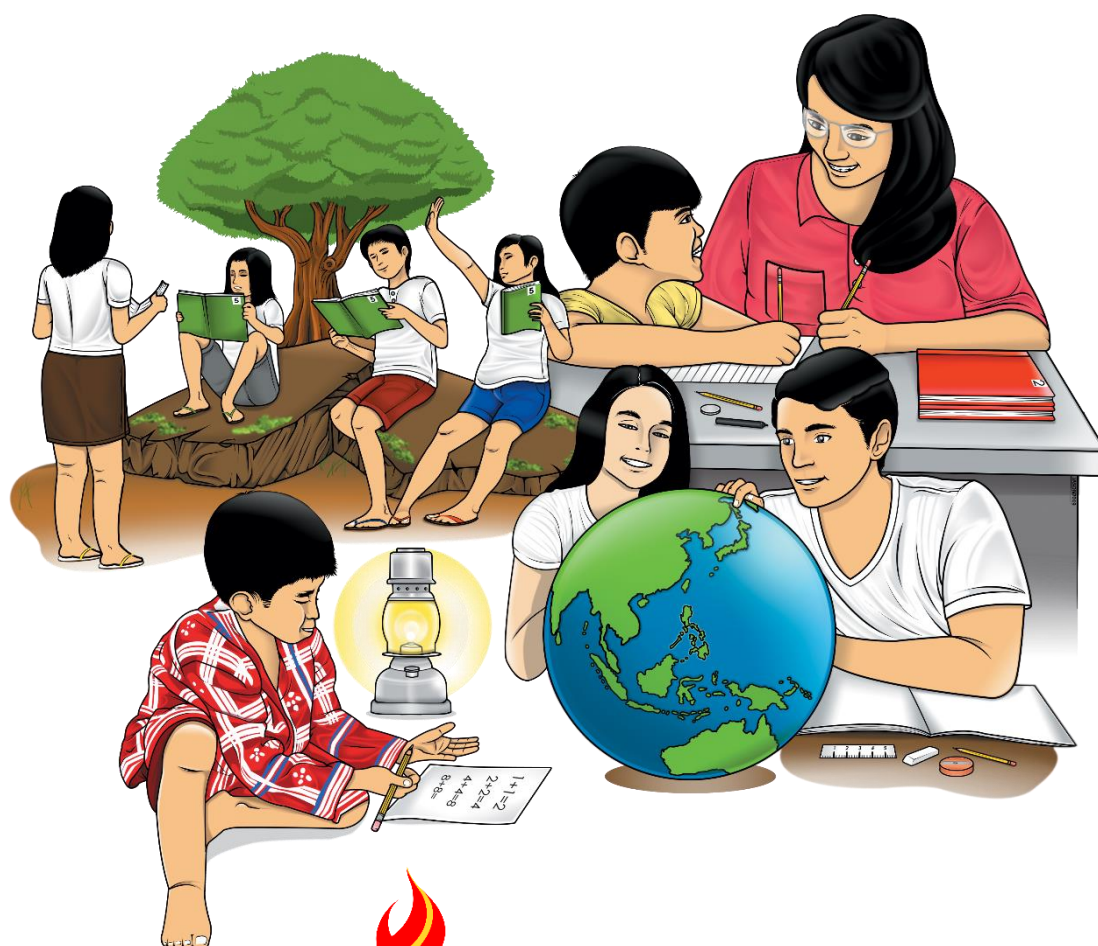


# Physical Science

## Quarter 1 – Module 8:

### Collision Theory and Chemical Reaction Rate



**Physical Science**

**Alternative Delivery Mode**

**Quarter 1 – Module 8: Collision Theory and the Rate of Chemical Reaction**

**First Edition 2021**

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# **Physical Science**

## **Quarter 1 – Module 8:**

### **Collision Theory and Chemical Reaction Rate**

## **Introductory Message**

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check you're learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.



## ***What I Need to Know***

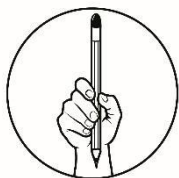
This module was designed and written with you in mind. It is here to help you master the use of simple collision theory to explain the effects of concentration, temperature, and particle size on the rate of reaction. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the textbook you are now using.

The module is divided into two lessons, namely:

- Lesson 1 – Collision Theory
- Lesson 2 – Factors Affecting the Rate of Chemical Reactions

After going through this module, you are expected to:

1. define collision theory and describe how it affects the chemical reaction,
2. explain the different factors affecting the rate of reaction, and
3. create an experiment video showing the effects of concentration, temperature, and particle size on the rate of reaction.



