

## Kinetics

Kinetics is a branch of Chemistry that studies the rate or speed of chemical reactions. There are many factors that determine the rate of reactions including temperature, the nature of reactants, concentration of reactants, pressure, surface area, and the presence of a catalyst. To understand how each of these factors affects the rate of a chemical reaction you must first understand the collision theory. The collision theory is one of the basic concepts of kinetics and it states that in order for a reaction to occur, reactant particles *must* collide. Collisions between particles will result in a chemical reaction if they collide with the proper alignment and amount of energy. The following discusses the various factors that will alter the rate of a chemical reaction. All of these factors affect the rate of a reaction by affecting the rate of collisions that take place between particles.

### Nature of Reactants

All reactions involve the breaking of existing bonds and the formation of new bonds. As a general rule covalent compounds take more time to break down than ionic compounds. This is due to the fact that in covalent compounds more bonds must be broken than in ionic compounds. Relating the nature of reactants to the collision theory, the breaking of more bonds requires that particles have more energy when they collide, thus covalent compounds take more time to react.

### Concentration of Reactants

The collision theory states that particles must collide with proper alignment and energy. Therefore, it is logical that the more particles that are present in a given area (which happens when you increase concentration) the more likely particles are to collide with one another. Therefore, as a general rule chemical reactions will proceed faster if the concentration of one or more of the reactants are increased.

### Pressure

Pressure has little to no effect on the rate of reactions between solids and liquids. However, pressure does play a role in the rate of reaction among gases. As pressure is increased gases are compressed making gas particles closer together and more likely to collide. Therefore, an increase of pressure will increase the rate of reaction for gases only.

### Temperature

Recall that temperature measures the average kinetic energy of particles. Therefore, the higher the temperature the faster the particles are moving. If particles are moving faster they are much more likely to collide. We can relate this to the collision theory (which says that particles **MUST** collide) by reasoning that a higher temperature will result in more collisions and a faster rate of a chemical reaction. Additionally, at a higher temperature particles are not just moving faster they also have a greater energy. Therefore, not only will more collisions occur, but the reacting particles will collide with more energy, making the collisions more effective! For example, milk will sour faster at room temperature than it does in the refrigerator.

### Surface Area

When more surface area of a reactant is exposed to the air there are more chances for reactant particles to collide, therefore increasing the reaction rate. Given this, a finely divided powder will react more rapidly than a single lump of the same mass. Think about which will dissolve faster - a cube of sugar or individual granules of sugar? The granules of sugar will dissolve faster because they have more surface area exposed to the air or the solvent that it is being dissolved in.

### Catalyst

A catalyst is a substance that is neither a reactant nor a product, but functions to speed up the rate of a chemical reaction by lowering activation energy. Another way of saying this is that the catalyst "provides a shorter or alternate pathway" for a reaction to occur. It is important to note that the catalyst does take part in a reaction, but remains unchanged when the reaction is complete. Your body is loaded with enzymes, which are natural catalysts that perform several important jobs like breaking down carbohydrates and proteins in your stomach and small intestine.

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### Review Questions

- 1) As the number of effective collisions between reacting particles increases what will happen to the rate of the reaction? Explain.

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\_\_\_\_\_

- 2) Which of the following pairs of reactants will react most quickly? Be sure to give an explanation for your answer.

- a) sodium chloride and silver nitrate  
b) ethane ( $C_2H_6$ ) and oxygen ( $O_2$ )

Reason: \_\_\_\_\_

- 3) Given the reaction:  $2 Mg_{(s)} + O_{2(g)} \rightarrow 2 MgO_{(s)}$

List four ways that you could speed up the rate of the reaction:

1. \_\_\_\_\_ 3. \_\_\_\_\_  
2. \_\_\_\_\_ 4. \_\_\_\_\_

- 4) Why does raising the temperature speed up the rate of reaction?

\_\_\_\_\_

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- 5) Factors that affect the rate of reaction are:

- a) \_\_\_\_\_, or the substances used  
b) \_\_\_\_\_, or the average kinetic energy of the molecules  
c) \_\_\_\_\_, or the amount of contact between reactants  
d) \_\_\_\_\_, which determines how close particles are to one another.  
e) \_\_\_\_\_, which lowers the activation energy for a reaction.

6) Explain how rate determining step and reaction rate are related.

7) What is the area of chemistry concerned with the speed of reactions?

8) Do all chemical reactions take place at the same speed? Why or why not?

9) Which statement most correctly describes the collision theory?

- a) if molecules collide with either proper alignment or enough energy, then reaction will occur
- b) when molecules collide a reaction always occurs
- c) collisions between particles often result in a reaction
- d) if molecules collide with enough energy and proper alignment, then a reaction will occur