

Factors Affecting the Rate of Chemical Reactions

Textbook pages 272–281

Before You Read

What do you already know about the speed of chemical reactions? Outline your ideas in the lines below.

What is rate of reaction and how does it apply to chemical reactions?

In a chemical reaction, how quickly or slowly reactants turn into products is called the **rate of reaction**. A reaction that takes a long time has a low reaction rate. A reaction that occurs quickly has a high reaction rate. A *rate* describes how quickly or slowly a change occurs. Every chemical reaction proceeds at a definite rate. However, you can speed up or slow down the rate of a chemical reaction.

What factors affect the rate of a chemical reaction?

The four main factors that affect the rate of chemical reactions are temperature, concentration, surface area, and the presence of a catalyst.

1. Increasing the **temperature** causes the particles (atoms or molecules) of the reactants to move more quickly so that they collide with each other more frequently and with more energy. Thus, the higher the temperature, the greater the rate of reaction. If you decrease the temperature, the opposite effect occurs. The particles move more slowly, colliding less frequently and with less energy. In this case, the rate of reaction decreases. ✓

2. **Concentration** refers to how much solute is dissolved in a solution.

If a greater concentration of reactant atoms and molecules is present, there is a greater chance that collisions will occur among them. More collisions mean a higher reaction rate. Thus, increasing the concentration of the reactants usually results in a higher reaction rate. At lower concentrations, there is less chance for collisions between particles. This



Reinforce Your Understanding

As you read the section, highlight the main point of each paragraph. Then write out an example that helps you explain this main point.



How does temperature affect the rate of a chemical reaction?

• means that decreasing the concentrations of the reactants
• results in a lower reaction rate.

• **3. Surface area** is the measure of how much area of an
• object is exposed.

• For the same mass, many small particles have a greater total
• surface area than one large particle. For example, steel wool
• has a larger surface area than a block of steel of the same
• mass. This allows oxygen molecules to collide with many
• more iron atoms per unit of time. The more surface contact
• between reactants, the higher the rate of reaction. The less
• surface contact, the lower the reaction rate.

• Surface area can also be important if a reaction occurs
• between two liquids that do not mix. In this case, the reaction
• occurs only at the boundary where the two liquids meet. It is
• also important to note that not all reactions depend on surface
• area. If both reactants are gases or liquids that mix together,
• then there is no surface, and surface area is not a factor.

• **4. A catalyst** is a substance that speeds up the rate of a
• chemical reaction without being used up in the reaction itself.
• Catalysts reduce the amount of energy required to break and
• form bonds during a chemical reaction. When catalysts are
• used, a reaction can proceed although less energy is added
• during the reaction. For example, enzymes are catalysts
• that allow chemical reactions to occur at relatively low
• temperatures within the body. ✓

✓ **Reading Check**

Is a catalyst used up in a
chemical reaction?

Use with textbook pages 272–277.

Rate of chemical reactions

Vocabulary

catalyst	energy
catalytic converter	heat
collisions	rate of reaction
concentration	surface area
dilute	temperature

Use the terms in the vocabulary box to fill in the blanks. You may use each term only once.

1. A freshly exposed surface of metallic sodium tarnishes almost instantly if exposed to air and moisture, while iron will slowly turn to rust under the same conditions. In these two situations, the _____ refers to how quickly or slowly reactants turn into products.
2. Adding _____ will increase the rate of reaction because this causes the particles of the reactants to move more quickly, resulting in more collisions and more _____.
3. Removing heat will lower the _____, causing the particles of the reactants to slow down, resulting in less frequent collisions.
4. _____ refers to how much solute is dissolved in a solution. If there is a greater concentration of reactant particles present, there is a greater chance that _____ among them will occur. More collisions mean a higher rate of reaction.
5. A concentrated acid solution will react more quickly than a _____ acid solution because there are more molecules present, increasing the chance of collisions.
6. Grains of sugar have a greater _____ than a solid cube of sugar of the same mass, and therefore will dissolve quicker in water.
7. A _____, for example an enzyme, is used to speed up a chemical reaction but is not used up in the reaction itself.
8. A _____ in a car has metallic catalysts where several reactions occur. Carbon monoxide, which was produced in the combustion of gasoline, is changed into carbon dioxide and water in the presence of these metallic catalysts.

