Get Ready for Unit 2
Chemical Reactions

Answers for page 48

Multiple Choice
1. d

2. c

3. a

4. a

5. d

6. b

7. e

8. a

Answers for page 49

9. Physical properties can be observed without changing the identity of the substance being studied. Chemical properties can only be observed after a chemical change, which changes the identity of the substance being studied.

10. *Sample answer*: An example of a chemical property is combustibility.

11. A metal atom tends to lose electrons and it becomes a positive ion because the number of protons is higher than the number of electrons. A non-metal atom tends to gain electrons and it becomes a negative ion because the number of electrons is higher than protons.

12. Electrons are shared between atoms in the formation of a covalent bond, and they are transferred between atoms in the formation of an ionic bond.

13. a. *Sample answers*: The candle is a solid. **b.** Combustibility is a chemical property of the candle. **c.** The compounds that make up a wax candle are molecular. The wax has a low melting point, a dull appearance, and is soft and pliable, which are properties that are generally associated with molecular compounds.

14. The compound is probably an ionic compound because the properties described are those of an ionic compound. The strong ionic bonds between the ions are hard to overcome, which gives the compound its high melting point. However, the ions tend to separate easily in water and form a solution that conducts an electric current.

15. Atoms of noble gases have a full outer level of electrons, which is the most stable electron configuration. They do not need to gain, lose, or share electrons with other atoms to attain this.

16. In ionic bonding, the oppositely charged ions that form from the transfer of electrons attract one another. In covalent bonding, the positively charged nuclei attract the negatively charged electrons that are shared between the atoms.

Section 4.1 Review

Representing Ionic Compounds

Answers for page 50

Multiple Choice

1. d

2. c

3. b

4. c

5. c

6. d

7. d

8. e

Answers for page 51

9. b

10. a

11. d

12. d

13. b

14. e

15. c

16. d

Answers for page 52

Written Answer

17. The chemical formula for an ionic compound contains the chemical symbol of a metal and a non-metal, or the chemical symbol of a polyatomic ion.

18. a. The phrase *stable octet* is used to refer to the arrangement of electrons when an atom has a full outer energy level. **b.** This phrase is used because atoms of all noble gases, except helium, have eight electrons in their outer energy level, and noble gases are non-reactive, or highly stable.

19. Characteristics of Ion Formation for Some Elements

Element Name	Group	Number of Electrons Lost/Gained	Charge	Ion Symbol	Ion Name
sodium	1	1 lost	1+	Na^+	sodium
magnesium	2	2 lost	2+	Mg^{2+}	magnesium
phosphorus	15	3 gained	3–	P^{3-}	phosphide
sulfur	16	2 gained	2–	S^{2-}	sulfide
chlorine	17	1 gained	1–	Cl^-	chloride

20. Roman numerals are used when naming multivalent metal ions to indicate ion charge for that particular compound.

21. a. The name of Br^- is bromide ion. **b.** The name of Li^+ is lithium ion. **c.** The name of Fe^{2+} is iron(II) ion. **d.** The name of O^{2-} is oxide ion. **e.** The name of P^{3-} is phosphide ion.

22. The ions of manganese include manganese(II) ion (Mn^{2+}), manganese(III) ion (Mn^{3+}), and manganese(IV) ion (Mn^{4+}).

23. a. The name for NaI is sodium iodide. **b.** The name for $MgBr_2$ is magnesium bromide **c.** The name for Cu_2O is copper(I) oxide. **d.** The name for Ca_3P_2 is calcium phosphide. **e.** The name for $FeCl_3$ is iron(III) chloride.

24. Write the ions beside each other. Take the amount of charge from each ion (ignoring the signs) and place it as the subscript of the other ion.

Answers for page 53

25. a. The aluminum atom has three valence electrons, and each chlorine atom has seven. **b.** Three electrons move from the aluminum atom and one electron goes to each chlorine atom. **c.** The number of electrons lost equals the number of electrons gained. **d.** The chemical formula for the compound formed is $AlCl_3$.

26. Find the total negative charge in the compound. Divide the amount of charge by the number of metal ions in the chemical formula to determine the positive charge of each multivalent metal ion.

27. Brackets are used whenever more than one of a polyatomic ion must be shown in the chemical formula.

28. Ammonium (NH_4^+), hydroxide (OH^-), and peroxide (O_2^{2-}) are polyatomic ions whose names do not end in *-ate* or *-ite*.

29. a. The name of NO_3^- is nitrate ion. **b.** The name of SO_3^{2-} is sulfite ion. **c.** The name of PO_4^{3-} is phosphate ion. **d.** The name of $CO_3{}^{2-}$ is carbonate ion.

30. A binary ionic compound is composed of two different elements, and a ternary ionic compound is composed of three different elements. Both compounds are formed from a positive ion and a negative ion and have no charge overall.

31. a. The name of K_2SO_3 is potassium sulfite. **b.** The name of NH_4Cl is ammonium chloride. **c.** The name of $SnCO_3$ is tin(II) carbonate. **d.** The name of $NiPO_3$ is nickel(III) phosphite.

32. a. The chemical formula for sodium chloride is NaCl. **b.** The chemical formula for potassium nitride is K_3N. **c.** The chemical formula for aluminum oxide is Al_2O_3. **d.** The chemical formula for calcium phosphide is Ca_3P_2. **e.** The chemical formula for strontium hydroxide is $Sr(OH)_2$. **f.** The chemical formula for chromium(II) chloride is $CrCl_2$. **g.** The chemical formula for nickel(II) sulfate is $NiSO_4$.

Section 4.2 Review
Representing Molecular Compounds

Answers for page 54

Multiple Choice

1. b

2. d

3. b

4. c

5. b

6. b

7. d

8. e

Answers for page 55

9. e

10. b

11. b

12. c

13. e

14. c

15. d

16. c

Answers for page 56

Written Answer

17. Knowing that the compound being described is water would have allowed the students to make more sense of the dangerous properties and uses that were presented.

18. A molecular compound forms as a result of the sharing of electrons in a covalent bond between atoms. The atoms of two non-metals tend to share electrons with each other, but the atoms of a metal and a non-metal tend to transfer electrons between them.

