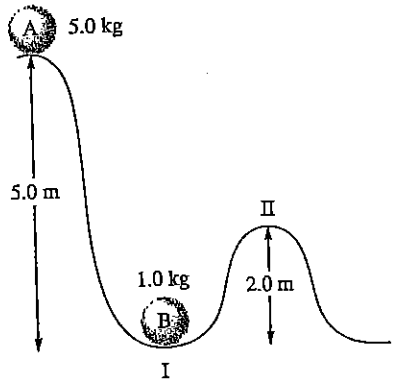
Chapter 6 and 16 Book Problems

CH6 p.279-284
CH16 p.814-816

Energy

9. Explain why ΔH is obtained directly from a coffee-cup calorimeter, whereas ΔE is obtained directly from a bomb calorimeter.

20. Consider the accompanying diagram. Ball A is allowed to fall and strike ball B. Assume that all of ball A's energy is transferred to ball B, at point I, and that there is no loss of energy to other sources. What is the kinetic energy and the potential energy of ball B at point II? The potential energy is given by PE = mgz, where m is the mass in kilograms, g is the gravitational constant (9.8 m/s^2), and z is the distance in meters.



23. A gas absorbs 45 kJ of heat and does 29 kJ of work. Calculate ΔE.

24. A system releases 125 kJ of heat while 104 kJ of work is done on it. Calculate ΔE.

25. The volume of an ideal gas is decreased from 5.0 L to 5.0 mL at a constant pressure of 2.0 atm. Calculate the work associated with this process.

27. A balloon filled with 39.1 mol helium has a volume of 876 L at 0.0°C and 1.00 atm pressure. The temperature of the balloon is increased to 38.0°C as it expands to a volume of 998 L, the pressure remaining constant. Calculate q, w, and ΔE for the helium in the balloon. (The molar heat capacity for helium gas is 20.8 J/°C · mol.)

29. The equation for the fermentation of glucose to alcohol and carbon dioxide is

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

The enthalpy change for the reaction is −67 kJ. Is the reaction exothermic or endothermic? Is energy, in the form of heat, absorbed or evolved as the reaction occurs?

31. Are the following processes exothermic or endothermic?
   a. When solid KBr is dissolved in water, the solution gets colder.
   b. Natural gas (CH_4) is burned in a furnace.
   c. When concentrated H_2SO_4 is added to water, the solution gets very hot.
   d. Water is boiled in a teakettle.

33. For the reaction

$$S(s) + O_2(g) \longrightarrow SO_2(g) \qquad \Delta H = -296 \text{ kJ/mol}$$

   a. How much heat is evolved when 275 g sulfur is burned in excess O_2?
   b. How much heat is evolved when 25 mol sulfur is burned in excess O_2?
   c. How much heat is evolved when 150. g sulfur dioxide is produced?

35. Consider the combustion of propane:

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l) \qquad \Delta H = -2221 \text{ kJ}$$

Assume that all the heat in Sample Exercise 6.3 comes from the combustion of propane. What mass of propane must be burned to furnish this amount of energy?

Calorimetry

37. The specific heat capacity of aluminum is 0.900 J/°C · g.
   a. Calculate the energy needed to raise the temperature of a 8.50×10^2-g block of aluminum from 22.8°C to 94.6°C.
   b. Calculate the molar heat capacity of aluminum.

39. It takes 78.2 J to raise the temperature of 45.6 g lead by 13.3°C. Calculate the specific heat capacity and molar heat capacity of lead.

43. A 28.2-g sample of nickel is heated to 99.8°C and placed in a coffee-cup calorimeter containing 150.0 g water at 23.5°C. After the metal cools, the final temperature of metal and water is 25.0°C. Calculate the specific heat capacity of nickel, assuming that no heat escapes to the surroundings or is transferred to the calorimeter.

