Name ______________________ Class ______ Date ______

17 Thermochemistry

Big idea MATTER AND ENERGY

17.1 The Flow of Energy

For students using the Foundation edition, assign problems 1–5, 7, 8, 12–21, 23, 24, 26.

Essential Understanding All processes, whether physical or chemical, absorb or release energy according to the law of conservation of energy.

Reading Strategy

Cause and Effect A cause and effect chart is a useful tool when you want to describe how, when, or why one event causes another. As you read, draw a cause and effect chart that shows the relationship between heat flow and endothermic and exothermic processes.

As you read Lesson 17.1, use the cause and effect chart below. Complete the chart with the terms *system* and *surroundings*.

Process	Cause	Effect
endothermic	*surroundings* lose(s) heat	*system* gain(s) heat
exothermic	*system* lose(s) heat	*surroundings* gain(s) heat

EXTENSION **Provide an example of each of the causes and effects in the chart.**

Sample answers:
endothermic: A hot oven loses heat to cake batter; the cake batter gains heat.

exothermic: A hot cup of coffee cools; the air around the coffee becomes warmer.

Lesson Summary

Energy Transformations Thermochemistry is the study of energy transformations, or changes, that happen during chemical reactions or changes in state.

- Energy changes can involve heat transfer and/or work.
- Heat is the energy transferred from a warmer object to a cooler object.

Endothermic and Exothermic Processes Endothermic and exothermic processes involve the gain and loss of heat between a system and its surroundings.

- The system is the area of focus, and the surroundings are everything else in the universe.
- During any energy change, the total amount of energy is conserved.
- In an endothermic process, energy from the surroundings is absorbed by the system; in an exothermic process, energy from the system is released to the surroundings.
- Calories and joules are two units used to measure heat flow.

Name ______________________ Class ______ Date ______

Heat Capacity and Specific Heat An object's heat capacity and specific heat describe how much heat must be absorbed to raise the temperature of the object by a specific amount.

- Heat capacity is the amount of heat needed to raise the temperature of an object 1°C.
- Specific heat is the amount of heat needed to raise the temperature of 1 g of a substance 1°C.
- To calculate specific heat, use the formula $C = \frac{q}{m} \times \Delta T$ where q is heat, m is mass, and ΔT is the change in temperature.

BUILD Math Skills

Algebraic Equations An algebraic equation is a way of writing a mathematical relationship that includes an equal sign and at least one variable. We usually write a variable as a letter, and the value of a variable depends on the information in the problem.

Algebraic equations can contain more than one variable, or the whole equation may have only variables, such as $x^2 + 3y = z$. It's best to rearrange these kinds of equations so that the variable you're solving for is the only thing on one side of the equal sign.

$x^2 + 3y = z$ can be rewritten as $y = \frac{(z - x^2)}{3}$

There are a few rules to follow when rearranging algebraic expressions:

Rule	Example	Solution
To move a variable in the *denominator* to the opposite side, *multiply* both sides of the equation by that variable.	$\frac{2}{x} = y$	$\frac{2}{x} = y$ $x \cdot \left(\frac{2}{x}\right) = y \cdot x$ $2 = yx$
To move a variable in the *numerator* to the opposite side, *divide* both sides of the equation by that variable.	$\frac{x}{2} = y$	$\frac{x}{2} = y$ $\left(\frac{1}{x}\right) \cdot \left(\frac{x}{2}\right) = \frac{y}{x}$ $\frac{1}{2} = \frac{y}{x}$
To move a variable that is by itself, do the opposite of its sign to both sides of the equation.	$x + 4y = z$	$x + 4y = z$ $x + 4y - 4y = z - 4y$ $x = z - 4y$
If the variable has an exponent, multiple both sides of the equation by 1 raised to the reciprocal of the exponent.	$x^2 = 3 + y$	$x^2 = 3 + y$ $1^{\frac{1}{2}} \cdot x^2 = (3 + y) \cdot 1^{\frac{1}{2}}$ Recall that $\frac{1}{2}$ is the reciprocal of 2.