**19.** Valence electrons are shared between atoms when a molecular compound forms.

20. The shared electrons are attracted to the nuclei of both atoms through the attraction of opposite electric charges.

21. a. A covalent bond is shown, since the electrons are shared between the atoms. **b.** The compound is water. **c.** The advantage to sharing electrons is that each atom has a full outer energy level of electrons, which is a very stable configuration.

22. The major difference is the way that the chemical bonds between atoms in each compound are shown. Bohr-Rutherford diagrams of ionic compounds show separate ions with the charge of each, which have been formed from the transfer of one or more electrons. Bohr-Rutherford diagrams of molecular compounds show valence electrons in the covalent bonds being shared between two atoms.

23. A molecule is a neutral particle composed of two or more atoms joined together by covalent bonds.

24. a. Elements that exist as diatomic molecules include hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine, and iodine. **b.** The chemical formulas for these elements are H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2. **c.** All diagrams should indicate a covalent bond formed between two atoms of the same element. *Sample answer*: fluorine
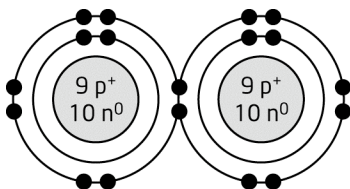
Answers for page 57

25. The chemical formulas for both compounds are composed of nitrogen atoms and oxygen atoms in a 1:2 ratio. The difference is that the formula for nitrogen dioxide has one nitrogen atom and two oxygen atoms, and the formula for dinitrogen tetroxide has two nitrogen atoms and four oxygen atoms.

26. The name of the compound will not use the prefix *tri-*. There are three atoms, but they are not of a single element. Therefore, the prefix *tri-* will not be used.

27. To write the name of a binary molecular compound, write the name of the first element. Add a prefix in front of the name that represents the same number as is shown by the subscript on that element's symbol in the chemical formula. Then, write the name of the second element, but use the *-ide* ending. Add a prefix in front of the name that represents the same number as is shown by the subscript on that element's symbol in the chemical formula.

28. a. The name of SBr_6 is sulfur hexabromide. **b.** The name of IF_5 is iodine pentafluoride. **c.** The name of SO is sulfur monoxide. **d.** The name of CF_4 is carbon tetrafluoride.

29. Although the ratios of atoms are the same, the compounds are not the same. The chemical formulas represent the actual composition of the individual molecules, so these two formulas represent different compounds.

30. A subscript in the chemical formula of a binary molecular compound is found after, or to the right of, the symbol of the element it describes. The prefix in the name of the compound that represents that subscript is found before, or to the left of, the name of the element.

31. To write the chemical formula of a binary molecular compound, write the symbol of the first element followed by a subscript for the number shown by the prefix on that element. Then, write the symbol of the second element followed by a subscript for the number shown by the prefix on that element.

32. a. The chemical formula for diphosphorus trioxide is P_2O_3. **b.** The chemical formula for bromine pentafluoride is BrF_5. **c.** The chemical formula for sulfur tetroxide is SO_4. **d.** The chemical formula for dihydrogen monosulfide is SH_2.

Section 4.3 Review

Conservation of Mass and Chemical Equations

Answers for page 58

Multiple Choice

1. e

2. d

3. b

4. a

5. d

6. b

7. c

8. d

Answers for page 59

Written Answer

9. A reactant is a starting material, and a product is a substance formed in a chemical reaction. Reactants change into products during a chemical reaction.

10. The total mass of the starting materials and the total mass of the products of a chemical reaction must be equal.

11. The scientist collected 9.3 g of iron(III) sulfide. The product must have the same mass as the iron and sulfur that reacted, so the difference between the mass of the test tube with iron and sulfur and the mass of the test tube alone should be the mass of the product that forms.

12. When balancing a chemical equation it is often helpful to balance hydrogen and oxygen last. Because these elements often appear in more than one reactant or product, they are easier to balance after the other elements are balanced.

13. a. The balanced chemical equation is $Na_2SO_4(aq) + Ba(NO_3)_2(aq) \parallel 2NaNO_3(aq) + BaSO_4(s)$. **b.** The balanced chemical equation is $2Rb(s) + 2H_2O([\text{script } l]) \parallel 2RbOH(aq) + H_2(g)$. **c.** The balanced chemical equation is $K_2O(s) + H_2O([\text{script } l]) \parallel 2 KOH(s)$ **d.** The balanced chemical equation is $3Mg(s) + 2NH_3(g) \parallel 3H_2(g) + Mg_3N_2(s)$ **e.** The balanced chemical equation is $3N_2H_2(g) \parallel 2NH_3(g) + 2N_2(g)$

14. *Sample answer*: I would tell my friend to check that each chemical formula is correctly written. When coefficients keep increasing and the chemical equation does not balance, it is usually a sign that a formula is incorrect.

15. The skeleton equation is Na + I$_2$ → NaI. The balanced chemical equation is 2Na + I$_2$ → 2NaI.

16. Understanding of the law of conservation of mass can help manufacturers reduce production costs and the waste materials created during the manufacturing process because it enables them to make the most efficient use of the chemicals involved.

Chapter 4 Review
Developing Chemical Reactions

Answers for page 60

Multiple Choice
1. e

2. e

3. c

4. a

5. e

6. b

7. d

8. a

Answers for page 61

Written Answer
9. The suffix *-ide* is used on the second element's name for naming both ionic compounds and molecular compounds.

10. a. The compound is ionic. The elements that make up the compound are a metal and a non-metal, and the arrows show how the electrons are transferred from the metal to the non-metal atoms. **b.** The chemical formula of the compound is $MgCl_2$. Its name is magnesium chloride.

11. a. The compound SCl_2 is molecular, and its name is sulfur dichloride. **b.** The compound K_2S is ionic, and its name is potassium sulfide. **c.** The compound $MnSO_3$ is ionic, and its name is manganese(II) sulfite.

12. a. Copper(II) hydroxide, $Cu(OH)_2$, is an ionic compound. **b.** Nitrogen tribromide, NBr_3, is a molecular compound. **c.** Sodium carbonate, Na_2CO_3, is an ionic compound.

