## Reflecting on Chapter 14

Summarize this chapter in the format of your choice. Here are a few ideas to use as guidelines:

- Describe how fossil fuels are an important source of energy in our society.
- Describe how to write combustion equations, and how to measure the heat changes caused by physical processes such as dissolving.
- Describe the importance of isolating a system to reduce heat flow when measuring heat.
- Describe society's use of fossil fuels, and the resulting effects on the environment.
- Explain how to weigh the risks and benefits of an activity, and perform a risk-benefit analysis. This skill will help you make more informed decisions on issues that affect society, the economy, and the environment.

## Reviewing Key Terms

For each of the following terms, write a sentence that shows your understanding of its meaning.

| | |
|---|---|
| benefit | bomb calorimeter |
| bond energy | Calorie |
| calorimeter | calorimetry |
| $\Delta T$ | combustion |
| complete combustion | endothermic |
| exothermic | fossil fuels |
| global warming | greenhouse gases |
| heat | heat capacity |
| heat of combustion | incomplete combustion |
| isolated system | potential energy |
| risk | risk-benefit analysis |
| specific heat capacity | sustainable development |
| temperature | thermal energy |
| thermal equilibrium | thermochemical equation |

## Knowledge/Understanding

1. (a) What are the products of the complete combustion of a hydrocarbon?
   (b) What products form if the combustion is incomplete?
2. (a) Why can incomplete combustion be dangerous if it occurs in your home?
   (b) How can you tell, by looking at a flame, that incomplete combustion is taking place?
3. Indicate whether each process is endothermic or exothermic.
   (a) water evaporating
   (b) a piece of paper burning
   (c) rubbing your hands together
   (d) clouds forming
4. How can a balanced thermochemical equation tell you whether a chemical reaction is exothermic or endothermic?
5. Describe the relationship between the amount of thermal energy that is released by water and
   (a) the mass of water
   (b) the temperature change of the water
6. Why is energy needed to sustain an endothermic reaction?
7. (a) The combustion of paraffin, $C_{25}H_{52(s)}$, is exothermic. Explain why by comparing the energy changes observed when chemical bonds are broken and formed.
   (b) The formation of 1-pentyne, $C_5H_{8(\ell)}$, is endothermic. Explain why by comparing the energy changes observed when chemical bonds are broken and formed.
8. Hydrogen is used as a fuel for the space shuttle because it provides more energy per gram than many other fuels. The combustion of hydrogen is described by the following equation.
   $$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} + 484 \text{ kJ}$$
   (a) Is this reaction exothermic or endothermic?
   (b) How much energy does the complete combustion of 1 g of hydrogen provide?
9. Write a balanced chemical equation for each reaction.
   (a) complete combustion of 4-methyl-1-pentene, $C_6H_{12(\ell)}$
   (b) incomplete combustion of benzene, $C_6H_{6(\ell)}$
   (c) incomplete combustion of propene, $C_3H_{6(g)}$
   (d) complete combustion of 3-ethyhexane, $C_8H_{18(\ell)}$
10. List three assumptions that you make when using a polystyrene calorimeter.

11. The same amount of heat is added to aluminum ($c_{Al}$ = 0.900 J/g·°C) and nickel ($c_{Ni}$ = 0.444 J/g·°C). Which metal will have a greater temperature increase? Explain.

12. Does propane burning in an outdoor barbecue have a negative or positive heat of combustion? Explain.

## Inquiry

13. To make four cups of tea, 1.00 kg of water is heated from 22.0°C to 99.0°C. How much energy is needed?

14. Two different foods are burned in a calorimeter. Sample 1 has a mass of 6.0 g and releases 25 Cal of heat. Sample 2 has a mass of 2.1 g and releases 9.0 Cal of heat. Which food releases more heat per gram?

15. A 3.00 g sample of a new snack food is burned in a calorimeter. The 2.00 kg of surrounding water change in temperature from 25.0°C to 32.4°C. What is the food value in Calories per gram?

16. A substance is burned completely in a bomb calorimeter. The temperature of the 2000 g of water in the calorimeter rises from 25.0°C to 43.9°C. How much energy is released?