Calorimetry

45. A coffee-cup calorimeter initially contains 125 g water at 24.2°C. Potassium bromide (10.5 g), also at 24.2°C, is added to the water, and after the KBr dissolves, the final temperature is 21.1°C. Calculate the enthalpy change for dissolving the salt in J/g and kJ/mol. Assume that the specific heat capacity of the solution is 4.18 J/°C · g and that no heat is transferred to the surroundings or to the calorimeter.

47. In a coffee-cup calorimeter, 50.0 mL of 0.100 *M* $AgNO_3$ and 50.0 mL of 0.100 *M* HCl are mixed to yield the following reaction:

$$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$$

The two solutions were initially at 22.60°C, and the final temperature is 23.40°C. Calculate the heat that accompanies this reaction in kJ/mol of AgCl formed. Assume that the combined solution has a mass of 100.0 g and has a specific heat capacity of 4.18 J/°C · g.

50. A 0.1964-g sample of quinone ($C_6H_4O_2$) is burned in a bomb calorimeter that has a heat capacity of 1.56 kJ/°C. The temperature of the calorimeter increases by 3.2°C. Calculate the energy of combustion of quinone per gram and per mole.

76. A swimming pool, 10.0 m by 4.0 m, is filled with water to a depth of 3.0 m at a temperature of 20.2°C. How much energy is required to raise the temperature of the water to 30.0°C?

77. Calculate $\Delta H°$ for the reaction

$$2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$$

A 5.00-g chunk of potassium is dropped into 1.00 kg water at 24.0°C. What is the final temperature of the water after the preceding reaction occurs? Assume that all the heat is used to raise the temperature of the water. (Never run this reaction. It is very dangerous; it bursts into flame!)

Hess' Law

52. Combustion reactions involve reacting a substance with oxygen. When compounds containing carbon and hydrogen are combusted, carbon dioxide and water are the products. Using the enthalpies of combustion for C_4H_4 (−2341 kJ/mol), C_4H_8 (−2755 kJ/mol), and H_2 (−286 kJ/mol), calculate ΔH for the reaction

$$C_4H_4(g) + 2H_2(g) \longrightarrow C_4H_8(g)$$

53. Given the following data:

$$S(s) + \tfrac{3}{2}O_2(g) \longrightarrow SO_3(g) \qquad \Delta H = -395.2 \text{ kJ}$$
$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g) \qquad \Delta H = -198.2 \text{ kJ}$$

calculate ΔH for the reaction

$$S(s) + O_2(g) \longrightarrow SO_2(g)$$

55. Given the following data:

$$2O_3(g) \longrightarrow 3O_2(g) \qquad \Delta H = -427 \text{ kJ}$$

$$O_2(g) \longrightarrow 2O(g) \qquad \Delta H = +495 \text{ kJ}$$

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g) \qquad \Delta H = -199 \text{ kJ}$$

calculate ΔH for the reaction

$$NO(g) + O(g) \longrightarrow NO_2(g)$$

56. The bombardier beetle uses an explosive discharge as a defensive measure. The chemical reaction involved is the oxidation of hydroquinone by hydrogen peroxide to produce quinone and water:

$$C_6H_4(OH)_2(aq) + H_2O_2(aq) \longrightarrow C_6H_4O_2(aq) + 2H_2O(l)$$

Calculate ΔH for this reaction from the following data:

$$C_6H_4(OH)_2(aq) \longrightarrow C_6H_4O_2(aq) + H_2(g) \qquad \Delta H = +177.4 \text{ kJ}$$

$$H_2(g) + O_2(g) \longrightarrow H_2O_2(aq) \qquad \Delta H = -191.2 \text{ kJ}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(g) \qquad \Delta H = -241.8 \text{ kJ}$$

$$H_2O(g) \longrightarrow H_2O(l) \qquad \Delta H = -43.8 \text{ kJ}$$

58. Calculate the ΔH for the reaction

$$N_2H_4(l) + O_2(g) \longrightarrow N_2(g) + 2H_2O(l)$$

given the following data:

$$2NH_3(g) + 3N_2O(g) \longrightarrow 4N_2(g) + 3H_2O(l) \qquad \Delta H = -1010. \text{ kJ}$$

$$N_2O(g) + 3H_2(g) \longrightarrow N_2H_4(l) + H_2O(l) \qquad \Delta H = -317 \text{ kJ}$$

$$2NH_3(g) + \tfrac{1}{2}O_2(g) \longrightarrow N_2H_4(l) + H_2O(l) \qquad \Delta H = -143 \text{ kJ}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(l) \qquad \Delta H = -286 \text{ kJ}$$