13. Changing a subscript in a chemical formula changes the proportions of the elements shown, which means that the formula no longer represents the desired chemical.

14. a. The balanced chemical equation is $3CuCl_2(aq) + 2K_3PO_4(aq)$ $6KCl(aq) + Cu_3(PO_4)_2(s)$. **b.** The balanced chemical equation is $4Fe(s) + 3O_2(g)$ $2Fe_2O_3(s)$. **c.** The balanced chemical equation is $2Al_2O_3(s)$ $4Al(s) + 3O_2(g)$.

15. The balanced chemical equation is $Na_2CO_3(s) \rightarrow CO_2(g) + Na_2O(s)$.

16. The same number of atoms of each element in the reactants is found in the products. A chemical equation demonstrates this fact when it is balanced.

Answers for page 62

17. An atom of an element in Group 1 or Group 2 has the same number of valence electrons as the group number itself. An atom of an element in Groups 13 to 18 has a number of valence electrons equal to 10 less than the group number.

18. The chemical formula should represent one copper and two hydroxide ions. The incorrect formula lacks brackets around the hydroxide ion. The correct chemical formula is $Cu(OH)_2$.

19. The likely contents of the container is a ternary ionic compound. The "ate" at the end of the name is a common ending for a polyatomic ion which would be found in a ternary ionic compound.

20. The statement is true. A ternary ionic compound is composed of three different elements, so it must contain a polyatomic ion in order to have enough elements to qualify as being ternary.

21. Groups 1, 2, and 3 contain only metals that are not followed by a Roman numeral in the name of an ionic compound. The metals in these groups form only one ion, so there is no uncertainty about the charge of one of these ions.

22. Five carbon atoms make up a molecule of pentane.

23. Hydrogen does not satisfy the octet rule. The outer energy level of hydrogen can hold only two electrons, so a full outer energy level of a hydrogen atom has only two valence electrons.

24. An ionic compound is composed of ions, so the correct chemical formula can be written from the name based on balancing the charges of the ions. However, because a molecular compound involves the sharing of electrons, there are no charges to balance. The prefixes are necessary to specify how many atoms of each element should be represented when writing the compound's chemical formula.

Answers for page 63

25. *Sample answer*: Determine if the first element is a metal or a non-metal. If the first element is a metal, the compound is a binary ionic compound. If the first element is a non-metal, the compound is a binary molecular compound.

26. a. According to the law of conservation of mass, the total mass of the products must be equal to the total mass of the reactants. The increase in mass of the system is due to oxygen from the surrounding air acting as a reactant and being incorporated into the product. **b.** The balanced chemical equation for the reaction is $2Cu + O_2 \rightarrow 2CuO$

27. When investigating the law of conservation of mass, you need to measure and compare the total mass of the reactants with the total mass of the products. If any matter enters or leaves the system, the masses would not be accurate, so a closed system is needed.

28. The flowchart should include the following steps: Count the number of atoms of each element in the reactants and in the products. Select an element that has different numbers of atoms. Place a coefficient in front of the chemical formula for a substance that has the element to make the numbers of atoms of that element equal on both sides of the chemical equation. Repeat this step for each element. Check the final chemical equation to make sure that the number of atoms of each element in the reactants and in the products is equal.

29. a. The word equation is mercury(II) oxide → oxygen + mercury. The skeleton equation is $HgO → O_2 + Hg$. The balanced chemical equation is $2HgO(s) → O_2(g) + 2Hg([script l])$. **b.** The word equation is magnesium + hydrochloric acid → hydrogen + magnesium chloride. The skeleton equation is $Mg + HCl → H_2 + MgCl_2$. The balanced chemical equation is $Mg(s) + 2HCl(aq) → H_2(g) + MgCl_2(aq)$.

30. The balanced chemical equation for this reaction is $NaNO_3 + KCl → KNO_3 + NaCl$.

31. a. The chemical formula for oxygen gas should be diatomic. The correctly balanced chemical equation is $2LiNO_3(aq) → 2LiNO_2(aq) + O_2(g)$. **b.** The chemical formula for the product should be CsCl because the cesium ion has a 1+ charge and the chloride ion has a 1– charge. The correctly balanced chemical equation is $2Cs(s) + Cl_2(g) → 2CsCl(s)$.

32. Four principles of green chemistry are preventing waste, using safer solvents, using renewable raw materials, and ensuring that reactions are energy efficient. The first principle, preventing waste, involves the law of conservation of mass. By determining the proper amounts of reactants and other chemicals used in the manufacturing process, chemists reduce the amount of chemicals and waste that will require treatment or disposal.

Section 5.1 Review
Synthesis and Decomposition Reactions

Answers for page 64

Multiple Choice

1. c

2. d

3. e

4. b

5. e

6. a

7. b

8. c

Answers for page 65

9. d

10. d

11. c

12. b

13. e

14. b

15. e

16. d

Answers for page 66

Written Answer

17. Six pieces of evidence that suggest a chemical change has occurred are formation of a gas, formation of a precipitate, change in colour, change in odour, change in temperature, and production of light.

18. The change in colour and appearance of the metal's surface help to show that an iron object has rusted.

19. The production of heat indicates that a chemical reaction occurs.

20. Understanding the different types of chemical reactions makes it easier to identify what products are most likely to form.

21. a. The four different types of chemical reactions covered in this chapter are synthesis, decomposition, single displacement, and double displacement. **b.** A general equation for a synthesis reaction is A + B   AB. A general equation for a decomposition reaction is AB   A + B. A general equation for a single displacement reaction is A +BC   AC + B. A general equation for a double displacement reaction is AB + CD   AD + CB. **c.** Answers will vary. *Sample answers*: An analogy for a synthesis reaction is adding two ingredients together when cooking something. An analogy for a decomposition reaction is a piece of equipment being dismantled into separate parts. An analogy for a single displacement reaction is someone throwing a ball to another person. An analogy for a double displacement reaction is two couples dancing who then switch partners.

