Lesson Check Answers

1. The rate of a chemical reaction is the amount of reactant changing per unit of time.
2. temperature, concentration, particle size, use of a catalyst
3. Rate = 0.2 mol Zn/month
4. No, the collision must have sufficient energy to break and form bonds.
5. Chemical reactions involved in food spoilage occur faster at higher temperatures because more energy is available.
6. **BIG**IDEA Concentration and particle size should be in the circle labeled *Matter* because each of these factors increase the reactant itself that is available for collisions. Temperature and catalysts should be in the circle labeled *Energy* because each of these factors manipulate the energy of the reactant or the energy of the activated complex, respectively.

Sample Problems

You do **NOT** have to do problems 7-8

7. $\text{Rate}_1 = 0.5 \text{ mol/(L·s)}$

$\text{Rate}_2 = x$

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{x^1}{0.5^1} = \left(\frac{1}{2}\right)^1$$

$2x = 0.5 \text{ mol/(L·s)}$

$$x = \frac{0.5 \text{ mol/(L·s)}}{2} = 0.25 \text{ mol/(L·s)};$$

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{x^1}{0.5^1} = \left(\frac{1}{4}\right)^1$$

$4x = 0.5 \text{ mol/(L·s)}$

$$x = \frac{0.5 \text{ mol/(L·s)}}{4} = 0.125 \text{ mol/(L·s)}$$

8. $\text{Rate} = k[\text{A}]$

$$k = \frac{\text{Rate}}{[\text{A}]} = \frac{\frac{\cancel{\text{mol}}}{(\cancel{\text{L}}\cdot\text{s})}}{\frac{\cancel{\text{mol}}}{\cancel{\text{L}}}} = \frac{1}{\text{s}} = \text{s}^{-1}$$

Lesson Check Answers

9. The larger the specific rate constant, *k*, the faster the reaction.

10. Most reactions consist of two or more elementary reactions, each resulting in the formation of an intermediate.

11. The rate at any given point on the graph is determined by calculating the slope of the tangent to the curve at that point.

12. first order in A; first order overall

13. Rate = $k[NO][O_3]$

14. An elementary reaction is a reaction in which reactants are converted to products in a single step. A reaction mechanism is a series of elementary reactions that comprise a complex chemical reaction.

15. Both, it is a product in one step in a reaction mechanism and a reactant in the next step.

16. multistep; To proceed in a single-step reaction, three molecules would have to collide in the correct orientation, which is unlikely.

Sample Problems

FIGURE 18.16 Increasing the pressure causes a decrease in volume, which shifts the equilibrium in the direction of fewer gas molecules.

17. Le Chatelier's Principle

a. lowering the temperature favors the products because it decreases the "heat" which is a product… so the reaction will shift to the right to relieve the stress (add the heat back in)

b. decreasing the pressure favors the reactants because there are more moles of gas on the left (reactants) than the right (products). Less pressure means less collisions so the reactions will shift to increase collisions.

c. removing oxygen favors the reactants because oxygen is a reactant that gets used up and therefore the reaction will shift to replace it.

d. add sulfur trioxide favors the reactants because more product was added in so the reaction will shift to the left to relieve the stress (make less product)

18. Le Chatelier's Principle

a. lowering the temperature favors the reactants because it decreases the "heat" which is a reactant… so the reaction will shift to the left to relieve the stress (add the heat back in)

b. increasing the pressure favors the reactants because there are more moles of gas on the right (products) than the left (reactants). More pressure means more collisions so the products will collide more and force the reverse reaction to form more of the original reactants and to decrease the collisions of the product molecules.

c. removing hydrogen favors the products because hydrogen is a product that gets taken away and therefore the reaction will shift to replace it.

d. add water vapor favors the products because more reactant was added in so the reaction will shift to the right to relieve the stress.

19. $K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.10M)^2}{(0.25M) \times (0.15M)^3} = 12$

20. $K_{eq} = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{(0.25M) \times (0.15M)^3}{(0.10M)^2} = 8.4 \times 10^{-2}$;

One is the inverse of the other.

21. $K_{eq} = \frac{[NO]^2}{[N_2][O_2]} = \frac{(0.02M)^2}{0.50M \times 0.50M} = 1.6 \times 10^{-3}$

You do **NOT** have to do problems 22-24

22. $0.047 \text{ mol } H_2O \times \frac{1 \text{ mol } H_2}{1 \text{ mol } H_2O} = 0.047 \text{ mol } H_2$

$0.10 - 0.047 = 0.053 \text{ mol } H_2$ at equilibrium

($\text{mol } H_2 = \text{mol } CO_2$)

$$K_{eq} = \frac{[H_2O][CO]}{[H_2][CO_2]} = \frac{(0.047M) \times (0.047M)}{(0.053M) \times (0.053M)} = 0.79$$