## ***What I Know***

Directions: Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. A chemical change that occurs when two or more substances combine to form a new substance.
  - a. Activation Energy
  - b. Chemical Kinetics
  - c. Chemical Reaction
  - d. Product
2. The measure of the change in the concentration of the reactants or products.
  - a. Activation Energy
  - b. Activation Rate
  - c. Chemical Reaction
  - d. Concentration

3. The substance or particles that enter into and is altered in the course of a chemical reaction.
  - a. Catalyst
  - b. Enzyme
  - c. Product
  - d. Reactant
4. The number of particles present in a given volume of solution.
  - a. Catalyst
  - b. Concentration
  - c. Product
  - d. Temperature
5. The measure of how fast or slow a reaction happens.
  - a. Activation Energy
  - b. Collision Theory
  - c. Particle Size
  - d. Rate of Reaction
6. Condition that needs to be met for a chemical reaction to occur.
  - a. Substance must be homogenous.
  - b. Temperature should be kept constant.
  - c. Particles should maintain a certain distance to each other.
  - d. Particles in the substance must collide and have enough energy.
7. The factor that would NOT affect the rate of chemical reaction.
  - a. Concentration
  - b. Humidity
  - c. Particle Size
  - d. Temperature
8. The factor that will slow down the rate of chemical reaction.
  - a. Manual stirring of the substance.
  - b. Placing substance in a hot water.
  - c. Placing products in iced water.
  - d. Placing reactants in ice bath.
9. The factor that does NOT show evidence of chemical reaction.
  - a. Absorption of heat
  - b. Change of color
  - c. Change of size
  - d. Liberation of heat
10. The measure of the hotness and coldness of a substance.
  - a. Energy
  - b. Humidity
  - c. Temperature
  - d. Thermometer

11. The substance formed as a result of a chemical reaction.
  - a. Product
  - b. Reactant
  - c. Resistance
  - d. Substrate
12. The measure of how much exposed area a solid object has, expressed in square units.
  - a. Concentration
  - b. Surface
  - c. Surface Area
  - d. Volume
13. The substance that is dissolved in a solution.
  - a. Solid
  - b. Solute
  - c. Solvent
  - d. Substance
14. The component of a solution that is present in the greatest amount.
  - a. Sample
  - b. Solute
  - c. Solvent
  - d. Substance
15. A form of matter that has definite composition and distinct characteristics.
  - a. Atoms
  - b. Compound
  - c. Mixture
  - d. Substance

## Lesson

# 1

## Collision Theory

Chemical reactions have been a part of this world ever since everything began. From the Big bang to the present day, everything happening around us has something to do with chemical reactions and chemical processes. Chemical reactions are common in our daily lives: from cooking, eating, cleaning to the different chemical processes like respiration, corrosion, and fermentation. How our body lives and grows are results of many chemical reactions that take place, although you may not recognize them. This is the reason we need to understand how chemical processes take place, be it naturally occurring or not.

This lesson will help enhance your understanding about how chemical reaction occurs and what are the different factors affecting chemical reaction.



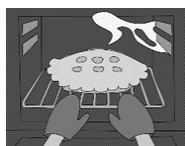
## ***What's In***

### **Recall**

#### **Chemical or Physical Change?**

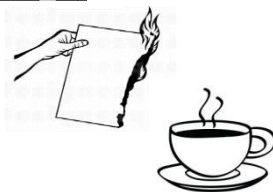
Directions: Identify what kind of change occurs by writing the word **Physical** change or **Chemical** change.

1. Baking a pie



\_\_\_\_\_

2. Burning a paper



\_\_\_\_\_

3. Dissolving coffee in hot water

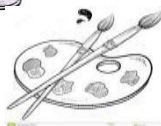
\_\_\_\_\_

4. Dissolving sugar in water



\_\_\_\_\_

5. Mixing paint to make a new



color

\_\_\_\_\_



***Notes to the Teacher***

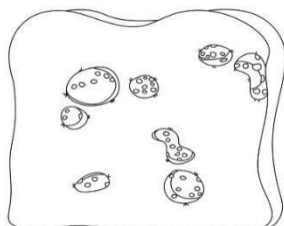




## What's New

### Picture Analysis

Directions: List down ideas you think of based on the given picture.



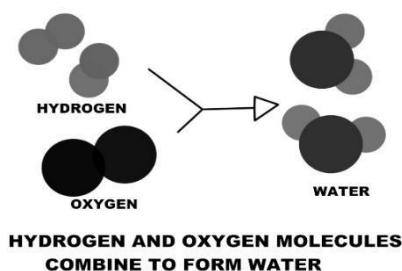
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Directions: Complete the sentence about reaction based on the given illustration.



