrons.
 7. A molecule of an element, such as O_2 , is composed of only one type of atom. A molecule of a compound, such as H_2O , is composed of different elements.
 8. A neon atom has two energy shells, and they are both entirely filled with electrons.
 9. Metals combine with non-metals or with non-metal polyatomic ions to form ionic compounds.
 10. Non-metals combine with other non-metals or with non-metal polyatomic ions to form molecular compounds.
 11. The law of conservation of mass states that the total mass of the products in a chemical reaction is always equal to the total mass of the reactants.
 12. A word equation tells you the names of the reactants and the products of a chemical reaction.
 13. The reactants in a chemical equation are located on the left side of the arrow. The products in a chemical equation are located on the right side of the arrow.
 14. Ionic compounds have these properties.
 - At room temperature, most are hard, brittle solids that can be crushed.
 - They form crystals.
 - Ionic crystals have very high melting points.
 - When ionic compounds dissolve in water, the solutions conduct electricity.
- The properties of molecular compounds are as follows:
- They are often soft.
 - If they dissolve in water, they form solutions that do not conduct electricity.
 - They tend to have relatively low melting points.

5

15. The range of numbers on the pH scale is 1 to 14.
16. The pH range of bases is 7.1 to 14.
17. The pH range of acids is 0 to 6.9.
18. The reactants in a neutralization reaction are an acid and a base.
19. An ionic compound called a salt is produced in a neutralization reaction.
20. You can identify the formula of an acid if it starts with H (hydrogen) or ends in $COOH$ (carboxyl). You can identify the formula for a base if the chemical formula starts with a metallic ion or with the ammonium ion, NH_4^+ , and ends with OH (called a hydroxyl group).
21. Acid precipitation is rain, snow, fog, or dew that has a pH of less than 5.6. (Rain usually has a pH of around 5.6.)

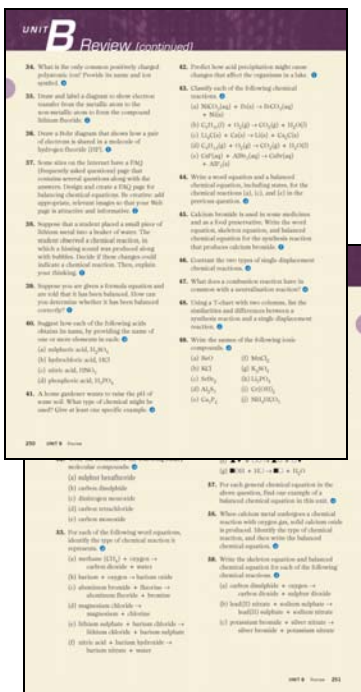
22. The pH of a neutral liquid would be 7.0.
23. (a) Scrubbers are devices that remove sulphur dioxide gas or nitrogen oxides from industrial emissions.
- (b) Scrubbers would be used inside the smokestacks of any industry that produces sulphur dioxide gas or nitrogen oxide gases as a by-product of their industrial processes.

6

24. A general chemical equation (GCE) is an equation that uses letters of the alphabet (A, B, C, D, X), as well as some element symbols, to represent different chemical reactions.
25. The opposite of a synthesis reaction is a decomposition reaction.
26. (a) synthesis
(b) combustion
27. (a) $2\text{Na} + \text{Br}_2 \rightarrow 2\text{NaBr}$
This is now balanced correctly.
- (b) $\text{Mg} + \text{F}_2 \rightarrow \text{MgF}_2$
- (c) $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$
- (d) $6\text{K} + \text{N}_2 \rightarrow 2\text{K}_3\text{N}$
- (e) $6\text{Ca} + \text{P}_4 \rightarrow 2\text{Ca}_3\text{P}_2$
28. A single displacement reaction will occur.
29. This is a combustion reaction.

