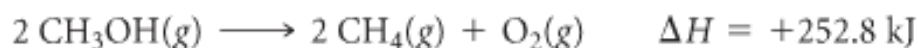


**5.27** Calculate  $\Delta E$  and determine whether the process is endothermic or exothermic for the following cases: (a)  $q = 0.763$  kJ and  $w = -840$  J; (b) a system releases 66.1 kJ of heat to its surroundings while the surroundings do 44.0 kJ of work on the system; (c) the system absorbs 7.25 kJ of heat from the surroundings while its volume remains constant (assume that only  $P$ - $V$  work can be done).

**5.40** The decomposition of *slaked lime*,  $\text{Ca}(\text{OH})_2(s)$ , into *lime*,  $\text{CaO}(s)$ , and  $\text{H}_2\text{O}(g)$  at constant pressure requires the addition of 109 kJ of heat per mole of  $\text{Ca}(\text{OH})_2$ . (a) Write a balanced thermochemical equation for the reaction. (b) Draw an enthalpy diagram for the reaction.

5.44 Consider the following reaction:



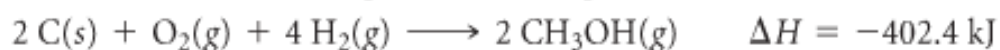
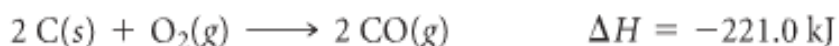
(a) Is this reaction exothermic or endothermic? (b) Calculate the amount of heat transferred when 24.0 g of  $\text{CH}_3\text{OH}(g)$  is decomposed by this reaction at constant pressure. (c) For a given sample of  $\text{CH}_3\text{OH}$ , the enthalpy change during the reaction is 82.1 kJ. How many grams of methane gas are produced? (d) How many kilojoules of heat are released when 38.5 g of  $\text{CH}_4(g)$  reacts completely with  $\text{O}_2(g)$  to form  $\text{CH}_3\text{OH}(g)$  at constant pressure?

5.57 A 2.200-g sample of quinone ( $\text{C}_6\text{H}_4\text{O}_2$ ) is burned in a bomb calorimeter whose total heat capacity is 7.854 kJ/ $^\circ\text{C}$ . The temperature of the calorimeter increases from 23.44  $^\circ\text{C}$  to 30.57  $^\circ\text{C}$ . What is the heat of combustion per gram of quinone? Per mole of quinone?

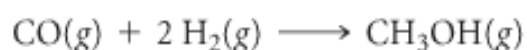
**5.60** Under constant-volume conditions, the heat of combustion of benzoic acid ( $C_6H_5COOH$ ) is 26.38 kJ/g. A 2.760-g sample of benzoic acid is burned in a bomb calorimeter. The temperature of the calorimeter increases from 21.60 °C to 29.93 °C. (a) What is the total heat capacity of the calorimeter? (b) A 1.440-g sample of a new organic substance is combusted in the same calorimeter. The temperature of the calorimeter increases from 22.14 °C to 27.09 °C. What is the heat of combustion per gram of the new substance? (c) Suppose that in changing samples, a portion of the water in the calorimeter were lost. In what way, if any, would this change the heat capacity of the calorimeter?

A piece of unknown metal with a mass of 5.19 g is heated to 100.00 °C and dropped into 10.0 mL of water at 22.00 °C. The final temperature of the system is 23.83 °C. What is the specific heat capacity of the metal? Attempt to identify the metal using the attached data.

5.64 From the enthalpies of reaction



calculate  $\Delta H$  for the reaction

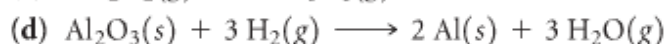
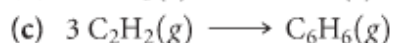
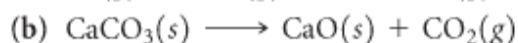
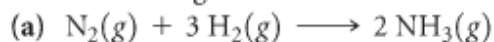


5.70 Write balanced equations that describe the formation of the following compounds from elements in their standard states, and use **Appendix C** to obtain the values of their standard enthalpies of formation: (a)  $\text{H}_2\text{O}_2(g)$ , (b)  $\text{CaCO}_3(s)$ , (c)  $\text{POCl}_3(l)$ , (d)  $\text{C}_7\text{H}_5\text{OH}(l)$ .

5.72 Many portable gas heaters and grills use propane,  $\text{C}_3\text{H}_8(g)$ , as a fuel. Using standard enthalpies of formation, calculate the quantity of heat produced when 10.0 g of propane is completely combusted in air under standard conditions.

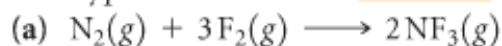
19.42 For each of the following pairs, indicate which substance possesses the larger standard entropy: (a) 1 mol of  $\text{P}_4(g)$  at 300 °C, 0.01 atm, or 1 mol of  $\text{As}_4(g)$  at 300 °C, 0.01 atm; (b) 1 mol of  $\text{H}_2\text{O}(g)$  at 100 °C, 1 atm, or 1 mol of  $\text{H}_2\text{O}(l)$  at 100 °C, 1 atm; (c) 0.5 mol of  $\text{N}_2(g)$  at 298 K, 20-L volume, or 0.5 mol  $\text{CH}_4(g)$  at 298 K, 20-L volume; (d) 100 g  $\text{Na}_2\text{SO}_4(s)$  at 30 °C or 100 g  $\text{Na}_2\text{SO}_4(aq)$  at 30 °C.

19.43 Predict the sign of the entropy change of the system for each of the following reactions:

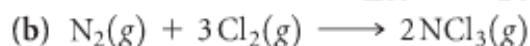


**19.57** For a certain chemical reaction,  $\Delta H^\circ = -35.4 \text{ kJ}$  and  $\Delta S^\circ = -85.5 \text{ J/K}$ . (a) Is the reaction exothermic or endothermic? (b) Does the reaction lead to an increase or decrease in the randomness or disorder of the system? (c) Calculate  $\Delta G^\circ$  for the reaction at 298 K. (d) Is the reaction spontaneous at 298 K under standard conditions?

**19.65** Classify each of the following reactions as one of the four possible types summarized in [Table 19.3](#):



$$\Delta H^\circ = -249 \text{ kJ}; \Delta S^\circ = -278 \text{ J/K}$$



$$\Delta H^\circ = 460 \text{ kJ}; \Delta S^\circ = -275 \text{ J/K}$$



$$\Delta H^\circ = 85 \text{ kJ}; \Delta S^\circ = 198 \text{ J/K}$$

**19.85** The value of  $K_a$  for nitrous acid ( $\text{HNO}_2$ ) at  $25\text{ }^\circ\text{C}$  is given in Appendix D. (a) Write the chemical equation for the equilibrium that corresponds to  $K_a$ . (b) By using the value of  $K_a$ , calculate  $\Delta G^\circ$  for the dissociation of nitrous acid in aqueous solution. (c) What is the value of  $\Delta G$  at equilibrium? (d) What is the value of  $\Delta G$  when  $[\text{H}^+] = 5.0 \times 10^{-2}\text{ M}$ ,  $[\text{NO}_2^-] = 6.0 \times 10^{-4}\text{ M}$ , and  $[\text{HNO}_2] = 0.20\text{ M}$ ?