22 Chapter Test

Rates of Reaction

On the line at the left, write the letter of the answer that best completes each statement.

1. The rate of a chemical reaction is
   a. determined from the balanced chemical equation.
   b. the change in concentration of products and reactants in a certain amount of time.
   c. not possible to determine experimentally.
   d. expressed in units of time required for completion of the reaction.

2. The average rate of a chemical reaction can be expressed as the
   a. concentration of reactants minus the concentration of products.
   b. concentration of products and reactants multiplied by the time required for the reaction.
   c. change in concentration of products or reactants divided by the change in time.
   d. change in time divided by the change in concentration of products or reactants.

3. A series of steps that leads from reactants to products is
   a. a reaction mechanism.
   b. determined from a balanced chemical reaction.
   c. not related to experimentation.
   d. an elementary step.

4. The rate-determining step of a reaction mechanism
   a. is the fastest elementary step.
   b. is the slowest elementary step.
   c. is the intermediate product.
   d. can be determined from the overall reaction.

5. For molecules to react, they must collide. An effective collision depends upon
   a. a molecule colliding with the wall of the container.
   b. three or more molecules colliding.
   c. molecules having proper orientation only.
   d. molecules having proper orientation and enough energy.

6. The energy required to physically break bonds among reactant molecules comes from the reactant molecules' ____________ energy.
   a. potential
   b. kinetic
   c. chemical
   d. electrical
22 Chapter Test (continued)

7. Activation energy is the energy required to form the
   a. original bonds.
   b. activated complex.
   c. reaction complex.
   d. reactant molecules.

8. Which of the following factors does not affect the speed of a chemical reaction?
   a. size of the beaker in which the reaction proceeds
   b. temperature
   c. nature of the reactants
   d. concentration

9. A catalyst increases the rate of a chemical reaction by
   a. causing more collisions between molecules.
   b. increasing the energy of the particles in a reaction.
   c. lowering the activation energy of the reaction.
   d. raising the activation energy so that the colliding molecules have more energy.

Answer the following questions in the space provided.

10. Explain the relationship between activation energy and collision theory.

11. What is the transition state of a chemical reaction?

12. Using collision theory, explain how increasing the temperature and concentration of reactants
    increases the rate of a chemical reaction.

13. Which would turn completely to rust (iron oxide) first, a cube of iron or a pad of steel wool?
    Explain your answers.
22 Chapter Test (continued)

14. What is the function of the catalyst in the catalytic converter in a car?

15. Nitrogen monoxide (NO) reacts with chlorine according to the following mechanism:
   \[ \text{NO} + \text{Cl}_2 \rightarrow \text{NOCl}_2 \]
   \[ \text{NOCl}_2 + \text{NO} \rightarrow 2\text{NOCl} \]
   Identify the reaction intermediate and write the net equation for the reaction.

16. The rate law for the reaction of \( \text{H}_2\text{O}_2 \) and \( \text{I}^- \) is rate = \( k [\text{H}_2\text{O}_2][\text{I}^-] \). What will happen to the reaction rate if \( [\text{H}_2\text{O}_2] \) is tripled? What will happen to the reaction rate if \( [\text{I}^-] \) is doubled?

17. An enzyme is a biological catalyst. These complex protein molecules are synthesized by living cells. Explain how these natural catalysts are important to living organisms.

18. List two types of inhibitors that would be useful to industry.

Essays

Write your answers to the following questions on a separate sheet of paper.

19. The hydrogenation of fats, in which hydrogen is added to a fat molecule, is catalyzed by finely powdered metal catalysts, such as platinum. Explain why powdered platinum is a better catalyst than a block of platinum. This metal is very expensive. How is it economically feasible to use it as a catalyst in industrial processes?

20. Foods are packaged and stored in different ways in order to prevent spoilage. Discuss three ways foods are packaged or stored and explain how each slows the reactions that lead to spoilage.
16 Chapter Test

Chemical Equilibrium

Multiple Choice

*On the line at the left, write the letter of the answer that best completes each statement.*

1. Which of the following is true?
   a. In a reversible reaction, products can react to form reactants.
   b. Reversible reactions are always reversible on their own.
   c. A reversible reaction must be forced to undergo the forward reaction.
   d. A reversible reaction always goes to completion.