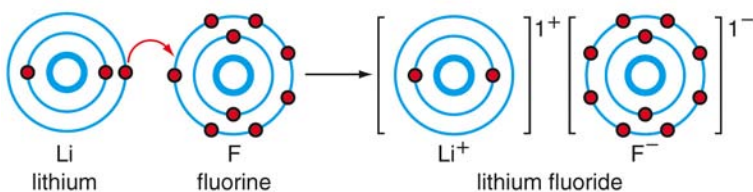
Connect Your Understanding

30. Students' answers will vary but may include lithium, calcium, and magnesium.
31. Students' answers will vary but may include oxygen (O^{2-}), bromine (Br^-) and sulphur (S^{2-}).
32. (a) There are four shells.
- (b) There are two valence electrons.
- (c) The charge on a metal ion represents the number of electrons in the outer shell that are pulled away when the ion combines with a non-metal ion to produce a compound. Since the valence shell contains two electrons, a calcium ion would lose two electrons, creating a calcium ion, Ca^{2+} .
33. Ionic compounds do not form molecules. Instead, they form a lattice of ions in which every ion is attracted to every other ion. Ionic compounds do not contain covalent bonds, which are necessary for a molecule to form.
34. Ammonium, NH_4^+ , is the only common positively charged polyatomic ion.



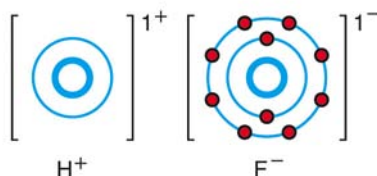
35.

Bohr Diagrams for the Creation of Lithium Fluoride



36.

Bohr Diagram of Hydrogen Fluoride



37. Students' FAQ pages will vary but might include the following questions.

What is a balanced chemical reaction?

What symbols are used to indicate the state of matter in a balanced chemical reaction?

What is a coefficient?

What is a subscript?

What are the six types of chemical reactions?

38. Yes, these could indicate a chemical reaction because the production of sound (hissing) and the production of a gas (bubbles) are two indications of a chemical reaction taking place.

39. In order to verify that the equation has been balanced correctly, you can check to see if the numbers of atoms of each element are the same on both sides of the equation.

40. The name of each acid comes from:

- (a) sulphur
- (b) hydrogen, chlorine
- (c) nitrogen
- (d) phosphorus

41. Raising the pH of soil requires a base. Examples of bases that could be used are calcium carbonate (lime) and calcium hydroxide (slaked lime).

42. Acid precipitation adds acid to the lake, which lowers the pH of the water. As the pH continues to fall, more lake organisms die because the water's pH is beyond the pH range that the organisms can tolerate.

43. The reactions are:
- (a) single displacement reaction
 - (b) combustion reaction
 - (c) single displacement reaction
 - (d) combustion reaction
 - (e) double displacement reaction
44. (a) word equation: nickel(II) carbonate + iron \rightarrow iron(II) carbonate + nickel
 balanced equation: $\text{NiCO}_3(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{FeCO}_3(\text{aq}) + \text{Ni}(\text{s})$
- (c) word equation: lithium carbide + calcium \rightarrow lithium + calcium carbide
 balanced equation: $\text{Li}_4\text{C}(\text{s}) + 2\text{Ca}(\text{s}) \rightarrow 4\text{Li}(\text{s}) + \text{Ca}_2\text{C}(\text{s})$
- (e) word equation: cesium fluoride + aluminum bromide \rightarrow cesium bromide + aluminum fluoride
 balanced equation: $3\text{CsF}(\text{aq}) + \text{AlBr}_3(\text{aq}) \rightarrow 3\text{CsBr}(\text{aq}) + \text{AlF}_3(\text{s})$
45. word equation: calcium + bromine \rightarrow calcium bromide
 skeleton equation: $\text{Ca} + \text{Br}_2 \rightarrow \text{CaBr}_2$
 balanced equation: $\text{Ca} + \text{Br}_2 \rightarrow \text{CaBr}_2$
46. There are two types of single-displacement chemical reactions. In the first type, a metal element displaces a metal element in an ionic compound. In the second type, a non-metal element displaces a non-metal element in a molecular compound.
47. In both a combustion reaction and a neutralization reaction, water (H_2O) is produced.
48. Comparing the similarities and differences between a synthesis reaction and a single displacement reaction.