17. A horseshoe can be shaped from an iron bar when the iron is heated to temperatures near 1500°C. The hot iron is then dropped into a bucket of water and cooled. An iron bar is heated from 1500°C and then cooled in 1000 g of water that was initially at 20.0°C. How much heat energy does the water absorb if its final temperature is 65.0°C?

18. A group of students decide to measure the energy content of certain foods. They heat 50.0 g of water in an aluminum can by burning a sample of the food beneath the can. When they use 1.00 g of popcorn as their test food, the temperature of the water rises by 24°C.
    (a) Calculate the heat energy that is released by the popcorn. Express your answer in both kilojoules and Calories per gram of popcorn.
    (b) Another student tells the group that she has read the label on the popcorn bag. The label states that 30 g of popcorn yields 110 Cal. What is this value in Calories per gram? How

can you account for the difference between the two values?

19. In Chapters 13 and 14, you have examined many properties of hydrocarbons. Describe one physical property and one chemical property of hydrocarbons. Explain how these two properties vary from one hydrocarbon to another. Describe how you might measure each property in a lab.

20. A reaction in a calorimeter causes 250.0 g of water to decrease in temperature by 2.40°C. How much heat did the reaction absorb?

21. A chemist wants to calibrate a new bomb calorimeter. He completely burns a mass of 0.930 g of carbon in a calorimeter. The temperature of the calorimeter changes from 25.00°C to 28.15°C. If the thermal energy change is 32.8 kJ/g of carbon burned, what is the heat capacity of the new calorimeter? What evidence shows that the reaction was exothermic?

22. 200 g of iron at 350°C is added to 225 g of water at 10.0°C. What is the final temperature of the iron-water mixture?

23. In this chapter, you learned that fats have long hydrocarbon sections in their molecular structure. Therefore, they have many C—C and C—H bonds. Sugars have fewer C—C and C—H bonds but more C—O bonds. Use Table 14.1 in this chapters. Explain why you can obtain more energy from burning a fat than from burning a sugar.

24. 2,2,4-trimethylpentane, an isomer of $C_8H_{18}$, is a major component of gasoline.
    (a) Write the balanced thermochemical equation, using the word "energy," for the complete combustion of this compound. Use $C_8H_{18(\ell)}$ as the formula for the compound.
    (b) What is the ideal ratio of fuel to air for this fuel?
    (c) In the previous unit, you learned how to solve problems involving gases. Calculate the volume of carbon dioxide, at 20.0°C and 105 kPa, that is produced from the combustion of 1.00 L of $C_8H_{18(\ell)}$. **Note:** The density of $C_8H_{18(\ell)}$ is 0.69 g/mL.

**25.** 100 g of calcium carbide is used to produce acetylene in a laboratory, as you did in Investigation 14-A.
   **(a)** What volume of water (density 1.00 g/mL) is needed to react completely with the calcium carbide?
   **(b)** What volume of acetylene gas will be produced at STP when the calcium carbide and water are mixed?

## Communication

**26.** Earlier in the chapter, you learned that poisonous carbon monoxide can form during incomplete hydrocarbon combustion. The use of carbon monoxide detectors in homes and businesses has reduced the number of deaths due to carbon monoxide poisoning. Are all carbon monoxide detectors the same? Telephone your local fire department, go to a library, or search the Internet to find out about carbon monoxide detectors.

**27.** Design a poster or a brochure to explain the concept of sustainable development to a student in a much younger grade.

**28.** Prepare a concept map to illustrate the effects of hydrocarbons on our society and the environment.

## Making Connections

**29.** When energy is wasted during an industrial process, what actually happens to this energy?

**30.** Look at Table 14.3. Compare caramels with raw carrots. Which food gives more Calories per gram?

**31.** Petrochemical products, such as plastics, have affected your life. Identify one benefit and one possible risk associated with the use of petrochemical products.

**32.** Define sustainable development. Suggest a condition that you feel society must agree on to achieve sustainable development.

**33.** The Hibernia Oil Field is located off the Grand Banks of Newfoundland, on Canada's east coast. It started oil production in the fall of 1997. Research and write a report on some of the risks and benefits of this massive oil operation. Consider ecological, economic, and social issues.