82. Given the following data:

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g) \qquad \Delta H^\circ = -23 \text{ kJ}$$

$$3Fe_2O_3(s) + CO(g) \longrightarrow 2Fe_3O_4(s) + CO_2(g) \qquad \Delta H^\circ = -39 \text{ kJ}$$

$$Fe_3O_4(s) + CO(g) \longrightarrow 3FeO(s) + CO_2(g) \qquad \Delta H^\circ = +18 \text{ kJ}$$

calculate ΔH° for the reaction

$$FeO(s) + CO(g) \longrightarrow Fe(s) + CO_2(g)$$

CH 16 ΔH, ΔS + ΔG Problems (p. 814-816)

27. Given the values of ΔH and ΔS, which of the following changes will be spontaneous at constant T and P?
    a. $\Delta H = +25$ kJ, $\Delta S = +5.0$ J/K, $T = 300.$ K
    b. $\Delta H = +25$ kJ, $\Delta S = +100.$ J/K, $T = 300.$ K
    c. $\Delta H = -10.$ kJ, $\Delta S = +5.0$ J/K, $T = 298$ K
    d. $\Delta H = -10.$ kJ, $\Delta S = -40.$ J/K, $T = 200.$ K
28. At what temperatures will the following processes be spontaneous?
    a. $\Delta H = -25$ kJ and $\Delta S = -5.0$ J/K
    b. $\Delta H = +25$ kJ and $\Delta S = +5.0$ J/K
    c. $\Delta H = +25$ kJ and $\Delta S = -5.0$ J/K
    d. $\Delta H = -25$ kJ and $\Delta S = +5.0$ J/K

37. Predict the sign of $\Delta S°$ and then calculate $\Delta S°$ for each of the following reactions.
    a. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$
    b. $3O_2(g) \rightarrow 2O_3(g)$
    c. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

Using data in Appendix 4, calculate $\Delta H°$, $\Delta S°$, and $\Delta G°$ for each of the following reactions at 25°C.
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$
Glucose

    c. $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$
    d. $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$
46. For the reaction at 298 K,

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

the values of $\Delta H°$ and $\Delta S°$ are -58.03 kJ/mol and -176.6 J/K · mol, respectively. What is the value of $\Delta G°$ at 298 K? Assume that $\Delta H°$ and $\Delta S°$ do not depend on temperature. At what temperature is $\Delta G° = 0$? Is $\Delta G°$ negative above or below this temperature?

47. Using data from Appendix 4, calculate $\Delta H°$, $\Delta S°$, and $\Delta G°$ for the following reactions that produce acetic acid:

$$CH_4(g) + CO_2(g) \rightarrow CH_3\overset{O}{\overset{\|}{C}}—OH(l)$$

$$CH_3OH(g) + CO(g) \rightarrow CH_3\overset{O}{\overset{\|}{C}}—OH(l)$$

Which reaction would you choose as a commercial method for producing acetic acid (CH_3CO_2H) at standard conditions? What temperature conditions would you choose for the reaction? Assume $\Delta H°$ and $\Delta S°$ do not depend on temperature.

54. Consider the reaction

$$Fe_2O_3(s) + 3H_2(g) \longrightarrow 2Fe(s) + 3H_2O(g)$$

    a. Use $\Delta G_f°$ values in Appendix 4 to calculate $\Delta G°$ for this reaction.
    b. Is this reaction spontaneous under standard conditions at 298 K?
    c. The value of $\Delta H°$ for this reaction is 100. kJ. At what temperatures is this reaction spontaneous at standard conditions? Assume that $\Delta H°$ and $\Delta S°$ do not depend on temperature.