22. In a synthesis reaction, two or more reactants combine to form a new product.

23. The diagram represents a synthesis reaction.

24. a. The chemical formula for ammonia is NH_3. **b.** The balanced chemical equation for the synthesis of ammonia is $N_2(g) + 3H_2(g)$ $2NH_3(g)$.**c.** Another name for the synthesis of ammonia reaction is the Haber process. **d.** Ammonia is such an important chemical product because it is used as a fertilizer, in making paper, in extracting zinc and nickel from ores, in explosives, and in cleaning products.

Answers for page 67

25. The product of a synthesis reaction between a metal and a non-metal is likely to be a binary ionic compound. You can determine the chemical formula of the most likely product formed by using the periodic table to determine the charges of the ions and then using the appropriate ratio of ions in the formula so that the overall charge of the compound is zero.

26. a. The balanced chemical equation is $2K(s) + Cl_2(g)$ $2KCl(s)$. **b.** The balanced chemical equation is $8Zn(s) + S_8(s)$ $8ZnS(s)$. **c.** The balanced chemical equation is $Pb(s) + O_2(g)$ $PbO_2(s)$. **d.** The balanced chemical equation is $2Na(s) + Cl_2(g)$ $2NaCl(s)$.
27. The force that is generated by TNT depends on the formation and rapid expansion of gases formed during the decomposition of TNT. If no gases were formed, TNT could not be used as an explosive.

28. The products of the decomposition reaction of a binary ionic compound are the elements that make up the compound. Write the chemical symbols of the metal and non-metal that make up the compound, keeping in mind the seven diatomic elements.

29. When calcium carbonate is heated to high temperatures in a kiln, it decomposes into carbon dioxide and calcium oxide for use in construction.

30. a. The balanced chemical equation is $2Cu_2O(s)$ $4Cu(s) + O_2(g)$. **b.** The balanced chemical equation is $2AlCl_3(s)$ $2Al(s) + 3Cl_2(g)$. **c.** The balanced chemical equation is $2CaO(s)$ $2Ca(s) + O_2(g)$. **d.** The balanced chemical equation is $2NaCl(l)$ $2Na + Cl_2(g)$.

31. a. The balanced chemical equation is $2RbF(s)$ $2Rb(s) + F_2(g)$. This is a decomposition reaction because the reactant is a single compound that forms two different products. **b.** The balanced chemical equation is $3Ba(s) + N_2(g)$ $Ba_3N_2(s)$. This is a synthesis reaction because the reactants are elements that form a product that is a single compound. **c.** The balanced chemical equation is $2H_2O([\text{script } l])$ $2H_2(g) + O_2(g)$. This is a decomposition reaction because the reactant is a single compound that forms two different products. **d.** The balanced chemical equation is $8Fe + S_8$ $8\,FeS$. This is a synthesis reaction because the reactants are elements that form a product that is a single compound.

32. a. This is a decomposition reaction. The balanced chemical equation is $2CdO(s)$ $2Cd + O_2$. **b.** This is a decomposition reaction. The balanced chemical equation is $2KBr(s)$ $2K + Br_2$. **c.** This is a synthesis reaction. The balanced chemical equation is $Mg(s) + I_2(s)$ MgI_2. **d.** This is a decomposition reaction. The balanced chemical equation is $2HgO$ $2Hg + O_2$. **e.** This is a synthesis reaction. The balanced chemical equation is $2Mg(s) + O_2(g)$ $2MgO$. **f.** This is a synthesis reaction. The balanced chemical equation is $4Fe(s) + 3O_2(g)$ $2Fe_2O_3$.

Section 5.2 Review

Displacement Reactions

Answers for page 68

Multiple Choice

1. a

2. d

3. e

4. d

5. e

6. b

7. c

8. b

Answers for page 69

9. a

10. d

11. b

12. c

13. a

14. c

15. a

16. a

Answers for page 70

Written Answer

17. A single displacement reaction is depicted in the diagram.

18. An activity series is a list of elements organized according to chemical reactivity. The most reactive element is at the top of the list and the least reactive element is at the bottom of the list.

19. The elements in order from most reactive to least reactive are sodium, iron, copper, and platinum.

20. The reverse reaction cannot happen because the single element is lower on the activity series than the element it is trying to replace.

21. Hydrogen ions can be positively charged, like metal ions are, and can be replaced from compounds by metals.

22. Alkali metals, such as lithium, potassium, and sodium, are some of the most active metals and would quickly react if they were in their pure form in nature.

23. a. The balanced chemical equation is $2Al(s) + 6HCl(aq)$ $2AlCl_3(s) + 3H_2(g)$. **b.** The balanced chemical equation is $Ca(s) + ZnCl_2(aq)$ $CaCl_2(aq) + Zn(s)$. **c.** This reaction will not occur. **d.** The balanced chemical equation is $F_2(g) + 2CsBr(aq)$ $Br_2([script l]) + 2CsF(aq)$. **e.** This reaction will not occur. **f.** The balanced chemical equation is $ZnF_2(aq) + Mg(s)$ $MgF_2(aq) + Zn(s)$.

24. The non-metal element replaces a less active non-metal from a compound. For example, $F_2(g) + 2NaCl(aq)$ $Cl_2(g) + 2NaF(aq)$.

Answers for page 71

25. a. This reaction is a single displacement. **b.** The products would be nickel(II) oxide and sulfur.

26. *Sample answer*: Both reactions involve the displacement or switching of atoms or ions to produce two new products. In a single-displacement reaction, an element replaces a second element in a compound to produce a new element and new compound. In a double-displacement reaction, however, there is an exchange of positive ions between two reacting compounds to produce two new compounds.

27. The reactants of a double displacement reaction are usually aqueous solutions of ionic compounds. The formation of a precipitate shows that one of the compounds, which results from switching ions, is not soluble and is a new product that is formed.

28. a. The balanced chemical equation is $Na_2CO_3(aq) + SrI_2(aq)$ $2NaI + SrCO_3$. **b.** The balanced chemical equation is $2K_3PO_4(aq) + 3CuI_2(aq)$ $Cu_3(PO_4)_2 + 6KI$.