Turn the page to learn more about algebraic equations.

Name ______________________ Class ________ Date ________

Sample Problem Rearrange the following equation for x: $\frac{4x^3}{5y} + 6 = z$.

Start with any variables or numbers that are not multiplied or divided by the variable you want to isolate. In this case, it would be the number 6.

$$\frac{4x^3}{5y} + 6 = z$$
$$\frac{4x^3}{5y} + \cancel{6} - \cancel{6} = z - 6$$
$$\frac{4x^3}{5y} = z - 6$$

Multiply both sides by $5y$ since it is in the denominator.

$$5y \cdot \left(\frac{4x^3}{5y}\right) = (z - 6) \cdot 5y$$
$$\cancel{5y} \cdot \left(\frac{4x^3}{\cancel{5y}}\right) = (z - 6) \cdot 5y$$
$$4x^3 = (z - 6) \cdot 5y$$

Now divide both sides by 4 since x has a coefficient of 4.

$$\frac{4x^3}{4} = \frac{(z-6) \cdot 5y}{4}$$
$$\frac{\cancel{4}x^3}{\cancel{4}} = \frac{(z-6) \cdot 5y}{4}$$
$$x^3 = \frac{(z-6) \cdot 5y}{4}$$

Finally, since x has an exponent, multiply both sides by 1 raised to its reciprocal, which, in this case, is $\frac{1}{3}$.

$$1^{\frac{1}{3}} \cdot x^3 = \left(\frac{(z-6) \cdot 5y}{4}\right) \cdot 1^{\frac{1}{3}}$$
$$1^{\cancel{\frac{1}{3}}} \cdot x^{\cancel{3}} = \left(\frac{(z-6) \cdot 5y}{4}\right) \cdot 1^{\frac{1}{3}}$$
$$x = \left(\frac{(z-6) \cdot 5y}{4}\right)^{\frac{1}{3}}$$

Now it's your turn to practice rearranging algebraic equations. Remember that whatever operation you perform, you must apply it to both sides of the equation.

1. Rearrange the following equation for y: $x^2 + \frac{3y}{2z} = 7$

$y = \frac{(7 - x^2) \cdot 2z}{3}$

2. Write the following equation so that only x appears on one side: $\frac{3zx^4}{5 + z} = 2y$

$x = \left(\frac{2y \cdot (5 + z)}{3z}\right)^{\frac{1}{4}}$

3. Rewrite the following equation for the variable z: $\frac{2x}{3y} - 12 + 3z^2 = 5x^3$

$z = \left(\frac{\left(\frac{15}{2}\right)x^2 + 12}{3}\right)^{\frac{1}{2}}$

4. Rearrange the following equation for the variable y: $6x^3 + \frac{2z}{3y} = z^2$

$y = \frac{2z}{3 \cdot (z^2 - 6x^3)}$

Name ______________________ Class ______ Date ______

After reading Lesson 17.1, answer the following questions.

Energy Transformations

5. What area of study in chemistry is concerned with the heat transfers that occur during chemical reactions? ***thermochemistry***

6. Where the use of energy is concerned (in a scientific sense), when is work done?

Work is done when a force is used to move an object.

7. Circle the letter next to each sentence that is true about energy.

(**a.**) Energy is the capacity for doing work or supplying heat.

(**b.**) Energy is detected only because of its effects.

c. Heat is energy that transfers from one object to another because they are at the same temperature.

(**d.**) Gasoline contains a significant amount of chemical potential energy.

8. Circle the letter next to each sentence that is true about heat.

(**a.**) One effect of adding heat to a substance is an increase in the temperature of that substance.

b. Heat always flows from a cooler object to a warmer object.

(**c.**) If two objects remain in contact, heat will flow from the warmer object to the cooler object until the temperature of both objects is the same.

Endothermic and Exothermic Processes

9. What can be considered the "system" and what are the "surroundings" when studying a mixture of chemicals undergoing a reaction? Write your answers where indicated below.

System:

The mixture of chemicals themselves is considered the system.

