Applying Inquiry Skills

5. Assume that 200 mL of solution is 200 g water.

$$q_{water} = mc\Delta T$$
$$= 200 \text{ g} \times 4.18 \text{ J/g•°C} \times (28.1 - 21.0)\text{°C}$$
$$q_{water} = 5.94 \text{ kJ}$$
$$\text{amount of KOH} = n$$
$$= 5.2 \text{ g} \times 1 \text{ mol}/56.1 \text{ g}$$
$$n = 0.0927 \text{ mol}$$
$$n\Delta H_{reaction} = q_{water}$$
$$\Delta H_{reaction} = \frac{q_{water}}{n}$$
$$= \frac{5.94 \text{ kJ}}{0.0927 \text{ mol}}$$
$$\Delta H_{reaction} = 64 \text{ kJ/mol } Ba(NO_3)_2$$

Because the reaction is exothermic, $\Delta H_{reaction}$ is −64 kJ/mol.

6. Answers will vary, but the student could use a polystyrene (Styrofoam) coffee cup calorimeter and thermometer to investigate temperature changes that occurred when the dextrose tablets were added to water. A mortar and pestle might be used to simulate the grinding process that occurs in chewing. Ambitious students might even investigate whether there was any effect of amylase (found in saliva) on the process.

Making Connections

7. See the Nelson *Chemistry 12* web site for possible useful sources of information. In general, the propane is used to vaporize and separate the components of an aqueous ammonia mixture. The ammonia gas then goes through cycles of condensation (outside the compartment, releasing heat to the air) and evaporation inside the compartment (absorbing heat from food).

5.3 REPRESENTING ENTHALPY CHANGES

PRACTICE

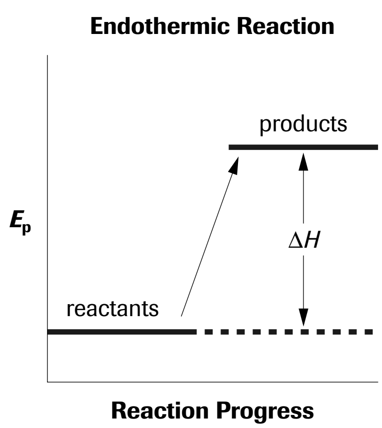
(Page 319)

Understanding Concepts

1. (a) $2\,C_{(s)} + H_{2(g)} + 228 \text{ kJ} \rightarrow C_2H_{2(g)}$

$2\,C_{(s)} + H_{2(g)} \rightarrow C_2H_{2(g)} \quad \Delta H = +228 \text{ kJ}$

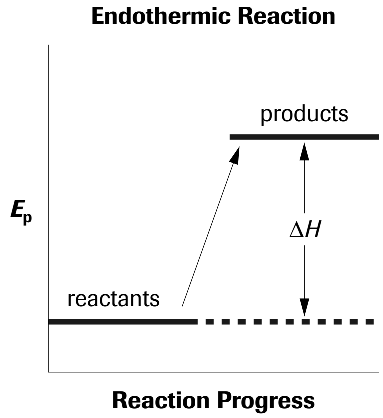
$\Delta H°_f = +228$ kJ/mol acetylene



(b) $Al_2O_{3(s)}$ + 1676 kJ $\rightarrow$ 2 $Al_{(s)}$ + 3/2 $O_{2(g)}$

$Al_2O_{3(s)} \rightarrow 2\ Al_{(s)} + 3/2\ O_{2(g)} \quad \Delta H = +1676$ kJ

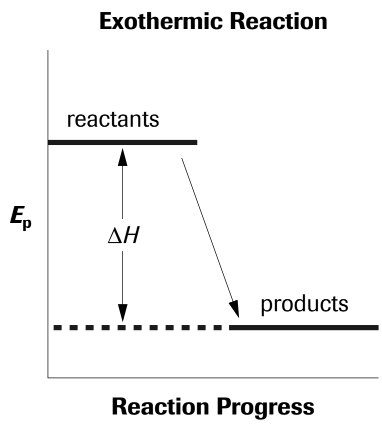
$\Delta H°_{decomp} = +1676$ kJ/mol aluminum oxide