29. The balanced chemical equation is $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$

30. a. The balanced chemical equation is $3Mg(s) + 2Fe(NO_3)_3(aq)$ $2Fe(s) + 3Mg(NO_3)_2(aq)$. This is a single displacement reaction. **b.** The balanced chemical equation is $2Al(NO_3)_3(aq) + 3Na_2CrO_4(aq)$ $Al_2(CrO_4)_3(s) + 6NaNO_3(aq)$. This is a double displacement reaction.

31. a. This is a double displacement reaction. The balanced chemical equation is $CaCl_2(aq) + 2AgNO_3(aq)$ $2AgCl + Ca(NO_3)_2$. **b.** This is a single displacement reaction. The

balanced chemical equation is $FeF_2(aq) + Mg(s) \rightarrow MgF_2 + Fe$. **c.** This is a single displacement reaction. The balanced chemical equation is $Cl_2(g) + 2KI(aq) \rightarrow I_2 + 2KCl$.

32. The reaction is a double displacement reaction. The formation of a precipitate from the two liquid solutions provides a clue to the type of reaction.

Section 5.3 Review
Reactions and Environmental Issues

Answers for page 72

Multiple Choice
1. b

2. c

3. d

4. a

5. d

6. e

7. c

8. b

Answers for page 73

Written Answer
9. Society has come to depend on the burning of fossil fuels for things such as heating, energy production, and transportation.

10. The balanced chemical equation is $2C_8H_{18}([\text{script l}]) + 25O_2(g) \quad 16CO_2(g) + 18H_2O(g)$.

11. Some harmful substances that can result are carbon monoxide, carbon (soot), and unburned gasoline vapours.

12. a. A catalyst is a substance that speeds up a reaction but is not used up in the reaction. **b.** A catalytic converter reduces emissions of nitrogen oxides through decomposition reactions.

13. Nitrogen oxides can contribute to smog and to the formation of ground level ozone.

14. The HHPS symbol for a corrosive chemical looks like a skeletal hand in a beaker of liquid. The image makes me think of a chemical that burns your flesh, which is a good reminder of the burning effect of a corrosive chemical.

15. a. Both symbols use a skull and crossbones. The WHMIS symbol is round, but the HHPS symbol is octagonal, like a stop sign. **b.** Each symbol represents a warning that a

substance is poisonous. **c.** The WHMIS symbol appears on laboratory and workplace products. The HHPS symbol appears on consumer products.

16. When bleach and ammonia are mixed they can react and form toxic gases, including chlorine and chloramines. Exposure to these substances can be fatal.

Chapter 5 Review
Classifying Chemical Reactions

Answers for page 74

Multiple Choice
1. b

2. b

3. d

4. b

5. e

6. a

7. c

8. d

Answers for page 75

Written Answer
9. The production of light or change in temperature is the result of a change in the energy of the substances.

10. A compound can form from its elements in a synthesis reaction. The same compound can break down into those same elements in a decomposition reaction.

11. a. This is a decomposition reaction because a single compound as a reactant can only break down into simpler substances. **b.** This is a single displacement reaction. An element and a compound are the reactants for a single displacement reaction. **c.** This is a synthesis reaction because two elements as reactants can only join together to make a compound. **d.** This is a double displacement reaction. Two ionic compounds generally react by switching ions in a double displacement reaction. **e.** This is a single displacement reaction. An element and a compound are the reactants for a single displacement reaction.

12. a. The balanced chemical equation is $2Ni_2O_3(s)$ $4Ni(s) + 3O_2(g)$. **b.** The balanced chemical equation is $Cl_2(g) + SrBr_2(aq)$ $SrCl_2(aq) + Br_2([script l])$. **c.** The balanced chemical equation is $6Na(s) + N_2(g)$ $2Na_3N(s)$. **d.** The balanced chemical equation is $CaI_2(aq) + Na_2S(aq)$ $CaS(s) + 2NaI(aq)$. **e.** The balanced chemical equation is $Mg(s) + ZnBr_2(aq)$ $Zn(s) + MgBr_2(aq)$.

13. Complete combustion happens when enough oxygen is present for all of the gasoline to form carbon dioxide and water vapour. Incomplete combustion happens when too little oxygen is present to completely burn the gasoline. In addition to carbon dioxide and water vapour, incomplete combustion can also result in the formation of carbon monoxide and carbon (soot), and in the release of unburned gasoline vapours.

14. a. The products of the complete combustion of the fuel are carbon dioxide and water vapour. **b.** Having a yellow flame could cause a harmful situation because during incomplete combustion, poisonous carbon monoxide is formed.

15. The catalysts used in a catalytic converter are precious metals, including platinum, palladium, and rhodium.

16. Cyanide compounds are highly toxic, and can be lethal even at low levels.

Answers for page 76

17. a. A glow stick and a fire involve the production of light. **b.** Milk going sour involves a change in odour. **c.** The formation of rust and the tarnishing of silver involve a change in colour.

18. *Sample answer*: A baseball player catching a fly ball represents the two elements coming together and joining to form a new compound.

19. The products of the decomposition of a binary ionic compound are the neutral elements, so it is not necessary to know the charge of the multivalent metal in the compound to write the chemical formulas of the products.

20. a. A single displacement reaction occurred. **b.** The balloon will contain hydrogen gas because hydrogen can be replaced by a metal, but chlorine can only be replaced by a non-metal.

21. The movie is not scientifically accurate because no reaction should occur. Gold placed in hydrochloric acid behaves as a single displacement reaction and is subject to the activity series for metals. Since gold is below hydrogen on the activity series, it is less active than hydrogen and cannot replace hydrogen from the acid.

22. The precipitate has a much lower solubility that the second product does. As a result, the precipitate is solid and is not dissolved in the solution.

23. A solid formed during a single displacement reaction is usually a metallic element that was displaced by a more active metal. A solid formed during a double displacement reaction is usually a precipitate of an insoluble ionic compound.

24. A single displacement reaction would be best to use if the ion were of a valuable element because you would recover the element itself without further processing.

Answers for page 77

25. *Sample answer*: The player with the puck represents a compound, and the checking player represents a single element. During the "reaction," the checking player displaces the

other player and takes the puck. This is a model for how the single element displaces a second element from a compound and takes its place.