23. $K_{eq} = \frac{[N_2O_4]}{[NO_2]^2}$

$$5.6 = \frac{0.66M}{[NO_2]^2}$$

$$[NO_2]^2 = \frac{0.66M}{5.6}$$

$$[NO_2] = \sqrt{\frac{0.66M}{5.6}} = 0.34M$$

24. $[H_2] = [I_2] = 0.50M$;

$$K_{eq} = \frac{[H_2][I_2]}{[HI]^2}$$

$$0.020 = \frac{0.50M \times 0.50M}{[HI]^2}$$

$$[HI]^2 = \frac{0.50M \times 0.50M}{0.020} = \frac{0.25M^2}{0.020} = 12.5M^2$$

$$[HI] = \sqrt{12.5M^2} = 3.5M$$

You do **NOT** have to do problem 31

Lesson Check Answers

25. There is not a net change in the amounts of reactants or products.

26. changes in concentrations of reactants and products, changes in temperature, and changes in pressure

27. For a large K_{eq}, products dominate the reaction mixture; for a small K_{eq}, reactants dominate the reaction mixture.

28. no; only in reversible reactions in which the mole ratios of gaseous reactants and products are unequal

29. An equilibrium constant expression is a ratio. In the numerator, product concentrations are multiplied. In the denominator, reactant concentrations are multiplied. Each concentration is raised to a power equal to the coefficient for that species in the balanced equation.

30. a; At large K_{eq} values, products dominate the reaction mixture at equilibrium.

~~**31.** 0.050 mol I_2 and 0.37 mol HI~~

32. **BIGIDEA** They will know how to manipulate concentrations, temperature, and pressure to increase the percent yield of the reaction.

Sample Problems

33. $K_{sp} = [Pb^{2+}] \times [S^{2-}]$

$3.0 \times 10^{-28} = [Pb^{2+}]^2$

$[Pb^{2+}] = \sqrt{3.0 \times 10^{-28} M^2} = 2 \times 10^{-14} M$

34. $K_{sp} = [Ca^{2+}] \times [CO_3^{2-}]$

$4.5 \times 10^{-9} = [Ca^{2+}]^2$

$[Ca^{2+}] = \sqrt{4.5 \times 10^{-9} M^2} = 6.7 \times 10^{-5} M$

35. $K_{sp} = [Pb^{2+}] \times [S^{2-}]$

$[S^{2-}] = \frac{K_{sp}}{[Pb^{2+}]} = \frac{(8 \times 10^{-19})}{0.04} = 2 \times 10^{-17} M$

36. $K_{sp} = [Sr^{2+}] \times [SO_4^{2-}]$

$[SO_4^{2-}] = \frac{K_{sp}}{[Sr^{2+}]} = \frac{(3.2 \times 10^{-7})}{0.10} = 3.2 \times 10^{-6} M$

You do **NOT** have to do problems 43-45

Lesson Check Answers

37. The smaller the K_{sp}, the lower the solubility of the compound.

38. If the product of the concentrations of two ions in a mixture is greater than the K_{sp} of the compound formed from the ions, a precipitate will form.

39. $[Ag^+]^2 \times [CO_3^{2-}] = K_{sp}$

40. FeS

41. 4×10^{-20}

42. $2 \times 10^{-14} M$

43. $7.3 \times 10^{-9} M$

44. Yes; The product $[Ag^+] \times [Cl^-] = 0.01M \times 0.0005M = 5 \times 10^{-6}$ is greater than the K_{sp} of AgCl (1.8×10^{-10})

45. **BIGIDEA** Adding a common ion (a product in the dissolution expression) disturbs the equilibrium and causes a shift toward the reactant side of the expression.

Sample Problems

41. NiS → $Ni^{+2} + S^{-2}$
$K_{sp} = [Ni^{+2}][S^{-2}] = [2 \times 10^{-10} M][2 \times 10^{-10} M] = 4 \times 10^{-20} M$

42. PbS → $Pb^{+2} + S^{-2}$ *There is 1 mol of both products, so* $[Pb^{+2}] = [S^{-2}]$.
$K_{sp} = [Pb^{+2}][S^{-2}] = [\text{product}]^2$
$[\text{product}] = \sqrt{K_{sp}} = \sqrt{(3.0 \times 10^{-28})} = 1.7 \times 10^{-14} M$

Lesson Check Answers

46. They produce substantial amounts of products at equilibrium and release free energy.

47. An increase in entropy favors a spontaneous reaction; a decrease favors a nonspontaneous reaction.

48. The size and direction of enthalpy and entropy changes together determine whether a reaction is spontaneous.

49. The reaction is spontaneous.

50. the energy available to do work

51. unfavorable

52. A change in state of a reactant, due to change in temperature or pressure, may change the balance between ΔS and ΔH.

53. The reaction of nitroglycerine releases 1427 kJ of heat, and in the process, converts 4 mol of a liquid into 29 mol of four different gases. Thus, both enthalpy and entropy changes favor spontaneity.