(c) $C_{(s)}$ + $O_{2(g)}$ $\rightarrow$ $CO_{2(g)}$ + 393.5 kJ

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta H = -393.5$ kJ

$\Delta H°_{comb} = -393.5$ kJ/mol carbon



2. (a) $\Delta H_{comb} = -241.8$ kJ/mol H_2

(b) $\Delta H_{comb} = -283.6$ kJ/mol NH_3

(c) $\Delta H_{comb} = +81.6$ kJ/mol N_2

(d) $\Delta H_{comb} = -372.8$ kJ/mol Fe

3. (a) $\Delta H = -114$ kJ

(b) $H_2SO_{4(aq)} + 2\ NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2\ H_2O_{(l)} \quad \Delta H = -114$ kJ

(c) $\Delta H_{neut} = -114$ kJ/mol H_2SO_4

(d) $\Delta H_{neut} = -57$ kJ/mol NaOH

4. (a) $H_{2(g)} + 1/2\ O_{2(g)} \rightarrow H_2O_{(g)} \quad \Delta H = -241.8$ kJ

$H_2O_{(g)} \rightarrow H_{2(g)} + 1/2\ O_{2(g)} \quad \Delta H = +241.8$ kJ

(b) Such equations have the same enthalpy change with a different sign.

5. (a) The reaction is exothermic because potential energy is converted to heat lost to the surroundings.

(b) The reaction is endothermic because heat absorbed from the surroundings is converted to potential energy.

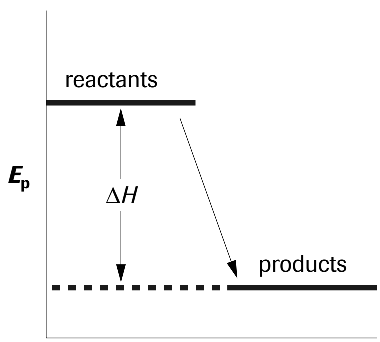
SECTION 5.3 QUESTIONS

(Page 320)

Understanding Concepts

1. (a) Since the reaction is exothermic, the PE diagram will resemble this. Reactants are octane and oxygen; the products are carbon dioxide and water.

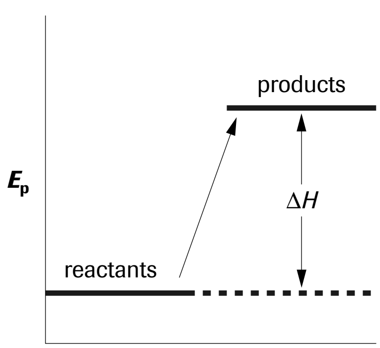
Exothermic Reaction



Reaction Progress

(b) Since the reaction is endothermic, the PE diagram will resemble this. Reactants are boron and hydrogen; the product is diborane.

Endothermic Reaction



Reaction Progress

2. (a) $Mg_{(s)} + O_{2(g)} + H_{2(g)} \rightarrow Mg(OH)_{(s)} \quad \Delta H = -925 \text{ kJ}$

(b) $C_5H_{12(g)} + 8\,O_{2(g)} \rightarrow 5\,CO_{2(g)} + 6\,H_2O_{(g)} \quad \Delta H° = -2018 \text{ kJ}$

(c) $NiO_{(s)} \rightarrow Ni_{(s)} + 1/2\,O_{2(g)} \quad \Delta H° = 240 \text{ kJ}$

3. (a) $C_4H_{10(g)} + 13/2\,O_{2(g)} \rightarrow 4\,CO_{2(g)} + 5\,H_2O_{(g)} + 2.87 \text{ MJ}$