**34.** On an episode of *The Nature of Things*, Dr. David Suzuki made the following comment: "As a society and as individuals, we're hooked on it [oil]." Discuss his comment. Explain how our society has benefitted from hydrocarbons. Describe some of the problems that are associated with the use of hydrocarbons. Also describe some possible alternatives for the future.

### Answers to Practice Problems and Short Section Review Questions:

**Practice Problems 1.(a)** complete **2.(a)** $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ **(b)** $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ **(c)** $6C_2H_6 + 15O_2 \rightarrow 4CO_2 + 4CO + 4C + 18H_2O$, $3C_2H_6 + 6O_2 \rightarrow CO_2 + CO + 4C + 9H_2O$, **3.(a)** $C_4H_{10} + 4O_2 \rightarrow CO_2 + CO + 2C + 5H_2O$ **(b)** $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ **4.** $C_{25}H52 + 38O_2 \rightarrow 25CO_2 + 26H_2O$ **5.(a)** $C_{13}H_{28} + 9O_2 \rightarrow CO_2 + 2CO + 10C + 14H_2O$, $C_{13}H_{28} + 10O_2 \rightarrow 2CO_2 + 2CO + 8C + 14H_2O$ **(c)** incomplete **6.(a)** $3C_{(s)} + 4H_{2(g)} \rightarrow C_3H_{8(g)} +$ energy **(b)** $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)} +$ energy **7.(b)** energy $+ 2C_{(s)} + 2H_{2(g)} \rightarrow C_2H_{4(g)}, C_2H_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(g)} +$ energy **8.** $6.2 \times 10^3$J **9.** $-4.6 \times 10^3$J **11.(a)** +4.22 kJ, +4.6 kJ **12.(a)** $m = Q/c\triangle T$ **(b)** $c = Q/m\triangle T$ **(c)** $\triangle T = Q/mc$ **13.(a)** $T_I = T_f - Q/mc$ **(b)** $T_f = T_I + Q/mc$ **14.** $2.14 \times 10^5$ J **15.** 0.7900 J/g•°C, granite **16.** 12.1 J/g•°C **17.** 15.5•°C **18.** $-2.30 \times 10^3$ J **19.** $1.26 \times 10^4$ J **20.** 661 J/g **21.(a)** $-2.2 \times 10^4$ J, $2.2 \times 10^4$ J **(b)** 8.0 J/g•°C **22.(a)** $C = Q/\triangle T$ **(b)** $\triangle T = Q/C$ **(c)** $T_f = T_I + Q/C$ **(d)** $T_i = T_f - Q/C$ **23.** $-20.3$ kJ/g **24.(a)** 100 g **(b)** 8.75 kJ/°C **Section Review: 14.1:** **3.(a)** $C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ **(b)** $C_5H_{10} + 6O_2 \rightarrow 3CO_2 + CO + C + 5H_2O$ **4.** $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, $4CH_4 + 6O_2 \rightarrow CO_2 + 2CO + C + 8H_2O$ **6.(a)** $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$ **(b)** 54 g **(c)** 392 L **14.2:** **1.(a)** endothermic, net energy is absorbed, formation of ethyne (acetylene) **(b)** exothermic, net energy is released, combustion of methane **4.(a)** endothermic **5.** 197 kJ/mol **14.3:** **3.(a)** $-4.54 \times 10^3$ J **4.(a)** 38.1 J **(b)** 76.2 J **(c)** 76.2 J **5.(a)** 0.237 J/g•°C **(b)** 3.43°C **6.** copper **14.4:** **3.** $-39.8$ kJ **4.** $-3.1 \times 10^3$ J **5.** 9.63 Cal, yes **14.5:** **6.(a)** $S_8 + 8O_2 \rightarrow 8SO_2$, $S_8 + 12O_2 \rightarrow 8SO_3$, $2NO + O_2 \rightarrow 2NO_2$, $SO_2 + H2O \rightarrow H_2SO_3$, $SO_3 + H_2O \rightarrow H_2SO_4$, $2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$