Similarities	Differences
There are two reactants in both types of reactions.	A synthesis reaction has a single product: a compound. A single displacement reaction has two products: an element and a compound.
Mass is conserved in both types of reactions.	There are two types of single displacement reactions, one for a metal and one for a non-metal.
The number of each kind of atom is conserved.	
Both reactions have a compound on the products side.	

49. (a) beryllium oxide
(b) potassium chloride
(c) strontium bromide
(d) aluminum sulphide
(e) calcium phosphide
(f) manganese(II) chloride
(g) potassium sulphate
(h) lithium phosphate
(i) chromium(II) hydroxide
(j) ammonium hydrogen carbonate
50. (a) NaBr
(b) Be₃P₂
(c) Cu₂O
(d) Pd(NO₃)₄
(e) (NH₄)₂SO₄
(f) NH₄NO₃
51. (a) disulphur trioxide
(b) diphosphorus pentasulphide
(c) oxygen difluoride
(d) dinitrogen trioxide
(e) carbon dioxide
52. (a) SF₆
(b) CS₂
(c) N₂O
(d) CCl₄
(e) CO
53. (a) combustion reaction
(b) synthesis reaction
(c) single displacement reaction
(d) decomposition reaction
(e) double displacement reaction
(f) neutralization reaction
54. $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$
55. Students' answers will vary. An example would be one player going into a basketball game to relieve another player who is tired.
56. (a) single displacement reaction
(b) neutralization reaction
(c) decomposition reaction
(d) single displacement reaction
(e) synthesis reaction
(f) double displacement reaction
(g) neutralization reaction

UNIT B REVIEW (continued)

40. Which of the chemical reactions in question 39 would be classified as a double-displacement reaction?

41. A chemist carefully combines hydrochloric acid (HCl) and ammonium hydroxide. Write the word equation, skeleton equation, and balanced chemical equation for this neutralization reaction.

42. Benzene, C_6H_6 , is a toxic liquid hydrocarbon that is used to produce plastics, adhesives, solvents, dyes, drugs, dyes, lubricants, explosives, and pesticides. Write the word equation, skeleton equation, and balanced chemical equation for the combustion of benzene.

43. For each of the following, suggest one or more situations in which chemical reactions are important.

(a) in your home

(b) in a forest

(c) in a car engine

(d) in a power plant

(e) in a nuclear reactor

44. Name several categories of consumer products that are produced through chemical reactions.

45. Suggest several ways that you can keep informed about chemicals and chemical reactions.

46. From substances are used to produce newspapers, paper towels, clothing, and many consumer products you use daily. What happens in these pure substances when you no longer need these products? Suggest several answers.

47. Every Canadian province has emergency teams and procedures to deal with chemical spill disasters. Why do you think it is important to have laws that cover an entire province?

48. Suggest a new substance with which hydrocarbons can be used. The most knowledge of chemical reactions is required to know an emergency response team could neutralize the effects of this chemical.

49. Write an e-mail to a friend in which you describe two or more applications of chemical reactions in daily life.

50. Name five or more jobs or professions where it would be important to know about chemical reactions.

51. The pulp and paper industry uses a number of different chemicals. The table below lists some of these chemicals and describes how they are used.

(a) Suggest several reasons why these chemicals are used as they are used.

(b) How the pulp and paper industry uses these chemicals, if you reduce your use of paper products, will this affect the amount of chemicals that are used in making pulp and paper? Explain.

Some Chemicals Used in the Pulp and Paper Industry

Chemical	Purpose	Use
chlorine	bleach	used to whiten paper
hydrogen peroxide	bleach	used to whiten paper
potassium permanganate	bleach	used to whiten paper
calcium hydroxide	neutralizer	used to neutralize acids
calcium chloride	dryer	used to dry paper

Following investigation, two students each containing a collection of papers, were weighed. The total mass was recorded. The two students were then combined, and a white solid was observed to form. The two students, one of which contained the solid product, were then weighed and the total mass recorded. Each group then compared the total mass before and after the chemical reaction had occurred. Most found that the total mass had not changed. However, some groups found that the mass decreased slightly. Suggest possible reasons for these observations.