26. Determine the ions that make up each reactant. Switch the positive ions between the two compounds. Use the cross-over method or balance the charges to write the correct chemical formula for each new product. Make sure that the overall charge on each compound is zero.

27. Decomposition and single displacement reactions would be the most likely reaction types used. Each of these reactions can produce an element from a compound.

28. Pamphlets should point out that chlorinating agents can be corrosive to skin and can create explosive mixtures if used incorrectly, but that chlorinating agents are helpful because they prevent the growth of bacteria and other organisms that could cause illness. Without the use of chlorinating agents, there would likely be an increase in cases of illness.

29. The diagram should show nitrogen and oxygen gases (N_2 and O_2) entering the car's engine. In the engine, the reactions that take place include: $N_2(g) + O_2(g)$ $2NO(g)$ and $N_2(g) + 2O_2(g)$ $2NO_2(g)$. In the catalytic converter, the reverse reactions take place: $2NO(g)$ $N_2(g) + O_2(g)$ and $2NO_2(g)$ $N_2(g) + 2O_2(g)$.

30. A product that has this HHPS symbol is flammable. Before using it in the kitchen, I should be sure that there are no open flames and that any hot surfaces are allowed to cool.

31. Aspects of a Hydrogen Economy

Positive	Negative
Vehicles produce no pollutants in exhaust.	Fuelling stations are not available.
Hydrogen for fuel is plentiful.	Large amounts of energy are needed to produce, store, and transport hydrogen.

32. The first person probably used a product that contained bleach to disinfect the surfaces. The second person used a glass cleaner that contained ammonia to clean the mirror. If some of the glass cleaner contacted residue of the disinfectant, the bleach and ammonia would react to form small amounts of chlorine and chloramines. Only the second person was affected because the harmful gases formed only after the second product was used.

Section 6.1 Review
Identifying Acids and Bases

Answers for page 78

Multiple Choice

1. c

2. e

3. a

4. a

5. e

6. b

7. a

8. c

Answers for page 79

9. b

10. e

11. c

12. c

13. a

14. d

15. b

16. d

Answers for page 80

Written Answer

17. Many acids and bases are deadly and corrosive.

18. Ionization is the process by which an acid dissolves in and reacts with water to produce ions.

19. The chemical equation for the ionization of hydrogen chloride is $HCl(aq)$ $H^+(aq) + Cl^-(aq)$.

20. The flowers on some hydrangeas are blue in acidic soil.

21. Hydrogen and a non-metal make up a binary acid.

22. The prefix *hydro-* belongs in the first blank and the ending *-ic acid* belongs in the second blank.

23. a. The classical name of $HF(aq)$ is hydrofluoric acid. **b.** The classical name of $HBr(aq)$ is hydrobromic acid. **c.** The classical name of $HI(aq)$ is hydroiodic acid. **d.** The classical name of $HCl(aq)$ is hydrochloric acid.

24. a. The IUPAC name of $HCl(aq)$ is aqueous hydrogen chloride. **b.** The IUPAC name of $HI(aq)$ is aqueous hydrogen iodide. **c.** The IUPAC name of $HBr(aq)$ is aqueous hydrogen bromide. **d.** The IUPAC name of $HF(aq)$ is aqueous hydrogen fluoride.

Answers for page 81

25. Hydrogen, oxygen, and another element make up an oxoacid.

26. a. The classical name of $HNO_3(aq)$ is nitric acid. **b.** The classical name of $H_2SO_3(aq)$ is sulfurous acid.

27. a. The IUPAC name of $HClO_3(aq)$ is aqueous hydrogen chlorate. **b.** The IUPAC name of $H_2SO_4(aq)$ is aqueous hydrogen sulfate.

28. If the acid name ends with *-ic acid*, use the ion that ends in *-ate*. If the acid name ends with *-ous acid,* use the ion that ends in *-ite*.

29. a. The chemical formula for phosphoric acid is $H_3PO_4(aq)$. **b.** The chemical formula for hydrobromic acid is $HBr(aq)$. **c.** The chemical formula for aqueous hydrogen sulfite is $H_2SO_3(aq)$. **d.** The chemical formula for aqueous hydrogen nitrate is $HNO_3(aq)$.

30. The chemical equation for the dissociation of lithium hydroxide in aqueous solution is $LiOH(aq)$ $Li^+(aq) + OH^-(aq)$.

31. The base formed from the chlor-alkali process is used in paper production, in aluminum production, in soaps and detergents, and in the manufacture of other chemicals.

32. a. The chemical formula for aqueous rubidium hydroxide is $RbOH(aq)$. **b.** The chemical formula for aqueous strontium hydroxide is $Sr(OH)_2(aq)$.

Section 6.2 Review
The pH Scale and Indicators

Answers for page 82

Multiple Choice

1. c

2. d

3. a

4. b

5. e

6. d

7. c

8. e

Answers for page 83

Written Answer

9. If the water in a pool is too acidic it could react with substances in the concrete and mortar of the pool.

10. The pH scale is a numerical scale that goes from 0 to 14 that is used to classify aqueous solutions as acidic, basic, or neutral.

11. Acidic solutions have pH values below 7. Neutral solutions have a pH value of 7. Basic solutions have pH values above 7.

12. Both universal indicator and pH paper can change to many colours to help identify the pH value of a solution. Universal indicator is in a solution, while pH paper has universal indicator dried onto strips of paper.

13. Colours of Indicators at pH 8

Indicator	Colour at pH 8
Methyl orange	yellow
Bromothymol blue	blue
Phenolphthalein	colourless
Indigo carmine	blue
Methyl red	yellow

14. Methyl orange and methyl red change from red to yellow.

15. Bromothymol blue changes colour around pH 7.

16. Colour Changes of Natural Acid-Base Indicators

Plant Extract	Colour at Acidic pH	Colour at Basic pH
Apple	red	green
Blueberry	red	blue
Plum	red	pale green

Section 6.3 Review
Reactions of Acids and Bases

Answers for page 84

Multiple Choice
1. b

2. c

3. e

4. a

5. d

6. c

7. d

8. a

Answers for page 85

Written Answer
9. A neutralization reaction is a double displacement reaction.

