

Factors Affecting the Rate of Chemical Reactions

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.

Collision Theory

For a reaction to occur, reacting particles must collide with sufficient energy for the reacting particles to convert into the products. This relatively simple idea suggests that there are two ways we can influence the rate of the reaction. The first is increasing the number of collisions. Simply making the reacting particles collide more often should mean that there are more collisions with enough energy to make the products. The second method would be to try to increase the amount of energy in a collision. This would also mean that more collisions have enough energy to form the products. Thus collision theory suggests that increasing the number of collisions, and increasing the energy in the collisions should both increase the rate of the reaction - and vice versa.

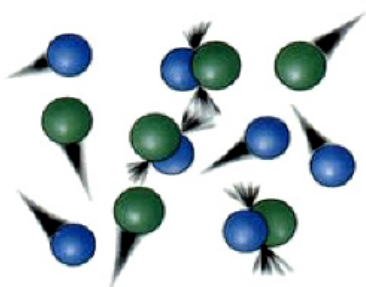
What factors affect the rate of a chemical reaction?

The four main factors that affect the rate of chemical reactions are

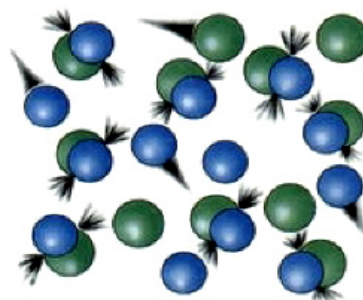
- Concentration of the reactants,
- Temperature of the reactants,
- Surface area of the reactants,
- Addition of a Catalyst.

1. Effect of Concentration on reaction rate

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



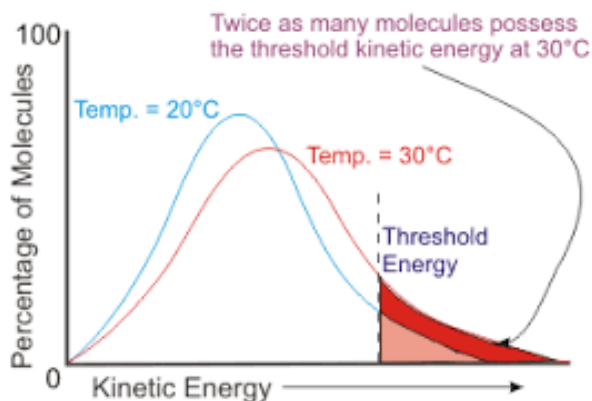
Low concentration = Few collisions



High concentration = More collisions

2. Effect of temperature on reaction rate

Increasing the **temperature** increases the kinetic energy of the particles (atoms or molecules) of the reactants, meaning the reacting particles move more quickly, so that they collide with each other more often and with more energy. Thus, there are more collisions which increases the rate, and the collisions also are more likely to have the activation energy of the reaction, which also increases the rate. These two effects are why small changes in temperature can have significant effects on the rate of reaction. If you decrease the temperature, the opposite effect occurs.



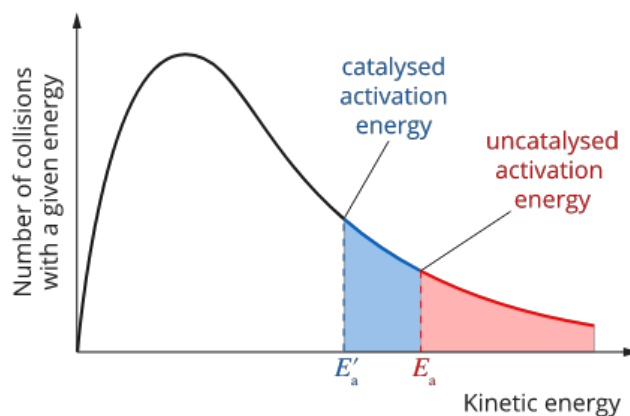
3. The effect of surface area on reaction rate

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. As more particles are on the surface, there are more collisions between the reacting particles, and a higher rate of reaction. The more surface contact between reactants, the higher the rate of reaction. The less surface contact, the lower the reaction rate. It is also important to note that it is only possible to increase the surface area of solids and liquids - not gases.



4. The effect of surface area on reaction rate

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 activation energy required for a chemical reaction. When catalysts are used, a greater proportion of collisions between reacting particles will be successful, making a higher rate of reaction. For example, enzymes are catalysts that allow chemical reactions to occur at relatively low temperatures within the body.



Rate of chemical reactions

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

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.

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) 		

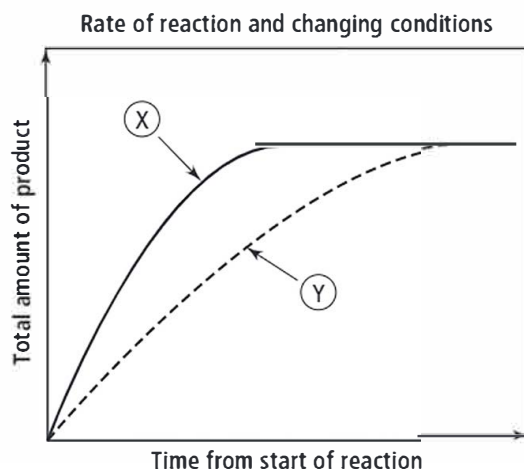
Name _____

Date _____

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

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. _____

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