Name _____ Date _____ Class _____

12–1 Review and Reinforcement

Chemical Reactions That Involve Heat

On the line at the left, write the letter of the definition that best matches each term.

_____	1. heat	a. reactions that release heat
_____	2. thermochemistry	b. the SI unit of energy and heat
_____	3. exothermic reactions	c. the energy that is transferred from one object to another
_____	4. endothermic reactions	d. the study of the changes in heat in chemical reactions
_____	5. joule	e. example of an exothermic reaction
_____	6. combustion	f. reactions that absorb heat

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.

_____ 7. It is <u>energy</u> that maintains your body temperature close to 37°C.

_____ 8. <u>Bond breaking</u> in chemical reactions releases energy.

_____ 9. Heat is transferred between two objects that are at <u>the same temperature</u>.

_____ 10. An <u>exothermic</u> reaction absorbs heat from the environment.

_____ 11. All combustion reactions are <u>exothermic</u>.

_____ 12. If a reaction is endothermic, the amount of heat appears on the <u>right</u> side of the arrow in the balanced equation.

_____ 13. Energy can be stored in the <u>chemical bonds</u> of a substance.

Answer each of the following questions in the space provided.

14. Provide two examples from daily life that demonstrate how heat is transferred from one object to another.

_____

_____

_____

_____

Name _____ Date _____ Class _____

12–1 *Review and Reinforcement (continued)*

15. Why is the joule, the SI unit of energy, also the appropriate unit for measuring heat?

16. Provide an analogy that explains why bond breaking requires energy.

17. When ammonium chloride dissolves in a beaker of water, the beaker becomes cold to the touch. Explain this phenomenon.

3

Name _____ Date _____ Class _____

12–4 Review and Reinforcement

Calorimetry

Complete each of the following sentences by filling in the appropriate word or phrase from the list below.

water	heat capacity	specific heat
heat	calorimetry	temperature
oxygen	calorimeter	carbohydrates

1. The study of heat flow and heat measurement is called _____.
2. The words calorimeter, calorimetry, and calorie are all derived from the Latin word *calor*, which means _____.
3. The amount of heat needed to raise an object's temperature depends on its _____.
4. Every substance has a _____, which tells you how much heat is necessary to raise the temperature of 1 gram of the substance by 1 Celsius degree.
5. _____ has one of the highest specific heats of any common substance.
6. A transfer of heat is detected by measuring a _____ change.
7. A _____ is a well-insulated container used to measure temperature changes.
8. On the average, _____ supply 17 kJ/g (4 Cal/g) of energy.
9. Foods are reacted with _____ in a laboratory calorimeter to determine their energy values.

Use your knowledge from Section 12–4 to write the meaning of each of the following symbols.

10. T_i _____
11. T_f _____
12. q_{rxn} _____
13. q_{sur} _____
14. m _____
15. C _____

Name _____ Date _____ Class _____

4

12–4 *Review and Reinforcement (continued)*

Answer the following question in the space provided.

16. Explain how a calorimeter is used to determine the quantity of heat transferred in a chemical reaction.

_____

_____

_____

_____

Solve each of the following problems as directed. Show all your work.

17. A metal that has a mass of 23.4 g has a heat capacity of 6.18 J/C°. What is the specific heat of the metal?

18. 15.3 g of $NaNO_3$ were dissolved in 100. g of water in a calorimeter. The temperature of the water dropped from 25.00°C to 21.56°C. Calculate ΔH for the solution process.

19. A 1.0-g sample of octane (C_8H_{18}) is burned in a calorimeter containing 1200 g of water. The temperature of the water rises from 25.00°C to 33.20°C. Calculate ΔH for this process.

20. How much heat is required to raise the temperature of 20.0 g of iron from 26°C to 72.30°C? The specific heat of iron is 0.447 J/g•C°.

Name _____ Date _____ Class _____

5

12–4 Practice Problems

1. When a 12.8-g sample of KCl dissolves in 75.0 g of water in a calorimeter, the temperature drops from 31.0°C to 21.6°C. Calculate ΔH for the process.

   $KCl(s) \rightarrow K^+(aq) + Cl^-(aq)$ $\Delta H = ?$

2. What is the specific heat of aluminum if the temperature of a 28.4-g sample of aluminum is increased by 8.1 C° when 207 J of heat is added?