Surroundings:

Everything but the mixture of chemicals is the surroundings, but practically speaking, it is the immediate vicinity of the system.

10. In thermochemical calculations, is the direction of heat flow given from the point of view of the system, or of the surroundings?

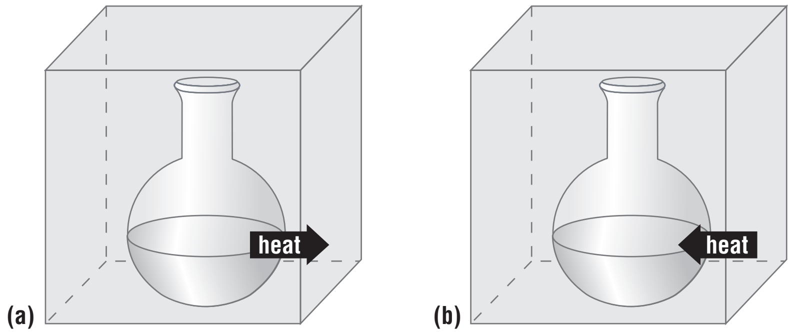
The direction is given from the point of view of the system.

11. What universal law states that energy can neither be created nor destroyed and can always be accounted for as work, stored potential energy, or heat?

the law of conservation of energy

Name ______________________ Class ______ Date ______

Questions 12 through 16 refer to the systems and surroundings illustrated in diagrams (a) and (b) below.



12. Which diagram illustrates an endothermic process? ***b***

13. Is heat flow positive or negative in diagram (a)? ***negative***

14. Which diagram illustrates an exothermic process? ***a***

15. Is heat flow positive or negative in diagram (b)? ***positive***

16. What does a negative value for heat represent?

It shows that a system is losing heat.

To answer Questions 17 and 18, use Figure 17.2.

17. A system is a person sitting next to a fire. Is this system endothermic or exothermic? Explain why.

The system is endothermic because the system is absorbing heat from the fire.

18. A system is a person who is perspiring. Is this system endothermic or exothermic? Explain why.

The system is exothermic because the system is cooling off by producing perspiration, which will evaporate, cooling the system.

19. Heat generated by the human body is usually measured in units called ***calories***.

20. Describe the chemical reaction that generates heat in the human body.

The body breaks down sugars and fats and releases heat.

21. What is the definition of a calorie?

A calorie is defined as the quantity of heat needed to raise the temperature of 1 g of pure water 1°C.

22. How is the calorie (written with a lowercase *c*) related to the dietary Calorie (written with a capital C)?

One dietary Calorie is equal to 1000 calories or 1 kilocalorie.

23. Circle the letter next to the SI unit of heat and energy.

a. calorie

b. Calorie

(c.) joule

d. Celsius degree

Heat Capacity and Specific Heat

24. Is the following sentence true or false? Samples of two different substances having the same mass always have the same heat capacity. ***false***

25. Compare the heat capacity of a 2-kg steel frying pan and a 2-g steel pin. If the heat capacities of these objects differ, explain why.

The frying pan has a greater heat capacity because its mass is greater.

26. Is the following sentence true or false? The specific heat of a substance varies with the mass of the sample. ***false***

17.2 Measuring and Expressing Enthalpy Changes

For students using the Foundation edition, assign problems 1–10.

Essential Understanding The amount of heat absorbed or released in a chemical reaction can be measured in a calorimeter and expressed in a chemical equation.

Lesson Summary

Calorimetry Calorimetry is the measurement of the amount of heat absorbed or released in a chemical or physical process.

- The device used to measure this heat change is a calorimeter.
- At constant pressure, the enthalpy (H) of a system accounts for the heat flow in the system.
- To calculate the enthalpy change in a calorimeter experiment, multiply the mass of the water by its specific heat and the change in temperature.

Thermochemical Equations Thermochemical equations include the enthalpy change.