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Different rates of reactions

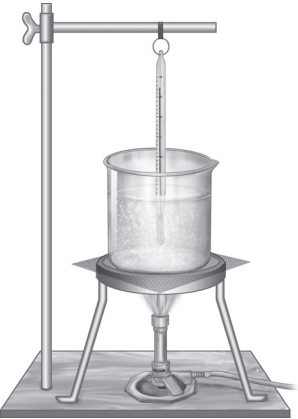

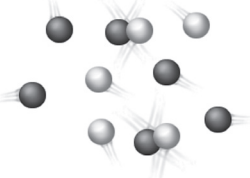
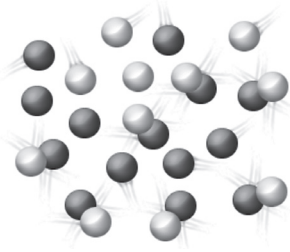




1. Indicate whether each of the following would increase or decrease the rate of reaction.

- (a) adding heat _____
- (b) removing heat _____
- (c) adding a catalyst _____
- (d) diluting a solution _____
- (e) removing an enzyme _____
- (f) lowering the temperature _____
- (g) increasing the temperature _____
- (h) decreasing the surface area _____
- (i) increasing the concentration of a solution

- (j) breaking a reactant down into smaller pieces

2. Identify which situation would have a higher reaction rate. Then state the factor that affected the rate of reaction in each situation.

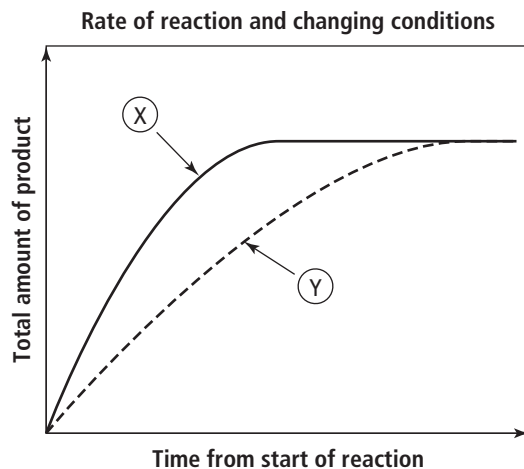
	Situation X	Situation Y	Situation with a higher reaction rate (X or Y)	Factor affecting the rate of reaction
(a)	1 g of sugar (cubes) 	1 g of sugar (grains) 		

<p>(b)</p>	<p>50 °C</p> 	<p>0 °C</p> 		
<p>(c)</p>	<p>low number of particles = few collisions</p> 	<p>high number of particles = more collisions</p> 		
<p>(d)</p>	<p>enzyme added</p> 	<p>no enzyme added</p> 		
<p>(e)</p>	<p>twigs</p> 	<p>logs</p> 		

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Four factors affecting the rate of reactions

Use the following graph to answer question 1.



- The graph above shows the differences in the rate of reaction at different temperatures, concentrations, surface area, and the presence or absence of a catalyst. A steeper line represents a greater rate of reaction. Indicate which line (X or Y) each of the following are associated with.

(a) lower temperature _____	(b) higher temperature _____
(c) lower concentration _____	(d) higher concentration _____
(e) absence of a catalyst _____	(f) presence of a catalyst _____
(g) larger pieces (small surface area) _____	
(h) smaller pieces (large surface area) _____	
- Which of the four factors affecting reaction rate is most important in each of the following examples? Choose from concentration, temperature, surface area, and catalyst.
 - Raw carrots are cut into thin slices for cooking. _____
 - Protein is broken down in the stomach by the enzyme pepsin. _____
 - A woolly mammoth is found, perfectly preserved, near the Arctic. _____
 - More bubbles appear when a concentrated solution of hydrochloric acid is added to a magnesium strip than when a dilute solution of the acid is added. _____

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Factors affecting the rate of chemical reactions

Match the Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. _____ catalyst	A. a measure of how much area of an object is exposed
2. _____ temperature	B. the amount of substance dissolved in a given volume of solution
3. _____ surface area	C. a measure of the average kinetic energy of all the particles in a sample of matter
4. _____ concentration	D. a substance that speeds up the rate of a chemical reaction without being used up itself or changed
5. _____ rate of reaction	E. a measure of how quickly products form, or given amounts of reactants react, in a chemical reaction
6. _____ catalytic converter	F. a stainless steel pollution-control device that converts poisonous gases from the vehicle's exhaust into less harmful substances

7. When you walk through a crowded hallway at school, you are more likely to bump into another person. To which of the following factors that affect rate of reaction is this analogy referring?

- A.** catalyst **C.** surface area
B. temperature **D.** concentration

8. Which of the following are true about how temperature affects the rate of reaction?

I.	heating causes the particles of the reactants to move more quickly
II.	lowering the temperature will raise the energy level of the particles
III.	increasing the temperature results in more collisions between the particles

- A.** I and II only
B. I and III only
C. II and III only
D. I, II, and III

9. Increasing which of the following will increase the frequency of collisions?

I.	temperature
II.	surface area
III.	concentration

- A.** I and II only
B. I and III only
C. II and III only
D. I, II, and III

10. Which of the following will lower the rate of reaction?

- A.** adding an enzyme to the reaction
B. decreasing the temperature from 40°C to 10°C
C. breaking a chunk of calcium up into smaller pieces
D. increasing the amount of solute dissolved in a solution