3. When a 25.7-g sample of NaI dissolves in 80.0 g of water in a calorimeter, the temperature rises from 20.5°C to 24.4°C. Calculate ΔH for the process.

   $NaI(s) \rightarrow Na^+(aq) + I^-(aq)$ $\Delta H = ?$

4. What is the specific heat of silicon if the temperature of a 4.11-g sample of silicon is increased by 3.8 C° when 11.1 J of heat is added?

5. When a 16.9-g sample of NaOH dissolves in 70.0 g of water in a calorimeter, the temperature rises from 22.4°C to 86.6°C. Calculate ΔH for the process.

   $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$ $\Delta H = ?$

6. What is the specific heat of gold if the temperature of a 8.21-g sample of gold is increased by 6.2 C° when 6.51 J of heat is added?

7. When a 19.2-g sample of KCN dissolves in 65.0 g of water in a calorimeter, the temperature drops from 28.1°C to 15.4°C. Calculate ΔH for the process.

   $KCN(s) \rightarrow K^+(aq) + CN^-(aq)$ $\Delta H = ?$

8. What is the specific heat of silver if the temperature of a 15.4-g sample of silver is increased by 11.2 C° when 40.5 J of heat is added?

9. When a 28.7-g sample of KI dissolves in 60.0 g of water in a calorimeter, the temperature drops from 27.2°C to 13.2°C. Calculate ΔH for the process.

   $KI(s) \rightarrow K^+(aq) + I^-(aq)$ $\Delta H = ?$

10. What is the specific heat of titanium if the temperature of a 36.7-g sample of titanium is increased by 4.8 C° when 91.6 J of heat is added?

Name _____ Date _____ Class _____

6

12–3 Practice Problems

1. From the following enthalpy changes,

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$ $\Delta H° = -110.5$ kJ

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -283.0$ kJ

calculate the value of $\Delta H°$ for the reaction $C(s) + O_2(g) \rightarrow CO_2(g)$.

2. From the following enthalpy changes,

$2P(s) + 3Cl_2(g) \rightarrow 2PCl_3(l)$ $\Delta H° = -640$ kJ

$2P(s) + 5Cl_2(g) \rightarrow 2PCl_5(s)$ $\Delta H° = -886$ kJ

calculate the value of $\Delta H°$ for the reaction $PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s)$.

3. From the following enthalpy changes,

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H° = -1234.7$ kJ

$CH_3OCH_3(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H° = -1328.3$ kJ

calculate the value of $\Delta H°$ for the reaction $C_2H_5OH(l) \rightarrow CH_3OCH_3(l)$.

4. From the following enthalpy changes,

$Cu(s) + Cl_2(g) \rightarrow CuCl_2(s)$ $\Delta H° = -206$ kJ

$2Cu(s) + Cl_2(g) \rightarrow 2CuCl(s)$ $\Delta H° = -136$ kJ

calculate the value of $\Delta H°$ for the reaction $CuCl_2(s) + Cu(s) \rightarrow 2CuCl(s)$.

5. From the following enthalpy changes,

$H_2(g) + F_2(g) \rightarrow 2HF(g)$ $\Delta H° = -542.2$ kJ

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H° = -571.6$ kJ

calculate the value of $\Delta H°$ for the reaction $2F_2(g) + 2H_2O(l) \rightarrow 4HF(g) + O_2(g)$.

6. From the following enthalpy changes,

$Xe(g) + F_2(g) \rightarrow XeF_2(s)$ $\Delta H° = -123$ kJ

$Xe(g) + 2F_2(g) \rightarrow XeF_4(s)$ $\Delta H° = -262$ kJ

calculate the value of $\Delta H°$ for the reaction $XeF_2(s) + F_2(g) \rightarrow XeF_4(s)$.

7. From the following enthalpy changes,

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$ $\Delta H° = -1170$ kJ

$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$ $\Delta H° = -1530$ kJ

calculate the value of $\Delta H°$ for the reaction $N_2(g) + O_2(g) \rightarrow 2NO(g)$.