- The heat of reaction is the enthalpy change for a chemical reaction exactly as it is written.
- An exothermic reaction has a negative heat of reaction, and an endothermic reaction has a positive heat of reaction.
- The heat of reaction depends on the number of moles and the state of matter of each reactant present.
- The heat of combustion is the heat of reaction for the complete combustion of one mole of a substance.

Name ______________________ Class ______ Date ______

After reading Lesson 17.2, answer the following questions.

Calorimetry

1. The property that is useful for keeping track of heat transfers in chemical and physical processes at constant pressure is called ***enthalpy***.

2. What is calorimetry?

Calorimetry is the accurate and precise measurement of heat change for chemical and physical processes.

3. Use Figure 17.6. Circle the letter next to each sentence that is true about calorimeters.

(**a.**) The calorimeter container is insulated to minimize loss of heat to, or absorption of heat from, the surroundings.

(**b.**) Because foam cups are excellent heat insulators, they can be used as simple calorimeters.

c. A stirrer is used to keep temperatures uneven in a calorimeter.

(**d.**) In the calorimeter shown in Figure 17.6, the chemical substances dissolved in water constitute the system, and the water is part of the surroundings.

4. Is the following sentence true or false? For systems at constant pressure, heat flow and enthalpy change are the same thing. ***true***

5. Complete the table below to show the direction of heat flow and type of reaction for positive and negative change of enthalpy.

Sign of enthalpy change	Direction of heat flow	Is reaction endothermic or exothermic?
ΔH is positive ($\Delta H > 0$)	***into system***	***endothermic***
ΔH is negative ($\Delta H < 0$)	***out of system***	***exothermic***

6. Name each quantity that is represented in the equation for heat change in an aqueous solution.

$$q = \Delta H = m \times C \times \Delta T$$

q	ΔH	m	C	ΔT
heat flow	***enthalpy change***	***mass of water***	***specific heat of water***	***change in temperature***

Thermochemical Equations

7. What happens to the temperature of water after calcium oxide is added?

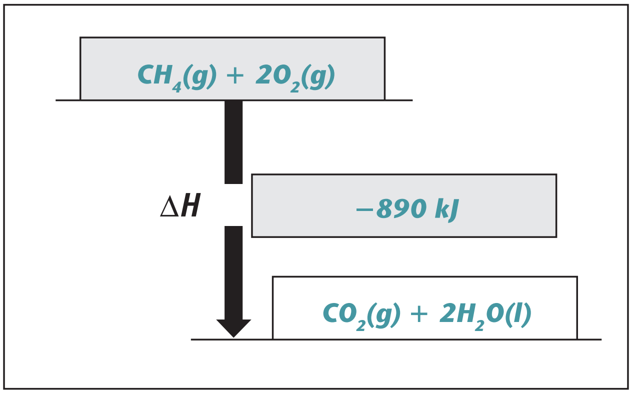
The temperature increases.

8. A chemical equation that includes the heat change is called a(n) ***thermochemical*** equation.

9. Why is it important to give the physical state of the reactants and products in a thermochemical equation?

The heat change values differ when the products or reactants are in different states.

10. Complete the enthalpy diagram for the combustion of natural gas. Use the thermochemical equations in this section as a guide.



17.3 Heat in Changes of State

For students using the Foundation edition, assign problems 1–11.

Essential Understanding Energy is either absorbed or released during all changes of state.

Lesson Summary

Heats of Fusion and Solidification For any substance, the molar heat of fusion equals the molar heat of solidification, but they have opposite signs.

- The molar heat of fusion for a substance is the amount of heat absorbed when one mole of a solid melts at a constant temperature.
- The molar heat of solidification for a substance is the amount of heat released when one mole of a liquid solidifies at a constant temperature.
- The molar heat of fusion has a positive value, and the molar heat of solidification has a negative value.

Heats of Vaporization and Condensation For any substance, the molar heat of vaporization equals the molar heat of condensation, but with opposite signs.

- The molar heat of vaporization for a substance is the amount of heat absorbed when one mole of a liquid vaporizes at a constant temperature.
- The molar heat of condensation for a substance is the amount of heat released when one mole of a vapor condenses at its normal boiling point.
- The molar heat of vaporization has a positive value, and the molar heat of condensation has a negative value.