52. In the first context there is the context of a chemical reaction. Suggest a substance.

53. Suggest one or more aspects of your lifestyle that you could alter to reduce the number of chemical reactions your daily activities require.

Reflection

54. In this unit, you have learned many things about how chemical reactions work. What is the most important thing you learned about chemical reactions? Why do you think it is the most important?

55. Think back to your work about the effects of chemical reactions on the environment at the start of this chapter. How have your ideas changed?

57. Students' examples will vary but may include the reactions listed below. Note that only five of the six types of chemical reactions are represented in question 56. Combustion is absent but is included below.
- synthesis reaction: p. 225 — $3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
- decomposition reaction: p. 226 — $2\text{HgO}(\text{s}) \rightarrow 2\text{Hg}(\text{l}) + \text{O}_2(\text{g})$
- combustion reaction: p. 232 — $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
- single displacement reaction: p. 233 — $2\text{AgNO}_3(\text{aq}) + \text{Mg}(\text{s}) \rightarrow \text{Mg}(\text{NO}_3)_2(\text{aq}) + 2\text{Ag}(\text{s})$
- double displacement reaction: p. 235 — $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2\text{NaI}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) + 2\text{NaNO}_3(\text{aq})$
- neutralization reaction: p. 209 — $2\text{HNO}_3(\text{aq}) + \text{Ca}(\text{OH})_2(\text{s}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
58. This is a synthesis chemical reaction. The balanced chemical equation is: $2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$.
59. (a) $\text{CS}_2 + 3\text{O}_2 \rightarrow \text{CO}_2 + 2\text{SO}_2$
- (b) $\text{Pb}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{PbSO}_4 + 2\text{NaNO}_3$
- (c) $\text{KBr} + \text{AgNO}_3 \rightarrow \text{AgBr} + \text{KNO}_3$
60. Reaction (b) in question 59 is a double displacement reaction.
61. Word equation: sulphuric acid + ammonium hydroxide → ammonium sulphate + water
- Skeleton equation: $\text{H}_2\text{SO}_4 + \text{NH}_4\text{OH} \rightarrow (\text{NH}_4)_2\text{SO}_4 + \text{H}_2\text{O}$
- Balanced chemical equation: $\text{H}_2\text{SO}_4 + 2\text{NH}_4\text{OH} \rightarrow (\text{NH}_4)_2\text{SO}_4 + 2\text{H}_2\text{O}$
62. Word equation: benzene + oxygen → carbon dioxide + water
- Skeleton equation: $\text{C}_6\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
- Balanced chemical equation: $2\text{C}_6\text{H}_6 + 15\text{O}_2 \rightarrow 12\text{CO}_2 + 6\text{H}_2\text{O}$
63. Students answers will vary but may include the following.
- (a) Chemical reactions are important for cooking, taking medicine, cleaning solutions, washing clothes, and gardening.
- (b) Chemical reactions are important at tourist resorts for cleaning solutions and disinfecting swimming pools.
- (c) Chemical reactions are important in restaurants for cooking and cleaning.
- (d) Chemical reactions are important for manufacturing various products including paints and textiles, steel, and ceramics.
64. Student answers will vary but may include some of the following categories of consumer products that are produced through chemical reactions: dyes, plastics for electronics, cosmetics, personal care products such as deodorant and toothpaste, and cleaning products.
65. You can keep informed about chemicals and chemical reactions by reading the daily newspaper, checking Internet sites, borrowing books from a library, or even asking your science teacher!
66. When you no longer need these products, these pure substances usually become waste. Waste can be burned in an incinerator, buried in landfills, or possibly recycled through a municipal recycling program.