2. Which of the following is false?
   a. As a reversible reaction reaches equilibrium, the rate of each reaction changes throughout the process.
   b. Any reaction carried out in a closed container will eventually reach equilibrium.
   c. At chemical equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction.
   d. Reaction rate is inversely proportional to concentration.

3. The equilibrium constant for a reaction
   a. is independent of temperature.
   b. is a measure of the extent to which a reaction proceeds to completion.
   c. is equal to the equilibrium position.
   d. changes with different concentrations.

4. Which of the following statements is true?
   a. \( \text{NH}_4\text{Cl(s)} \rightleftharpoons \text{NH}_3(g) + \text{HCl(g)} \) is a homogeneous reversible reaction.
   b. Solids are not an important part of equilibrium.
   c. Homogeneous equilibrium involves substances in different states.
   d. The concentration of a solid does not change substantially as a reaction heads toward equilibrium.

5. The reaction quotient
   a. can be used to determine whether a reaction is at equilibrium.
   b. is found by using the equilibrium expression.
   c. Both a and b are correct.
   d. Neither a nor b is correct.

6. According to Le Chatelier’s principle, an increase in the concentration of a reactant will cause a reaction to
   a. go to completion.
   b. consume the added reactant.
   c. never return to equilibrium.
   d. Both a and c are correct.

7. Increasing the pressure on an equilibrium system will
   a. affect only the gases.
   b. shift the equilibrium position.
   c. cause the reaction to go toward the side that produces fewer molecules of gas.
   d. All of the above are correct.
8. A reaction's equilibrium constant will change if ________ is changed.
   a. temperature
   b. pressure
   c. concentration
   d. None of these affects \( K_{eq} \).

9. Each of the following is effective in increasing the equilibrium concentration of \( D \) in the reaction \( 2A(g) + B(g) \rightleftharpoons 3C(g) + D(g) \) EXCEPT
   a. increasing the concentration of \( A \).
   b. removing \( D \) as it forms.
   c. decreasing the concentration of \( B \).
   d. decreasing the pressure on the system.

10. The Haber process
    a. requires low pressures.
    b. decreases the amount of \( NH_3 \) produced in a reaction.
    c. is used in the production of explosives.
    d. All of the above are correct.

Problems

Solve each of the following problems as directed. Show all your work.

In the space provided, write the equilibrium expression for the following reactions.

11. \( 2CO(g) \rightleftharpoons C(s) + CO_2(g) \)

12. \( 2NO_2(g) \rightleftharpoons N_2O_4(g) \)

13. \( 4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g) \)

14. What is the reaction quotient (\( Q \)) for \( NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g) \) given the following concentrations: \([NH_3] = 0.6 \text{ M}, [HCl] = 0.2 \text{ M}\)?

15. For the reaction \( H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \), the following concentrations are measured at a particular time: \([H_2] = 0.2 \text{ M}, [I_2] = 0.15 \text{ M}, [HI] = 0.8 \text{ M}\). The \( K_{eq} \) for this reaction is 50.5. Has this reaction reached equilibrium? If not, in which direction will the reaction proceed?
16 Chapter Test (continued)

Questions

Use the following reaction, which is at equilibrium, to answer each of the following questions in the space provided.

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) + \text{heat} \]

16. Describe what will happen if the pressure is increased.

__________________________________________________________

17. Describe what will happen if the concentration of \( \text{H}_2 \) is increased.

__________________________________________________________

18. Describe what will happen if the temperature is increased.

__________________________________________________________

Answer each of the following questions in the space provided.

19. How are reaction rates and concentration important to the formation of wanted and unwanted products in industry?

__________________________________________________________

20. What does the law of mass action express?

__________________________________________________________

21. How could you determine experimentally whether a reaction has reached equilibrium?

__________________________________________________________

22. If a reaction has a large \( K_{\text{eq}} \) does it mean that the reaction occurs very quickly? Explain.

__________________________________________________________

23. Describe how you might effectively create more products in an equilibrium system.

__________________________________________________________

Essay

Write your answer to the following question on a separate sheet of paper.

24. The Haber process is an important chemical discovery. Explain its uses historically and today.