10. The products of the reaction are water and aqueous sodium chloride.

11. a. Excess production of acid in the stomach causes heartburn. **b.** Bases such as magnesium hydroxide and aluminum hydroxide are used in antacids.

12. Rainwater is naturally acidic because carbon dioxide in the air dissolves in and reacts with water to form carbonic acid.

13. The balanced chemical equations are $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ and $SO_3(g) + H_2O([\text{script } l]) \rightarrow H_2SO_4(aq)$.

14. a. The original source of the sulfur is the coal that is burned in the furnace. **b.** The final product in which the sulfur becomes trapped is a wet slurry of $CaSO_3$.

15. Liming a lake involves adding basic materials, like calcium carbonate from limestone, to a lake in order to raise the water's pH and neutralize some of the acid in the water.

16. Liming a lake can increase the calcium ion concentration in the water, which could be harmful to some creatures.

Chapter 6 Review
Acids and Bases

Answers for page 86

Multiple Choice

1. b

2. a

3. d

4. b

5. c

6. e

7. a

8. d

Answers for page 87

Written Answer

9. Writing Classical Names for Acids

Acid	Prefix	Root	Ending
binary	hydro-	root	-ic acid
oxoacid with ion name ending -*ate*	no prefix used	root	-ic acid
oxoacid with ion name ending -*ite*	no prefix used	root	-ous acid

10. a. The chemical in the beaker is aqueous sodium hydroxide. **b.** This solution is basic. **c.** Methyl red will turn yellow in a sample of aqueous sodium hydroxide.

11. A molecule of water forms when a hydrogen ion and a hydroxide ion react.

12. The balanced chemical equation is $2NaCl(aq) + 2H_2O([\text{script l}]) \quad 2NaOH(aq) + Cl_2(g) + H_2(g)$.

13. A pH indicator must be able to undergo a change of colour at different pH values.

14. The balanced chemical equation is $2HNO_3(aq) + Mg(OH)_2(aq) \quad 2H_2O([\text{script l}]) + Mg(NO_3)_2(aq)$. The salt formed is magnesium nitrate, $Mg(NO_3)_2$.

15. As long as acidic water continues to enter the lake, the pH will drop again.

16. a. The spring snowmelt may carry a large amount of acid, which was trapped in the snow and ice, and deposit it into a nearby lake, which would cause a sharp drop in pH. **b.** There can be mass fish kills when the pH of a lake changes abruptly. **c.** Limestone-based rock has a natural basicity, which helps to neutralize the acid precipitation. Areas that contain mostly granite rock lack this natural ability to combat the effects of acid precipitation.

Answers for page 88

17. Edible acids are used to provide an extremely sour flavour to candies. A property of acids is a sour taste. Citric acid is an example of an edible acid that could be used in candy.

18. Many ant bites sting because of formic acid. Baking soda is a base that helps to neutralize the acid and relieve the pain.

19. Acids and bases are defined by the ion each produces when dissolved in water. If these compounds are not in aqueous solution, they would not form ions and would therefore not have the properties described.

20. Ionization is the process by which an acid forms ions in aqueous solution. The original substance, such as hydrogen chloride gas, is not made up of ions, so the ions form as water dissolves the molecules of the compound. Dissociation is the process by which a base forms ions in aqueous solution. The original substance, such as sodium hydroxide, is composed of ions, so the water simply separates, or dissociates, the ions from one another.

21. a. *Sample answer*: I would monitor the pH after each addition of acid using pH paper, until the solution was pH 6. Note that student answers could also include use of universal indicator or a pH meter to monitor the reaction. **b.** I could add a base to increase the pH back up to 6.

22. a. Higher pH values correspond to less acidic solutions. It is correct to say "As pH increases, a solution becomes less acidic." **b.** A decrease in pH corresponds to an increase in the hydrogen ion concentration. And, with each step on the pH scale, concentration changes by a factor of 10. It is correct to say "As pH changes from 4 to 2, the hydrogen ion concentration becomes 100 times greater." **c.** At pH 7, a solution is neutral because the concentrations of hydrogen ions and of hydroxide ions are equal, not because they are zero. It is correct to say "At pH 7, a solution contains equal concentrations of hydrogen ions and hydroxide ions."

23. *Sample answer*: I would choose to bring a portable pH meter. It would provide more accurate data and I could store the data on a laptop for later analysis and to include in reports.

24. a. The solution is basic. **b.** A solution that has a hydrogen ion concentration 1000 times higher has a pH value of 8. **c.** A neutral solution has a pH value of 7, which is 4 pH units away from the pH of solution tested. Therefore, the hydrogen ion concentration in a neutral solution is 10 000 times higher than the hydrogen ion concentration in solution A.

Answers for page 89

25. a. A red solution is more acidic than a green one. **b.** Litmus is red at low pH values and blue at high pH values, similar to universal indicator.

26. Carbon dioxide is a non-metal oxide and should react with water to form an acidic solution. Acidic solutions turn blue litmus paper red and have no effect on red litmus paper.

27. a. Using methyl red indicator would not provide any additional knowledge about the solution because any basic solution causes methyl red to be yellow. **b.** Two indicators that would be most likely to help me learn more about the pH of the solution are phenolphthalein and indigo carmine. Each of these indicators change colours within the basic range and might help me to narrow down the pH of the solution.

28. For each indicator, if the colour listed is the colour below the change in colour, then the pH will be less than the lowest pH value of the change in colour. If the colour listed is the colour above the change in colour, then the pH will be greater than the highest pH value of the change in colour. Once you determine the pH range shown by each indicator, you must determine their intersection, or what range of pH values is true for all indicators.

29. Based on the data, the nitrogen oxide emissions from industrial sources and electric utilities are only about 36 percent, and the emissions from transportation are 60 percent of the total emissions. Research into reducing emissions from vehicles has the potential to have a bigger effect on overall emissions and would be the better place to invest.