(b) $C_{(graphite)} + 2 \text{ kJ} \rightarrow C_{(diamond)}$

(c) $C_2H_6O_{(l)} + 3\,O_{2(g)} \rightarrow 2\,CO_{2(g)} + 3\,H_2O_{(g)} + 1.28 \text{ MJ}$

Applying Inquiry Skills

4. **Analysis**

(a) $q_{water} = mc\Delta T$

$= 200.0 \text{ g} \times 4.18 \text{ J/(g•°C)} \times (76.0 - 21.0)\text{°C}$

$q_{water} = 45.9(8) \text{ kJ}$ [Digit in parentheses will be lost in rounding.]

$$q_{copper} = mc\Delta T$$
$$= 50.0\ g \times 0.385\ J/(g{\bullet}°C) \times (76.0 - 21.0)°C$$
$$q_{copper} = 1.06\ kJ$$
$$n\Delta H_{reaction} = q_{total}$$
$$= q_{water} + q_{copper}$$
$n\Delta H_{reaction} = 47.0(4)$ kJ [Digit in parentheses will be lost in rounding.]
$$m_{eicosane} = 8.567 - 7.357\ g$$
$$m_{eicosane} = 1.21\ g$$
$$M_{eicosane\ (C_{20}H_{42})} = 282\ g/mol$$
$$n_{eicosane} = 1.21\ g \times \frac{1\ mol}{282\ g}$$
$$n_{eicosane} = 4.29 \times 10^{-3}\ mol$$
$$\Delta H_{comb} = \frac{q_{total}}{n}$$
$$= \frac{47.0(4)\ kJ}{4.29 \times 10^{-3}\ mol}$$
$$\Delta H_{comb} = 1.10 \times 10^{4}\ kJ/mol\ C_{20}H_{42}$$

Because the reaction is exothermic, $\Delta H_{reaction}$ is –11.0 MJ/mol.

(b) The reaction was exothermic, because heat was released to the surroundings and the temperature increased.

(c) $C_{20}H_{42(s)} + 61/2\ O_{2(g)} \rightarrow 20\ CO_{2(g)} + 21\ H_2O_{(g)} + 11.0\ MJ$

$C_{20}H_{42(s)} + 61/2\ O_{2(g)} \rightarrow 20\ CO_{2(g)} + 21\ H_2O_{(g)} \quad \Delta H = -11.0\ MJ$

Evaluation

(d) Percentage error $= \frac{(13.3 - 11.0)}{13.3} \times 100$

$= 17\%$

5.4 HESS'S LAW OF ADDITIVITY OF REACTION ENTHALPIES

PRACTICE

(Page 326)

Understanding Concepts

1. **1 × (1):** $2\ Al_{(s)} + \frac{3}{2} O_{2(g)} \rightarrow Al_2O_{3(s)} \quad \Delta H = \mathbf{(1)}(-1675.7)\ kJ$

   –1 × (2): $Fe_2O_{3(s)} \rightarrow 2\ Fe_{(s)} + \frac{3}{2} O_{2(g)} \quad \Delta H = \mathbf{(-1)}(-824.2)\ kJ$

   $Fe_2O_{3(s)} + 2\ Al_{(s)} \rightarrow Al_2O_{3(s)} + 2\ Fe_{(s)} \quad \Delta H = -851.5\ kJ$

2. $\mathbf{\frac{1}{2}}$ **× (1):** $C_{(s)} + \frac{1}{2} O_{2(g)} \rightarrow CO_{(g)} \quad \Delta H = (\mathbf{\frac{1}{2}})(-221.0)\ kJ$

   $\mathbf{-\frac{1}{2}}$ **× (2):** $H_2O_{(g)} \rightarrow H_{2(g)} + \frac{1}{2} O_{2(g)} \quad \Delta H = (\mathbf{-\frac{1}{2}})(-483.6)\ kJ$

   $H_2O_{(g)} + C_{(s)} \rightarrow CO_{(g)} + H_{2(g)} \quad \Delta H = 131.3\ kJ$