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Name ______________________ Class ________ Date ________

Heat of Solution Heat is either released or absorbed during the solution process.

- The molar heat of solution is the amount of energy released or absorbed when one mole of the substance dissolves.
- If the temperature of the solution rises when the solute dissolves, the solution process is exothermic.
- If the temperature of the solution lowers when the solute dissolves, the solution process is endothermic.

After reading Lesson 17.3, answer the following questions.

Heats of Fusion and Solidification

1. Is the following sentence true or false? A piece of ice placed in a bowl in a warm room will remain at a temperature of 0°C until all of the ice has melted. ***true***

2. Circle the letter next to each sentence that is true about heat of fusion and heat of solidification of a given substance.

- (**a.**) The molar heat of fusion is the negative of the molar heat of solidification.
- **b.** Heat is released during melting and absorbed during freezing.
- (**c.**) Heat is absorbed during melting and released during freezing.
- (**d.**) The quantity of heat absorbed during melting is exactly the same as the quantity of heat released when the liquid solidifies.

3. Use Table 17.3. Determine ΔH for each of these physical changes.

a. $H_2(s) \rightarrow H_2(l)$ $\Delta H =$ ***0.12 kJ/mol***

b. $NH_3(s) \rightarrow NH_3(l)$ $\Delta H =$ ***5.66 kJ/mol***

c. $O_2(s) \rightarrow O_2(l)$ $\Delta H =$ ***0.44 kJ/mol***

Heats of Vaporization and Condensation

4. Is the following sentence true or false? As liquids absorb heat at their boiling points, the temperature remains constant while they vaporize. ***true***

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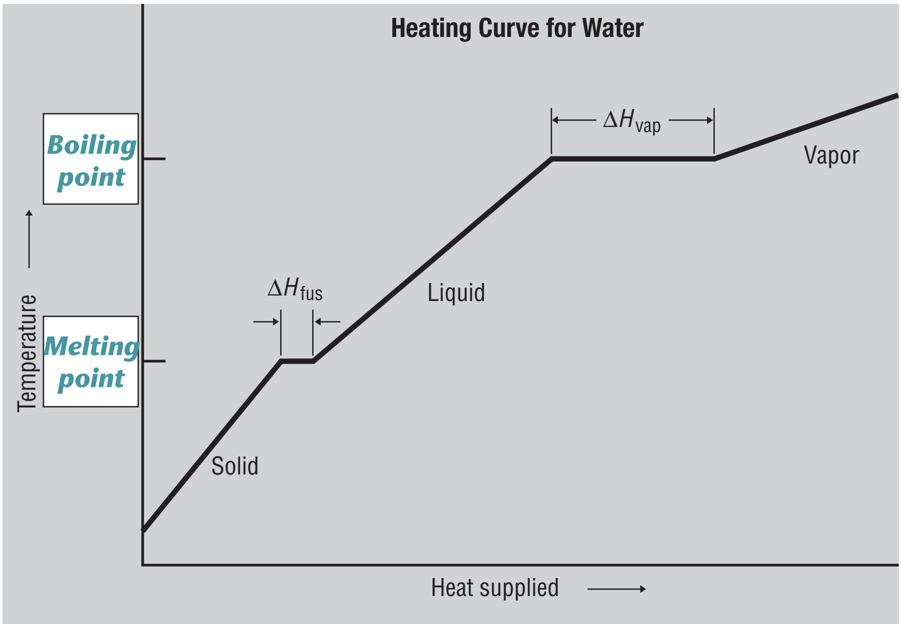
Name ______________________ Class ______ Date ______

Use the heating curve for water shown below to answer Questions 5, 6, and 7.



5. Label the melting point and boiling point temperatures on the graph.

6. What happens to the temperature during melting and vaporization?

The temperature stays constant at the melting point and boiling point, respectively.