A reaction \_\_\_\_\_

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## What is It

### The Collision Theory

All substances are composed of millions of tiny particles in constant motion. These particles are colliding with each other constantly in any substance. All collisions between particles do not result in a reaction. There are two factors that determine whether a reaction will occur between two particles that are colliding:

1. Substances or particles of reactants must physically collide with enough energy
2. Substance or particles must come into contact or collide in the correct orientation (facing the correct way).

The *collision theory* states that reacting substances must come into contact (collide) with enough activation energy, and in the correct orientation (facing the correct way),

so that their electron shells can rearrange to form the products of the reaction. Therefore, any factor which changes the frequency or energy of the collisions will change the rate of the reaction.

Try to analyze the illustrations given below:

**Factors affecting the formation of NO from N<sub>2</sub> and O<sub>2</sub>**

**Collision forms products**

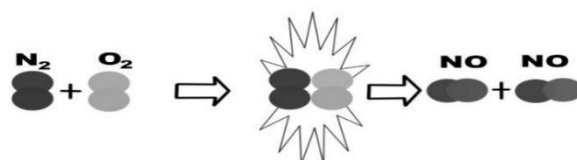


Figure 1

As shown in figure 1, two atoms of Nitrogen react with two atoms of Oxygen to yield two molecules of Nitrogen Oxide. The shared atoms form a bond by completing the valence shells of both atoms.

**Collisions do not form products**

**Insufficient energy**



**Wrong orientation**



Figure 2

As shown in figure 2, a chemical reaction does not take place if the collision between molecules does not have sufficient energy to break the bonds in the reactants and if the molecules are not properly aligned.

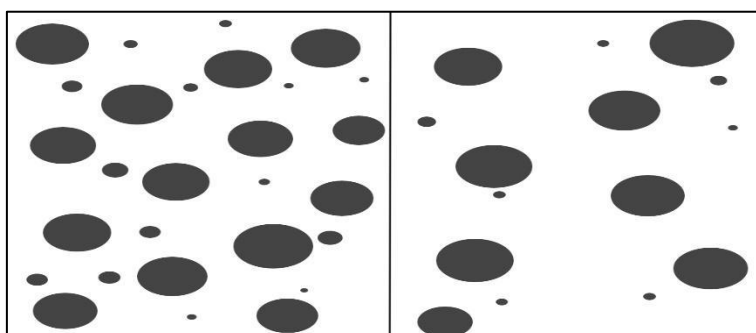


Figure 3

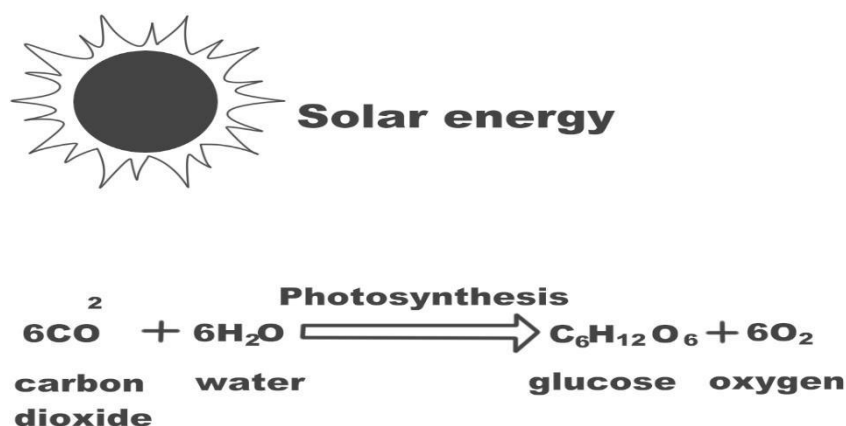
Figure 4

As shown in figures 3 and 4, no reaction can take place between two particles if they are far apart. To form new bonds, atoms must come in contact with each other and have correct relative orientations so that the correct bonds are broken, atoms transfer to the correct positions (see also Figure 1).

## What is a Chemical Reaction?

When two particles collide, sometimes a chemical reaction can occur, which means the bonds between two or more particles are broken and reformed, creating one or more new substances. The substances or particles that enter and is changed in the chemical reaction are called **reactants** and the substances that are formed are called **products**.

Let us look at the chemical reaction in photosynthesis:



The reactants (left part of the equation) are carbon dioxide, water, and light while the products (right side of the equation) are sugar and oxygen. But for a chemical reaction to occur, several things must happen:

1. The particles must come into contact with one another or collide.
2. When the particles collide, the particles must be aligned correctly so that the right parts of the atoms or molecules are exposed. If they are not oriented correctly, no chemical reaction will take place.
3. The particles must collide with enough energy to break their chemical bonds. The amount of energy that must be available for a reaction to occur is often referred to as the *activation energy*. It is the measure of the change in the concentration of the reactants or products.