8. From the following enthalpy changes,

$2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s)$ $\Delta H° = -1601$ kJ

$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$ $\Delta H° = -821$ kJ

calculate the value of $\Delta H°$ for the reaction $2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(s) + Al_2O_3(s)$.

9. From the following enthalpy changes,

$H_2O_2(l) \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$ $\Delta H° = -94.6$ kJ

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -286.0$ kJ

calculate the value of $\Delta H°$ for the reaction $H_2(g) + H_2O_2(l) \rightarrow 2H_2O(l)$.

10. From the following enthalpy changes,

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -393.5$ kJ

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H° = -285.8$ kJ

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$ $\Delta H° = -2598.8$ kJ

calculate the value of $\Delta H°$ for the reaction $2C(s) + H_2(g) \rightarrow C_2H_2(g)$.

Name _____ Date _____ Class _____

12–2 Review and Reinforcement

Heat and Enthalpy Changes

Complete each of the following sentences by filling in the appropriate word or phrase from the list below.

less	endothermic	change
moles	exothermic	pressure
energy	standard enthalpy change	enthalpy

1. The heat absorbed or released in a reaction depends on a quantity called _____.
2. The enthalpy of a substance is similar to, but not exactly the same as, the _____ of a substance.
3. The symbol ΔH literally means a _____ in enthalpy.
4. The ΔH for a(n) _____ reaction always has a positive sign.
5. In an exothermic reaction, $H_{products}$ will always be _____ than $H_{reactants}$.
6. Conditions such as temperature, _____, and the physical states of the substances in a reaction can affect ΔH.
7. The enthalpy change measured at 1 atm and 25°C, when the reactants and products are in their standard states, is called a _____.
8. You must know the number of _____ of reactants involved in a reaction to calculate ΔH.

Answer each of the following questions in the space provided.

9. How is the enthalpy of a substance related to the energy of a substance?

10. If you were given $\Delta H°$ of a reaction, could you determine whether the reaction was exothermic or endothermic? Explain your answer.

Name _____ Date _____ Class _____

12–2 *Review and Reinforcement (continued)*

11. Compare the enthalpy of the reactants and the products in both exothermic and endothermic reactions.

12. What is meant by the standard state of an element?

Solve each of the following problems as directed. Show all your work.

13. Calculate the amount of heat released by the combustion of 1.75 mol of benzene (C_6H_6).

$$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O \qquad \Delta H^\circ = -98.0 \text{ kJ}$$

14. How much heat is transferred when 100.0 g of calcium oxide (CaO) reacts with carbon according to the equation below? Is this reaction endothermic or exothermic?

$$CaO + 3C \rightarrow CaC_2 + CO \qquad \Delta H^\circ = +464.8 \text{ kJ}$$

15. Ammonium dichromate decomposes in a vigorous reaction when it is heated. Calculate the heat transferred for the decomposition of 53.0 g of ammonium dichromate according to the following equation.

$$(NH_4)_2\,Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3 \qquad \Delta H^\circ = -315 \text{ kJ}$$

Name _____ Date _____ Class _____

9

12–2 Practice Problems

1. How much heat will be released when 6.44 g of sulfur reacts with excess O_2 according to the following equation?

   $2S + 3O_2 \rightarrow 2SO_3$ $\quad \Delta H° = -791.4$ kJ

2. How much heat will be released when 4.72 g of carbon reacts with excess O_2 according to the following equation?

   $C + O_2 \rightarrow CO_2$ $\quad \Delta H° = -393.5$ kJ

3. How much heat will be absorbed when 38.2 g of bromine reacts with excess H_2 according to the following equation?

   $H_2 + Br_2 \rightarrow 2HBr$ $\quad \Delta H° = 72.80$ kJ

4. How much heat will be released when 1.48 g of chlorine reacts with excess phosphorus according to the following equation?

   $2P + 5Cl_2 \rightarrow 2PCl_5$ $\quad \Delta H° = -886$ kJ

5. How much heat will be released when 4.77 g of ethanol (C_2H_5OH) reacts with excess O_2 according to the following equation?

