24. A saturated solution is at equilibrium and contains the maximum concentration of solute. But the actual concentration of dissolved solute may be high or low, depending on the solubility.

25. soluble: greater than 1 g/100 g water; insoluble: less than 0.1 g/100 g water; slightly soluble: between these limits

26. Ion concentration is very low.

27. If the ion product is less than K_{sp}, the solution is unsaturated and precipitation will not occur. If the ion product is greater than K_{sp}, precipitation will occur until the ion concentrations decrease to equilibrium values.

28. 7.14×10^{-11}

29. a. 1.1×10^{-10} **b.** 5.06×10^{-5}

30. 2.8×10^{-3} mol/L

31. a. 7.1×10^{-7} mol/L
b. 6.3×10^{-11} mol/L

32. a. $PbSO_4(s) \rightleftarrows$
$$Pb^{2+}(aq) + SO_4^{2-}(aq)$$
b. $K_{sp} = [Pb^{2+}][SO_4^{2-}]$

33. 7.69×10^{-46}

34. 3.1×10^{-7} mol/L

35. No precipitate will form.

36. A precipitate of AgCl will form.

37. A precipitate of $Fe(OH)_3$ will form.

38. a. $CaCO_3(s) \rightleftarrows$
$$Ca^{2+}(aq) + CO_3^{2-}(aq)$$
b. $K_{sp} = [Ca^{2+}][CO_3^{2-}]$

39. 1.3×10^{-26} mol/L; 8 ions

40. 1.6

41. 5.2×10^{-7} mol/L

42. 8.7×10^{-6} mol/L

43. The solubility is 6.1×10^{-8} mol/L. The fluoridation produces a lowered solubility, which protects tooth enamel. Answers will vary.

31. Use the K_{sp} values given in **Table 3** to evaluate the solubility of each of the following in moles per liter.
   a. AgBr
   b. CoS

32. Complete each of the following relative to the reaction that occurs when 25.0 mL of 0.0500 M $Pb(NO_3)_2$ is combined with 25.0 mL of 0.0400 M Na_2SO_4 if equilibrium is reached at 25°C.
   a. Write the solubility equilibrium equation at 25°C.
   b. Write the solubility equilibrium expression for the net reaction.

33. The ionic substance T_3U_2 ionizes to form T^{2+} and U^{3-} ions. The solubility of T_3U_2 is 3.8×10^{-10} mol/L. What is the value of the solubility product constant?

34. A solution of AgI contains 2.7×10^{-10} mol/L Ag^+. What is the maximum I^- concentration that can exist in this solution?

35. Calculate whether a precipitate will form if 0.35 L of 0.0044 M $Ca(NO_3)_2$ and 0.17 L of 0.000 39 M NaOH are mixed at 25°C. (See **Table 3** for K_{sp} values.) (Hint: See Sample Problem D.)

36. Determine whether a precipitate will form if 1.70 g of solid $AgNO_3$ and 14.5 g of solid NaCl are dissolved in 200. mL of water to form a solution at 25°C.

37. If 2.50×10^{-2} g of solid $Fe(NO_3)_3$ is added to 100. mL of a 1.0×10^{-4} M NaOH solution, will a precipitate form?
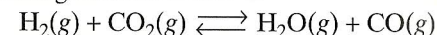
MIXED REVIEW

38. Calcium carbonate is only slightly soluble in water.
   a. Write the equilibrium equation for calcium carbonate in solution.
   b. Write the solubility product constant expression, K_{sp}, for the equilibrium in a saturated solution of $CaCO_3$.

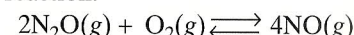**39.** Calculate the concentration of Hg^{2+} ions in a saturated solution of HgS(s). How many Hg^{2+}

40. Calculate the equilibrium constant, K, for the following reaction at 900°C.
$$H_2(g) + CO_2(g) \rightleftarrows H_2O(g) + CO(g)$$
The components were analyzed, and it was found that $[H_2] = 0.061$ mol/L, $[CO_2] = 0.16$ mol/L, $[H_2O] = 0.11$ mol/L, and $[CO] = 0.14$ mol/L.

41. A solution in equilibrium with solid barium phosphate is found to have a barium ion concentration of 5.0×10^{-4} M and a K_{sp} of 3.4×10^{-23}. Calculate the concentration of phosphate ion.

42. At 25°C, the value of K is 1.7×10^{-13} for the following reaction.
$$2N_2O(g) + O_2(g) \rightleftarrows 4NO(g)$$
It is determined that $[N_2O] = 0.0035$ mol/L and $[O_2] = 0.0027$ mol/L. Using this information, what is the concentration of NO(g) at equilibrium?

43. Tooth enamel is composed of the mineral hydroxyapatite, $Ca_5(PO_4)_3OH$, which has a K_{sp} of 6.8×10^{-37}. The molar solubility of hydroxyapatite is 2.7×10^{-5} mol/L. When hydroxyapatite is reacted with fluoride, the OH^- is replaced with the F^- ion on the mineral, forming fluorapatite, $Ca_5(PO_4)_3F$. (The latter is harder and less susceptible to cavities.) The K_{sp} of fluorapatite is 1×10^{-60}. Calculate the molar solubility of fluorapatite in water. Given your calculations, can you support the fluoridation of drinking water?

44. Determine if a precipitate will form when 0.96 g Na_2CO_3 is combined with 0.20 g $BaBr_2$ in a 10. L solution ($K_{sp} = 2.8 \times 10^{-9}$).
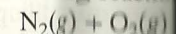
45. For the formation of ammonia, the equilibrium constant is calculated to be 5.2×10^{-5} at 25°C. After analysis, it is determined that $[N_2] = 2.00$ M and $[H_2] = 0.80$ M. How many grams of ammonia are in the 10. L reaction vessel at equilibrium? Use the following equilibrium equation.
$$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$$
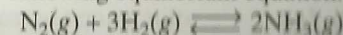
CRITICAL THINKING

46. Relating Ideas Let s equal the solubility, in mol/L, of AB_2. In terms of s, what is the molar concentration of A? of B? What is the K_{sp} of

47. Predicting Outcomes an automobile engine, n from oxygen and nitrog major air pollutant. High those found in a combu for the following reactio
$$N_2(g) + O_2(g)$$
K for the reaction is 0.0 of N_2, 0.1 mol of O_2, and placed in a 1.0 L vessel reaction will be favored.

USING THI

48. An equilibrium system of the blood. Review the dioxide–bicarbonate ion Group 14 of the *Elemen* answer the following.
   a. Write the equation f system that responds concentration.
   b. Use Le Châtelier's p hyperventilation affe
   c. How does this system acid is added?

49. The reactions used in e transition metal ions oft of precipitates. Review th transition metals in the A that information and Tab minimum concentration a duce a precipitate that c Zn. Assume enough sulfi to the unknown solution duce a sulfide ion concen

RESEARCH A

50. Find photos of several c and stalactites in vario equilibrium processes in of stalagmites and stala