7. Circle the letter next to the process that *releases* the most heat.

a. Melting of 1 mol of water at 0°C

b. Freezing of 1 mol of water at 0°C

c. Vaporization of 1 mol of water at 100°C

(d.) Condensation of 1 mol of water at 100°C

Use Table 17.3 to help you answer Questions 8 and 9.

8. How many of the 6 substances listed have a higher molar heat of vaporization than water? Which one(s)? ***none***

9. It takes ***3.22 kJ*** of energy to convert 1 mol of methanol molecules in the solid state to 1 mol of methanol molecules in the liquid state at the normal melting point.

Heat of Solution

10. The heat change caused by dissolution of one mole of a substance is the ***molar heat of solution***.

11. How does a cold pack containing water and ammonium nitrate work?

When activated, the cold pack allows water and ammonium nitrate to mix, producing an endothermic reaction. As heat is absorbed in the reaction, the temperature of the pack falls.

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Name ______ Class ______ Date ______

17.4 Calculating Heats of Reaction

For students using the Foundation edition, assign problems 1–7.

Essential Understanding Heats of reaction can be calculated when it is difficult or impossible to measure them directly.

Lesson Summary

Hess's Law Hess's law provides a way to calculate a reaction's heat of reaction when each heat of reaction is known for intermediate reactions.

- Hess's law states that if you add two or more thermochemical equations to get an overall equation, you also can add the heat of reaction of each step to get the overall heat of reaction.
- Hess's law is also called Hess's law of heat summation.

Standard Heats of Formation Using standard heats of formation is another way to determine heat of reaction when it cannot be measured directly.

- Standard heats of formation are determined at the standard state of a substance, which is its stable form at 25°C and 101.3 kPa.
- A compound's standard heat of formation is the change in enthalpy when one mole of the compound is formed from its elements with all substances in their standard states.
- For any reaction, the standard heat of reaction is calculated by subtracting the sum of the standard heats of formation of all the reactants from the sum of the standard heats of formation of all the products.

After reading Lesson 17.4, answer the following questions.

Hess's Law

1. For reactions that occur in a series of steps, Hess's law of heat summation says that if you add the thermochemical equations for each step to give a final equation for the reaction, you may also ***add the heats of reaction for each step to give the final heat of reaction***
______.

2. Is the following sentence true or false? Graphite is a more stable form of elemental carbon than is diamond at 25°C, so diamond will slowly change to graphite over an extremely long period of time. ***true***

3. Look at Figures 17.14 and 17.15. According to Hess's law, the enthalpy change from diamond to carbon dioxide can be expressed as the sum of what three enthalpy changes?

   a. ***diamond to graphite (−1.9 kJ)***

   b. ***graphite to carbon monoxide (−110.5 kJ)***

   c. ***carbon monoxide to carbon dioxide (−283.0 kJ)***

Name ______________________ Class ________ Date ________

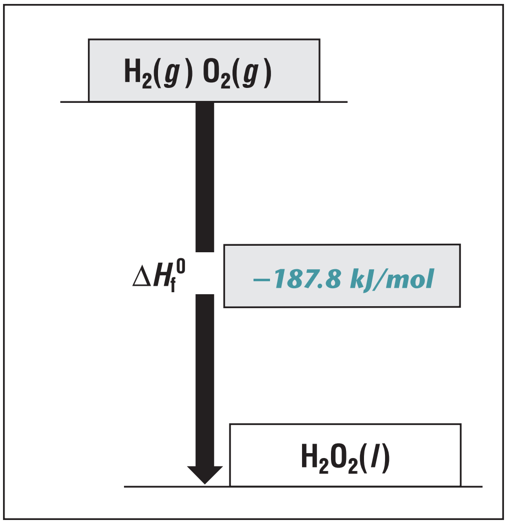
Standard Heats of Formation

4. The change in enthalpy that accompanies the formation of one mole of a compound from its elements with all substances in their standard states at 25°C and 101.3 kPa is called the ***standard heat of formation***.