- 67.** It would pose a danger to human health and the environment if chemical spills were dealt with differently in different parts of the province. Remote regions might not have the expertise or resources to deal with spills properly. This could mean that some people in the province would be more at risk than others, depending on where the spill happened. By having laws that apply to the whole province, no matter where in the province a spill happened, it would have to be cleaned up according to the law. Remote areas that do not have the resources or expertise would get help from other regions in order to follow the laws governing spills. This could save lives and also protect the environment.
- 68.** Sodium hydroxide is a base. An emergency response team could neutralize the effects of a sodium hydroxide spill by applying an acid, such as hydrochloric acid, to the soil.
- 69.** Students answers will vary but might include the following examples: food preparation (cooking), gardening (pH of soil), painting a house, and digesting food.
- 70.** Student answers will vary but might include the following examples of jobs or professions involving knowledge of chemical reactions: environmental chemist, laboratory technician, polymer chemist, chef, and firefighter.
- 71. (a)** These chemicals are reused as often as possible because they are expensive, so reusing them cuts costs. By reusing them, the industry uses fewer resources to produce paper. Reusing them also cuts down on the amount waste requiring treatment as well as the cost of buying and transporting replacement chemicals.
- (b)** Yes. If you reduce your use of paper products, this will reduce the demand for paper and so reduce the amount of chemicals (and trees) used to make pulp and paper, as well as reducing the energy used to transport raw materials and finished paper products.
- 72.** A career in chemistry or chemical engineering can be rewarding because you could produce new products (such as medicines) that help people. You could find ways to reduce damage to the environment, or you could find ways to treat waste or toxic materials.
- 73.** In order to decide whether to allow the facility to be located in your community, you would need to know how raw materials (such as chemicals) would be brought to the factory safely, what kinds of chemicals would be used, what waste chemical products there would be, and how they would be handled.

Skills Practice

74. Students' procedures might include an indicator solution, pH paper, or a pH meter. A sample procedure, using pH paper, is as follows.

Procedure

1. Put on rubber gloves, safety glasses, and a lab apron.
 2. Obtain a small sample of the unknown liquid.
 3. Dip a piece of pH paper into the liquid.
 4. Compare the colour of the wet pH paper with the standard scale of pH colours to determine if the unknown liquid is acidic, basic, or neutral.
75. The decrease in mass can be explained by errors in weighing, or perhaps there were drops of liquid on the beakers that evaporated during the experiment.

Revisit the Big Ideas and Fundamental Concepts

76. Students' mind maps will vary. However, the maps should show how different concepts are connected. For example, they might show that neutralization reactions are connected to double displacement reactions.

Science, Technology, Society, and the Environment

77. The products of a combustion reaction are carbon dioxide gas and water. Excess carbon dioxide causes global warming. We can reduce global warming by performing fewer combustion reactions. For example, if we drove our cars less, we would burn less fuel and so create less carbon dioxide. By consuming fewer products, we would reduce the amount of fuel burned to make and transport those products, which would reduce the amount of carbon dioxide released into the atmosphere. If the electricity we use comes from generating stations that burn fossil fuels, we could reduce the amount of electricity we use by turning out lights or using energy-efficient light bulbs. This would reduce the amount of carbon dioxide emitted from the plant. If we produce less waste, it would reduce the amount of fossil fuels used to transport and incinerate garbage.
78. Acid rain is less of a problem in Ontario in the 21st century than in the century before because we use scrubbers (a technology) to remove sulphur and nitrogen compounds from waste gases produced by some industries. Also, catalytic converters on cars reduce the amount of emissions that cause acid rain. Another reason is that we have laws that require industries to reduce acid rain-causing emissions.
79. Students answers will vary. Examples are reducing automobile use, buying fewer items, using products less frequently, throwing away fewer personal items, and turning down the heat.

Reflection

- 80.** Students answers will vary but might include the following.
- There are only six types of chemical reactions. This is important to know so that we can identify the products of reactions.
 - Matter (atoms, molecules) is conserved during a chemical reaction. This is important to know so that we can estimate the quantity of each reactant and product in a chemical reaction.
 - Chemical reactions produce all the products we use. This is important because Ontario's economy is based partly on the manufacturing and sale of chemicals and the products of chemical reactions.
- 81.** Students' answers will vary but may include that they now know how acid rain is created and how it affects plants, lakes, and buildings. They might indicate that they are more aware of the damage that toxic spills from train derailments can have on soil and water. They might also refer to their increased knowledge of how emissions can be reduced through scrubbers and catalytic converters.

