19. $N_2H_{4(l)} \rightleftharpoons N_2H_{4(g)}$

$$T = \frac{\Delta H°}{\Delta S°}$$

$$= [\Delta H°_{f(N_2H_{4(g)})} - \Delta H°_{f(N_2H_{4(l)})}]$$

$$= 1 \text{ mol} \times (+50.6 \text{ kJ/mol}) - 1 \text{ mol} \times (+95.4 \text{ kJ/mol})$$

$$T = -44.8 \text{ kJ}$$

$$\Delta S° = [S°_{(N_2H_{4(g)})} - S°_{(N_2H_{4(l)})}]$$

$$= 1 \text{ mol} \times (+237.11 \text{ J/mol}\bullet\text{K}) - 1 \text{ mol} \times (+121.21 \text{ J/mol}\bullet\text{K})$$

$$= 237.11 \text{ J/mol}\bullet\text{K} - 121.21 \text{ J/mol}\bullet\text{K}$$

$$\Delta S° = 115.9 \text{ J/mol}\bullet\text{K}$$

$$= 115.9 \text{ J/K} \times \frac{1 \text{ kJ}}{1000 \text{ J}}$$

$$\Delta S° = 0.1159 \text{ kJ/K}$$

$$T = \frac{\Delta H°}{\Delta S°}$$

$$= \frac{-44.8 \text{ kJ}}{0.1159 \text{ kJ/K}}$$

$$T = 387 \text{ K}$$

$$t = (T - 273°C)$$

$$= (387 \text{ K} - 273°C)$$

$$t = 114°C$$

The boiling point of hydrazine is 114°C.

(b) Hydrazine is used mainly as a chemical intermediate in the production of agricultural chemicals, and spandex fibres. It is also a rocket fuel. Hydrazine is also used for plating metals on glass and plastics and as a component of photographic developers.

CHAPTER 7   LAB ACTIVITIES

INVESTIGATION 7.1.1 DISCOVERING THE EXTENT OF A CHEMICAL REACTION

(Page 513)

Prediction
(a) The reaction is quantitative since equimolar amounts of both reactants are combined.

Experimental Design
(b) $CaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow CaSO_{4(s)} + 2 \text{ NaCl}_{(aq)}$
(c) $Ca^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow CaSO_{4(s)}$

Procedure
(d)
1. Measure 10 mL (or 5 mL) of $CaCl_{2(aq)}$ in a clean graduated cylinder.
2. Pour the solution into a clean 50-mL or 100-mL beaker.
3. Measure 5 mL (or 10 mL) of $Na_2SO_{4(aq)}$ in a clean graduated cylinder.
4. Slowly add this quantity of $Na_2SO_{4(aq)}$ to the $CaCl_{2(aq)}$ while stirring.
5. Filter the precipitate from the mixture.
6. Collect about 5 mL of the filtrate into a small clean test tube.
7. Test the filtrate by adding a few drops of $Na_2CO_{3(aq)}$.

8. Collect another 5 mL of the filtrate in step 5 into a test tube and test with $Ba(NO_3)_{2(aq)}$.
9. Repeat the experiment again if time and supplies permit.

Analysis

(e) A white precipitate formed by mixing solutions of $CaCl_{2(aq)}$ and $Na_2SO_{4(aq)}$. White precipitates formed in both diagnostic tests of the filtrate. The same evidence was obtained when the experiment was repeated.

(f) According to the net ionic equation, $Ca^{2+}_{(aq)}$ and $SO_{4(aq)}^{2-}$ combine in a 1:1 ratio. It is logical to assume that if an excess of $Ca^{2+}_{(aq)}$, for example, is used, then $SO_{4(aq)}^{2-}$ should be totally consumed by the reaction. However, a white precipitate of $BaSO_{4(s)}$ was observed in all samples.

Evaluation

(g) The Experimental Design (combining precipitation with diagnostic tests for excess ions) is adequate since clear evidence was obtained to answer the question. Because the experiment required little time, it was repeated. To make the testing complete, at least one diagnostic test for one ion from each reactant is performed. Testing for sodium and chloride ions is not appropriate since these ions are expected to be in the filtrate regardless of the quantitative nature of the reaction.

  The prediction is falsified since the evidence indicates the presence of both reactants after the reaction was completed. The assumption of a quantitative reaction is judged to be unacceptable for this reaction.

(h) One improvement to the Experimental Design would be to assess the purity of the reagents. An impurity could have caused the unexpected positive diagnostic tests. Furthermore, the precipitate did not form immediately. Perhaps a pair of chemicals that do precipitate immediately would be a more appropriate test of the question.

(i) The use of the terms "limiting" and "excess reagents" does not seem appropriate since $Ca^{2+}_{(aq)}$ and $SO_{4(aq)}^{2-}$ were detected in all samples.

LAB EXERCISE 7.2.1 DEVELOP AN EQUILIBRIUM LAW

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Analysis

(a) The only relationship that gives a constant is #3.

Relationship	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
1. $[Fe^{3+}_{(aq)}][SCN^-_{(aq)}][FeSCN^{2+}_{(aq)}]$	2.89×10^{-11}	2.34×10^{-9}			
2. $[Fe^{3+}_{(aq)}] + [SCN^-_{(aq)}] + [FeSCN^{2+}_{(aq)}]$	4.01×10^{-2}	1.58×10^{-2}	6.37×10^{-2}		
3. $\dfrac{[FeSCN^{2+}_{(aq)}]}{[Fe^{3+}_{(aq)}][SCN^-_{(aq)}]}$	294	293	288	306	296
4. $\dfrac{[Fe^{3+}_{(aq)}]}{[FeSCN^{2+}_{(aq)}]}$	42.4	17.9	9.23		
5. $\dfrac{[SCN^-_{(aq)}]}{[FeSCN^{2+}_{(aq)}]}$	0.0870	0.231	0.555	1.52	

(b) This relationship is the concentration of the reaction product divided by the concentrations of the reactants multiplied together.

INVESTIGATION 7.3.1 TESTING LE CHÂTELIER'S PRINCIPLE

(Page 514)

Predictions

(a)   I. According to Le Châtelier's principle,
        (a) placing the flasks into a cold-water mixture will shift the equilibrium to the left.
        (b) placing the flasks into a hot-water mixture will shift the equilibrium to the right.
     II. According to Le Châtelier's principle, an increase in pressure will shift the equilibrium to the left.
    III. According to Le Châtelier's principle,
        (a) adding water will shift the equilibrium to the right.
        (b) adding saturated silver nitrate will shift the equilibrium to the right.