   $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ $\quad \Delta H° = -1366.7$ kJ

6. How much heat will be absorbed when 13.7 g of nitrogen reacts with excess O_2 according to the following equation?

   $N_2 + O_2 \rightarrow 2NO$ $\quad \Delta H° = 180$ kJ

7. How much heat will be released when 11.8 g of iron reacts with excess O_2 according to the following equation?

   $3Fe + 2O_2 \rightarrow Fe_3O_4$ $\quad \Delta H° = -1120.48$ kJ

8. How much heat will be released when 18.6 g of hydrogen reacts with excess O_2 according to the following equation?

   $2H_2 + O_2 \rightarrow H_2O$ $\quad \Delta H° = -571.6$ kJ

9. How much heat will be transferred when 14.9 g of ammonia reacts with excess O_2 according to the following equation? Is this reaction endothermic or exothermic?

   $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ $\quad \Delta H° = -1170$ kJ

10. How much heat will be transferred when 5.81 g of graphite reacts with excess H_2 according to the following equation? Is this reaction endothermic or exothermic?

    $6C(\text{graphite}) + 3H_2 \rightarrow C_6H_6$ $\quad \Delta H° = 49.03$ kJ

10

Chemistry in
Earth Systems

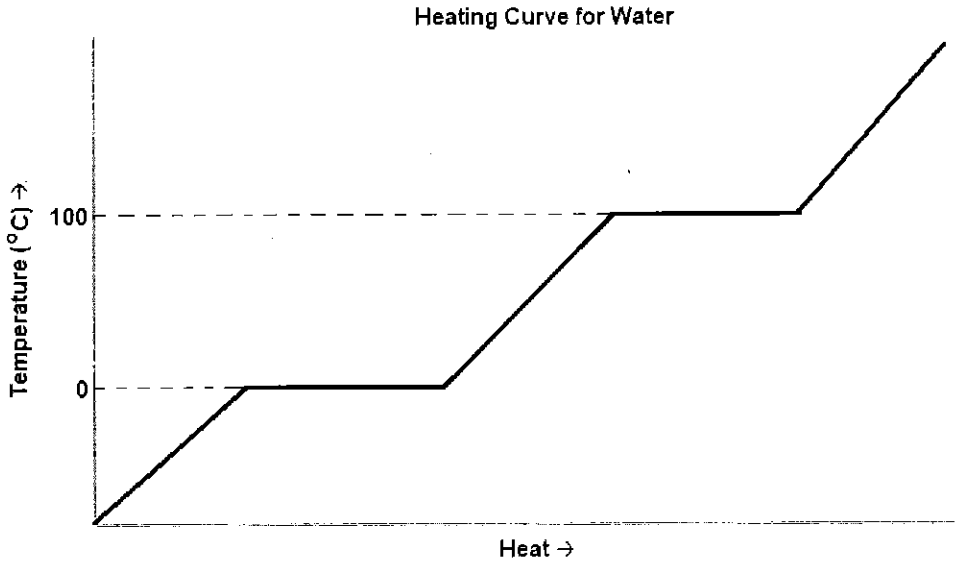
Mr. Thaler

Heat of Phase Changes

Use the data table below, the heating curve, dimensional analysis, and $q = m$ x *specific heat* x ΔT to solve the following problems.

Substance	**Specific Heat (J/g·K)**	**MP (°C)**	**ΔH_{fus} (kJ/mol)**	**BP (°C)**	**ΔH_{vap} (kJ/mol)**
$H_2O(s)$, ice	2.09	0.00	6.02	***	***
$H_2O(l)$, water	4.18	***	***	100.00	40.7
$H_2O(g)$, steam	1.84	***	***	***	***

*** *indicates data not available or not applicable*



SHOW YOUR WORK. WRITE YOUR ANSWERS IN JOULES.
All processes occur at a constant pressure of 1 atm.

1. Calculate the amount of heat required to change 80.0 g of ice at –12.0 °C to steam at 114 °C.

2. How much heat is transferred in the process of completely melting a 1.6-kg block of ice starting at –15.0 °C? Is this process endothermic or exothermic?

3. How much heat is exchanged with the environment when a sample of steam with a temperature of 109 °C condenses to 3.6 mL of liquid water with a density of 0.997 g/mL at 25.0 °C? Is this process endothermic or exothermic?

4. Calculate the amount of heat transferred when 2.0 L of water at 25.0 °C (density = 0.997 g/cm^3) is frozen to –10.0 °C. Is this process exothermic or endothermic?