

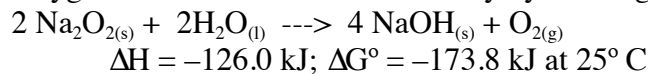
A Substantive Exercise

- 5.1 Which of the following are true for an exothermic reaction?
- The enthalpy of the system decreases
 - ΔH has a negative sign
 - The enthalpy of the products is higher than that of the reactants
 - Heat is absorbed from the surroundings.
- 5.2 When 6.00 g of calcium chloride dissolves in 100.0 g of water, the temperature rises from 18.0 to 28.7° C. The reaction is: $\text{CaCl}_{2(s)} \rightarrow \text{Ca}^{2+}_{(aq)} + 2 \text{Cl}^{-1}_{(aq)}$
- Is the reaction exothermic or endothermic?
 - What is the sign of ΔH ?
- 5.3 Consider the reaction $\text{Fe}_{(s)} + \text{Br}_{2(l)} \rightarrow \text{FeBr}_{2(s)}$; $\Delta H = -249.8 \text{ kJ}$
- Is the reaction exothermic or endothermic?
 - Draw a diagram qualitatively showing the enthalpy change in this reaction.
 - Calculate ΔH when 10.0 g FeBr₂ is formed
 - How many grams of iron must react to evolve 1.00 kJ of heat?
- 5.4 Consider the reaction $\text{Ag}^{+}_{(aq)} + \text{Cl}^{-}_{(aq)} \rightarrow \text{AgCl}_{(s)}$; $\Delta H = -65.5 \text{ kJ}$
- Calculate ΔH when one mole of AgCl dissolves in water
 - What is ΔH when 1.00 g AgCl dissolves?
- 5.8 Given the reactions on the right
- | | | |
|--|---|------------------------------|
| | $\text{Na}_{(s)} + 1/2 \text{Cl}_{2(g)} \rightarrow \text{Na}_{(g)} + \text{Cl}_{(g)}$; | $\Delta H = +230 \text{ kJ}$ |
| Calculate ΔH for the reaction | $\text{Na}_{(g)} + \text{Cl}_{(g)} \rightarrow \text{Na}^{+}_{(g)} + \text{Cl}^{-}_{(g)}$; | $\Delta H = +147 \text{ kJ}$ |
| $\text{Na}^{+}_{(g)} + \text{Cl}^{-}_{(g)} \rightarrow \text{NaCl}(s)$ | $\text{Na}_{(s)} + 1/2 \text{Cl}_{2(g)} \rightarrow \text{NaCl}_{(s)}$; | $\Delta H = -411 \text{ kJ}$ |
- 5.31 Which of the following are true for an endothermic reaction?
- ΔH is positive
 - Heat is transferred to the surroundings
 - The enthalpy of the system increase
 - The temperature of the surroundings decreases
- 5.32 The temperature of 50.0 g of water drops from 18.0 to 9.5° C when 10.0 g KBr are dissolved in it.
- Write a chemical reaction equation for this reaction
 - What is the sign of ΔH ?
- 5.33 Nickel tetracarbonyl, $\text{Ni}(\text{CO})_4$, decomposes upon heating:
- $$\text{Ni}(\text{CO})_{4(g)} \rightarrow \text{Ni}_{(s)} + 4 \text{CO}_{(g)}; \Delta H = +160.7 \text{ kJ}$$
- Is the reaction exothermic or endothermic?
 - Draw a diagram qualitatively showing the enthalpy change in this reaction.
 - Calculate ΔH when 1.00 g $\text{Ni}(\text{CO})_4$ decomposes
 - How many grams of $\text{Ni}(\text{CO})_4$ decompose when 1.00 kJ of heat is absorbed?
- 14.4 Consider the reaction $\text{Mg}_3\text{N}_{2(s)} + 6 \text{H}_2\text{O}_{(l)} \rightarrow 3 \text{Mg}(\text{OH})_{2(s)} + 2 \text{NH}_{3(g)}$ $\Delta H = -691 \text{ kJ}$
Calculate ΔH when 75.0 g Mg_3N_2 reacts with water.
- 14.5 Predict the sign of ΔS for
- a candle burning
 - ammonia vapor condensing
 - butter melting
 - tea dissolving in water

14.6 Predict the sign ΔS° for each of the following reactions:

- $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}_{(s)} \rightarrow \text{CuSO}_{4(s)} + 5 \text{H}_2\text{O}_{(g)}$
- $2 \text{Cl}_{(g)} \rightarrow \text{Cl}_{2(g)}$
- $2 \text{H}_{2(g)} + \text{O}_{2(g)} \rightarrow 2 \text{H}_2\text{O}_{(l)}$

14.16 Oxygen can be made in the laboratory by reacting sodium peroxide with water:



Calculate ΔS° for this reaction. Is the sign unreasonable? Why or why not?