5. Is the following sentence true or false? Chemists have set the standard heat of formation of free elements, including elements that occur in nature as diatomic molecules, at zero.

true

6. Complete the enthalpy diagram below by finding the heat of formation when hydrogen and oxygen gases combine to form hydrogen peroxide at 25°C. Use the data in Table 17.4 and the equation $\Delta H^0 = \Delta H_f^0$ (products) − ΔH_f^0 (reactants) to find the answer.



7. Look at Table 17.4. Methane burns to form carbon dioxide and water vapor.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

a. Will the heat of this reaction be positive or negative? How do you know?

It will be negative; the heats of formation for carbon dioxide and water vapor are much less than zero. The heat of formation of methane is much closer to zero.

b. How does your experience confirm that your answer to Question 7a is reasonable?

Burning fuels, such as methane, gives off heat. Exothermic reactions have negative heats of reaction.

Name ______________________ Class ________ Date ________

Guided Practice Problems

Answer the following questions about Practice Problem 3.

When 435 J of heat is added to 3.4 g of olive oil at 21°C, the temperature increases to 85°C. What is the specific heat of the olive oil?

Analyze

a. What is the formula for calculating specific heat? $C = \frac{q}{m \times \Delta T}$

b. What are the knowns and the unknown in this problem?

Knowns

m = ***3.4 g***

q = ***435 J***

ΔT = ***85°C − 21°C = 64°C***

Unknown

$C_{olive\ oil}$

Calculate

c. Substitute the known values into the equation for specific heat, and solve.

$$C_{\text{olive oil}} = \frac{435\ \text{J}}{3.4\ \text{g} \times 64°\text{C}} = 2.0\ \text{J/(g•°C)}$$

Evaluate

d. Explain why you think your answer is reasonable. Think about the time it takes to fry foods in olive oil versus the time it takes to cook foods in boiling water.

Because the specific heat of olive oil is lower than the specific heat of water, olive oil can reach a higher temperature than water when the same amount of energy is added to equal masses of each. This property makes olive oil good for cooking foods quickly because olive oil heats up more quickly than water under the same conditions.

e. Are the units in your answer correct? How do you know?

Yes; because specific heat is expressed in J/(g • °C), or cal/(g • °C).

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Name ______________________ Class ________ Date ________

Answer the following questions about Practice Problem 12.

When 50.0 mL of water containing 0.50 mol HCl at 22.5°C is mixed with 50.0 mL of water containing 0.50 mol NaOH at 22.5°C in a calorimeter, the temperature of the solution increases to 26.0°C. How much heat (in kJ) is released by this reaction?

a. Calculate the final volume of the water.
V_{final} = 50.0 mL + 50.0 mL = ***100.0 mL***

b. Calculate the total mass of the water, using the density of water.
$m = \textbf{100.0}\ \text{mL} \times \frac{\textbf{1.00}\ \text{g}}{\text{mL}} = \textbf{1.00} \times \textbf{10}^2\ \text{g}$

c. Calculate ΔT.
$\Delta T = 26.0°\text{C} - \textbf{22.5}\ °\text{C} = \textbf{3.5}\ °\text{C}$

d. Substitute the known quantities into the equation for changes in enthalpy (ΔH).
$\Delta H = -(\textbf{1.00} \times \textbf{10}^2\ \text{g}) \times (4.18\ \textbf{J/(g} \cdot \textbf{°C)}) \times \textbf{3.5}\ °\text{C}$

e. Solve.
−1500 J

f. Convert joules to kilojoules (kJ) and round to three significant figures.
$\textbf{-1500}\ \text{J} \times \frac{1\ \text{kJ}}{1000\ \text{J}} = \textbf{-1.5}\ \text{kJ}$

Answer the following questions about Practice Problem 22.