30. Student work should show the following: As the pH of the lake water decreases, small organisms such as insects, plankton, and crustaceans die. As the pH continues to decrease, less desirable species of plankton and moss thrive, and some fish populations die as a result of loss of food sources and difficulty in reproducing. As more fish species disappear, land animals around the lake that rely on the fish for food go hungry, and their numbers decline as well.

31. The acid precipitation and run-off that enter the lake can leach metal ions from the surrounding soil and transport them into the lake.

32. Metal oxides are not to blame for acid precipitation because they would react with water to form bases. Acid precipitation forms from non-metal oxides released into the atmosphere, such as $SO_3(g) + H_2O([script l])$ $H_2SO_4(aq)$.

Unit 2 Review
Chemical Reactions

Answers for page 90

Written Answer

1. The chemical formula of a binary ionic compound represents the lowest ratio of ions that make up the crystal lattice, so the formula should always represent the lowest ratio of the ions that make the total charge zero. The chemical formula of a binary molecular compound represents the actual number of atoms of the elements that make up a molecule of the compound, so the subscripts should not be reduced.

2. The cross-over method works when writing the chemical formula of an ionic compound because an ionic compound is made up of ions. By taking the amounts of the charges and crossing them over, you are writing a formula that has an overall charge of zero. This method does not work for molecular compounds because they are made up of neutral atoms that share electrons, so there are no charges to cross over.

3. a. The student is working with a binary ionic compound. **b.** The student has not used the models correctly. The error is that the total charge of the ions is not zero. Another F^- model is needed, which would make the correct chemical formula of MgF_2.

4. This chemical equation does not show a compound breaking up into different substances. The process represented is the dissociation of NaCl as the ions are separated from one another.

5. The general rule for the decomposition of a metal carbonate is that a metal carbonate decomposes to form a metal oxide and carbon dioxide. The balanced chemical equation for the decomposition of magnesium carbonate is $MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$.

6. A glow stick is a good way to study the law of conservation of mass because the reaction takes place in a closed container.

7. The mass of a gaseous product that is released during a chemical reaction of two aqueous solutions can be determined by measuring the reactants before the reaction occurs and subtracting the mass of the products that remain in the beaker once the reaction is complete. The difference between these masses is the mass of the gaseous product. The law of conservation of mass is the basis of this method.

8. A chemical equation can be balanced and yet be incorrect if one or more chemical formulas of the substances involved in the reaction are incorrect. For example, the chemical equation for the synthesis reaction of sodium chloride is correctly written using diatomic chlorine as $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$. However, a balanced but incorrect equation results by not representing chlorine as diatomic: $Na(s) + Cl(g) \rightarrow NaCl(s)$.

Answers for page 91

9. a. This is a double displacement reaction. The chemical formulas for the products are incorrect. Ions with the same type of charge have been paired in each of the products. The

correct chemical equation is $2HCl(aq) + Pb(NO_3)_2(aq)$ $PbCl_2(aq) + 2HNO_3(aq)$. **b.** This is a single displacement reaction. Each of the chemical formulas is correctly written, but this reaction should not occur because aluminum is lower on the activity series than magnesium. **c.** This is a synthesis reaction. The product formed is incorrect; it should be Fe_2O_3. The correct chemical equation is $4Fe(s) + 3O_2$ $2Fe_2O_3(s)$. **d.** This is a decomposition reaction. The chlorine product is a diatomic molecule so should be represented as Cl_2. The correct chemical equation is $2CsCl(s)$ $2Cs(s) + Cl_2(g)$. **e.** This is a double displacement reaction. One of the products is incorrect; it should be $BaSO_4$. The correct chemical equation is $Ba(NO3)_2(aq) + MgSO_4(aq)$ $BaSO_4(aq) + Mg(NO3)_2(aq)$.

10. Ionization is an important process to help explain the electrical conductivity of aqueous hydrogen chloride because ions are formed from molecular compounds during ionization. Ions in solution explain the electrical conductivity of acids.

11. *Sample answer*: An example of an acid with an important use, but which can be harmful, is sulfuric acid in car batteries. An example of a base with an important use, but which can be harmful, is sodium hydroxide in drain cleaners.

12. Two indicators that would helpful are methyl red and methyl orange. Each of these indicators changes colour in an acidic pH range and would help to more accurately determine the pH of the solution.

13. The bromothymol blue should be checked for possible contamination. The other indicators read a highly basic solution, but the bromothymol blue indicates an acidic solution.

14. *Sample answer*: There sure are a lot of carbon atoms around. Hey, why is it getting so hot. I'm burning up! Here comes some oxygen. I'll just join up with two oxygen atoms and we'll pass on out of this furnace as a gas. Where am I headed next? Oh no, not the scrubber. I'm getting sprayed with a calcium oxide solution. Now I'm stuck with a calcium and three oxygen atoms in this wet slurry.

15. Effects of Lake Acidification

Negative Impact	Addressing an Environmental Challenge
Acid entering a lake through acid precipitation, dumping, or through a spill would cause changes in pH levels that would harm organisms living in the lake and could leach other harmful substances, such as toxic metals, from the surrounding soil	Acid entering a lake as a treatment to neutralize a spill of a basic substance, such as from an overturned tanker transporting sodium hydroxide, is a way in which the acid helps to address an environmental challenge.

16. Flowcharts should contain the following information: The reactivity of the elements involved in a single displacement reaction should be compared using an activity series. If the element that is not part of a compound is higher on the activity series than the similar element that is in the compound, the reaction will happen. Otherwise, the reaction will not happen. Once it is determined that the reaction will happen, the products can be predicted. If the reacting element is a metal or hydrogen, then it replaces the cation in the reacting compound. If the reacting element is a halogen, then it will replace the anion in the reacting compound. Once the elements in the product compound are known, the correct chemical formula can be determined.

Literacy Test Prep
Drive Clean

Multiple Choice
17. c

18. d

19. c

20. d

21. b

Written Answer

22. The use of drive-through lanes most likely increases the amount of pollutants because of the added time spent idling the engine while waiting in line.

Literacy Test Prep
The Basics of Oven Cleaning

Multiple Choice
23. c

24. a

25. d

26. b

27. a

Written Answer
28. Ammonia vapours can cause eye, lung, and skin irritation. It is also very toxic at high concentrations.