14.18 Discuss the effect of temperature change upon the spontaneity of the following reactions at 1 atm:

- $2 \text{PbO}_{(s)} + 2 \text{SO}_{2(g)} \rightarrow 2 \text{PbS}_{(s)} + 3 \text{O}_{2(g)}$
 $\Delta H = + 839.4 \text{ kJ}$; $\Delta S^\circ = + 0.203 \text{ kJ/K}$
- $\text{N}_2\text{H}_{4(l)} \rightarrow \text{N}_{2(g)} + 2 \text{H}_{2(g)}$
 $\Delta H = - 50.4 \text{ kJ}$; $\Delta S^\circ = + 0.330 \text{ kJ/K}$
- $2 \text{As}_{(s)} + 3 \text{F}_{2(g)} \rightarrow 2 \text{AsF}_{3(l)}$
 $\Delta H = - 1897.9 \text{ kJ}$; $\Delta S^\circ = -0.318 \text{ kJ/K}$

14.19 At what temperature does ΔG° become zero for each of the reactions in Problem 14.18? Explain the significance of your answers.

14.34 Consider the reaction $2 \text{PbO}_{(s)} + 2 \text{SO}_{2(g)} \rightarrow 2 \text{PbS}_{(s)} + 3 \text{O}_{2(g)}$ $\Delta H = + 839.4 \text{ kJ}$

- Calculate ΔH when 10.0 g PbS is formed
- Given that the heats of formation of lead(II) sulfide and sulfur dioxide are -100 kJ/mole and -297 kJ per mole respectively, calculate the heat of formation of PbS.

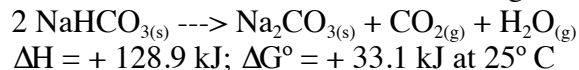
14.35 Predict the sign of ΔS for

- the freezing of water
- evaporation of a seawater sample to dryness
- weeding a garden
- separating air into its components

14.36 Predict the sign of ΔS° for each of the following reactions:

- $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2 \text{NH}_{3(g)}$
- $\text{H}_{2(g)} + \text{Cu}^{2+}_{(aq)} \rightarrow 2 \text{H}^{+}_{(aq)} + \text{Cu}_{(s)}$
- $\text{CaCl}_{2(s)} + 6 \text{H}_2\text{O}_{(g)} \rightarrow \text{CaCl}_2 \cdot 6\text{H}_2\text{O}_{(s)}$

14.46 Sodium carbonate, also called "washing soda," can be made by heating sodium hydrogen carbonate:



- Calculate ΔS° for this reaction. Is the sign reasonable?
- Calculate ΔG° at 0 K; at 1000 K

14.48 Discuss the effect of temperature upon the spontaneity of the following reactions at 1 atm:

- $\text{Al}_2\text{O}_{3(s)} + 2 \text{Fe}_{(s)} \rightarrow 2 \text{Al}_{(s)} + \text{Fe}_2\text{O}_{3(s)}$
 $\Delta H = + 847.6 \text{ kJ}$; $\Delta S^\circ = + 41.2 \text{ J/K}$
- $\text{CO}_{(g)} \rightarrow \text{C}_{(s)} + 1/2 \text{O}_{2(g)}$
 $\Delta H = + 110.5 \text{ kJ}$; $\Delta S^\circ = -89.7 \text{ J/K}$
- $\text{SO}_{3(g)} \rightarrow \text{SO}_{2(g)} + 1/2 \text{O}_{2(g)}$
 $\Delta H = + 99.1 \text{ kJ}$; $\Delta S^\circ = + 94.8 \text{ J/K}$

Substantive Answers

5.1 a. t b. t c. f d. f

5.2 a. exob. -

5.3 a. exo b. refer to text c. -11.56 kJd. .22 g

5.4 a. +65.5 kJ b. +.46 kJ

5.8 -788 kJ

5.31 a. t b. f c. t d. t

5.32 a. $\text{KBr(s)} \rightarrow \text{K}^+(\text{aq}) + \text{Br}^-(\text{aq})$ b. +

5.33 a. endo b. see text c. .941 kJ d. 1.06 g

14.4 a. -513.6 kJ b. -461.2 kJ

14.5 a. +, b. -, c. +, d. +

14.6 a. +, b. -, c. -

14.16 a. .16 kJ/K no--entropy should increase

b. 81.5 J/K c. -505 kJ

14.18 a. Temp increase creates spontaneity

b. Always spontaneous regardless of T

c. Increasing T creates nonspontaneity

14.19 a. 4134 K

b. The reaction goes to completion

c. 5968 K

When change in free energy is 0 the reaction is at equilibrium.

14.34 a. +17.5 kJ, b. -222 kJ/mole

14.35 a. -, b. +, c. -, d. -

14.36 a. -, b. -, c. -

14.51 a. 353.4 kJ, 242.9 kJ, 132.4 kJ, 21.9 kJ, -88.6 kJ

b. 840 K

14.46 a. .321 kJ/K b. 128.9 kJ, -192 kJ

14.48 a. reaction becomes spontaneous at high T

b. nonspontaneous at all T

c. reaction becomes spontaneous at high T