How many grams of ice at 0°C could be melted by the addition of 0.400 kJ of heat?

a. Write the conversion factors from ΔH_{fus} and the molar mass of ice.
$\frac{1\ \text{mol ice}}{\textbf{6.01}\ \text{kJ}}$ and $\frac{\textbf{18.0}\ \text{g ice}}{1\ \text{mol ice}}$

b. Multiply the known heat change by the conversion factors.
$0.400\ \cancel{\text{kJ}} \times \frac{1\ \cancel{\text{mol ice}}}{\textbf{6.01}\ \cancel{\text{kJ}}} \times \frac{\textbf{18.0}\ \text{g ice}}{1\ \cancel{\text{mol ice}}} = \textbf{1.20}\ \text{g ice}$

Apply the Big idea

A student dissolved a compound in water. The molar heat of solution of the compound is −54.3kJ/mol. The enthalpy of the solution changed by approximately 27 kJ.

Write three statements that you know to be true about dissolving this compound in water.

Sample answers:

The solution process is exothermic.

The temperature of the solution increases.

Approximately half a mole of the compound dissolves.

Name	Class	Date

17 Self-Check Activity

For Questions 1–10, complete each statement by writing the correct word or words. If you need help, you can go online.

17.1 The Flow of Energy

1. Energy changes occur as heat ***transfer*** and/or work.
2. The total amount of energy in the universe ***remains unchanged*** during any physical or chemical process.
3. The ***heat capacity*** of an object depends on its chemical composition and also on its mass.

17.2 Measuring and Expressing Enthalpy Changes

4. The enthalpy change of a reaction can be determined by measuring the heat flow of the reaction at constant ***pressure***.
5. In a(n) ***chemical equation***, enthalpy change can be written as a reactant, or it can be written as a(n) ***product***.

17.3 Heat in Changes of State

6. The quantity of heat released when a liquid solidifies ***equals*** the quantity of heat absorbed when the solid melts.
7. The quantity of heat released when a vapor condenses equals the quantity of heat absorbed when the ***liquid vaporizes***.
8. When a solute dissolves in a solvent, heat is either ***absorbed*** or released.

17.4 Calculating Heats of Reaction

9. Using ***Hess's law***, heat of reaction can be determined indirectly by using known heats of reaction of more than one thermochemical equation.
10. Heat of reaction can be calculated using standard heats of formation if the reaction occurs at ***standard conditions***.

If You Have Trouble With…

Question	1	2	3	4	5	6	7	8	9	10
See Page	556	557	559	562	565	569	572	574	578	580

Name ______________________ Class ______ Date ______

Review Key Equations

Match each of these problems with the equation you most likely would use to solve it. Use each equation only once.

a. $C = \frac{q}{m \times \Delta T}$

b. $q_{sys} = \Delta H = -q_{surr} = -m \times C \times \Delta T$

c. $\Delta H^0 = \Delta H_f^0 \text{ (products)} - \Delta H_f^0 \text{ (reactants)}$

___*b*___ **1.** What is the change in enthalpy if 50.0 mL of an aqueous solution of HCl at 20°C and 50.0 mL of an aqueous KOH solution at 20°C react in a calorimeter, and the temperature increases to 24°C?

___*c*___ **2.** What is the standard heat of reaction for the reaction of $SO_2(g)$ with $O_2(g)$ to form $SO_3(g)$?

___*a*___ **3.** The temperature of a piece of iron with a mass of 53 g increases from 10°C to 28°C when the iron absorbs 439 J of heat. What is the heat capacity of iron?

EXTENSION **What else do you need to know to solve Problem 2?**

You need to know the standard heats of formation of the reactants and the products in the reaction.

Review Vocabulary

In each set of three terms below, underline the term that does not belong with the other two terms. In the blanks provided, explain your answer. ***Sample answers are provided. Accept any answer that students can justify.***

4. molar heat of fusion, molar heat of solidification, <u>molar heat of solution</u>

The quantities of heat are the same for molar heat of fusion and molar heat of solidification.

5. heat capacity, <u>heat of reaction</u>, specific heat

Heat capacity and specific heat both relate to the amount of heat needed to raise the temperature of a sample of a substance 1°C. Heat of reaction does not.

6. Hess's law of heat summation, <u>heat of combustion</u>, heat of reaction

Hess's law and heat of reaction both relate to the heat of reaction of any type of chemical reaction. Heat of combustion refers to combustion reactions only.