The reaction rate of a chemical reaction is a measurement of the increase in the concentration of a product or the decrease in the concentration of a reactant as the reaction proceeds over time.

Keep in mind that not all reactions occur at the same speed. Some are very slow while others are fast.

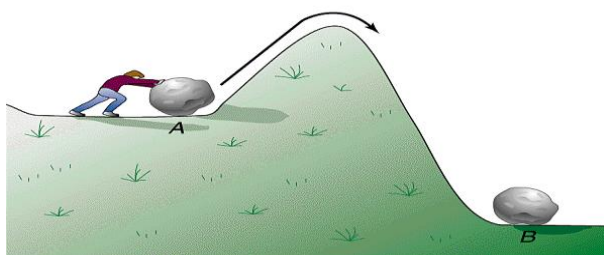
The rate of reaction also depends on the type of molecules that are combining. If there are low concentrations of an essential element or compound, the reaction will be slower.

# Lesson 2

## Factors Affecting Chemical Reaction Rate

### 1. Activation Energy

The *activation energy* refers to the minimum energy required for a reaction to take place. When a collision provides energy equal to or greater than the activation energy, product can form. On the other hand, if the particles have energy that is less than the activation energy, the collision is not effective, and they just bounce off each other unchanged.



The figure above shows a man trying to push a rock over the cliff. For the man to push the rock, he needs to have enough energy. If the man does not have enough energy, the rock will not move down the cliff. This energy needed for the man to push the rock over the cliff represents the *activation energy*.

Can you think of another example to show how activation energy works?

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### 2. Temperature

*Temperature* refers to how hot or cold a certain substance is. Usually, a rise in temperature of 10 °C doubles the reaction rate. The rate of a chemical reaction increases with increasing temperature. As the temperature increases, collision between atoms and molecules becomes faster resulting to build up of more energy. The increased kinetic energy will equal to or exceed the activation energy resulting to more collisions giving rise to a reaction.

Let's try to apply:

Arrange the following samples according to the rate of solubility of sugar. (1 -fastest, 3-slowest)



Cold water

\_\_\_\_\_



Hot water

\_\_\_\_\_



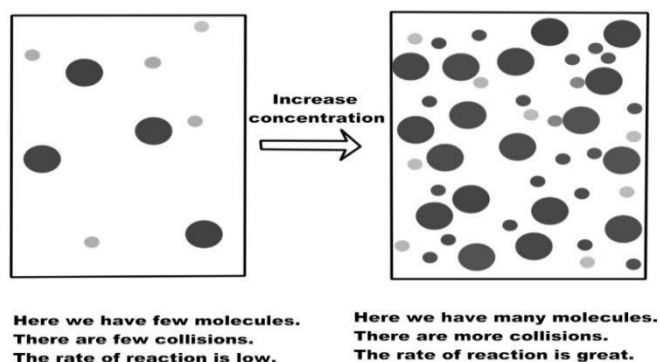
Tap water

\_\_\_\_\_

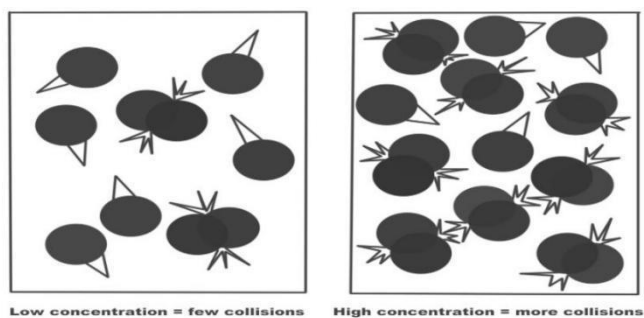
### 3. Concentration

The rate of a chemical reaction is affected by the concentration of reacting substances. The term *concentration* refers to the number of particles present in a given volume of solution. *Concentration* may also mean a measure of how much of the *solute* (something to be dissolved) is dissolved in a *solvent* (dissolving medium) to form a homogeneous mixture. So, a higher concentration means there is more of the solute in the solution. If the concentration of the reactant is increased, the rate of reaction also increases. When the number of particles of the reactant is increased, there is a great chance for particles to collide.

To illustrate:



Now, let's try to analyze the picture below:



Based on the Kinetic Molecular Theory (KMT) and properties of matter, why do you think there is less collision on the left side while there is more collision on the right side?

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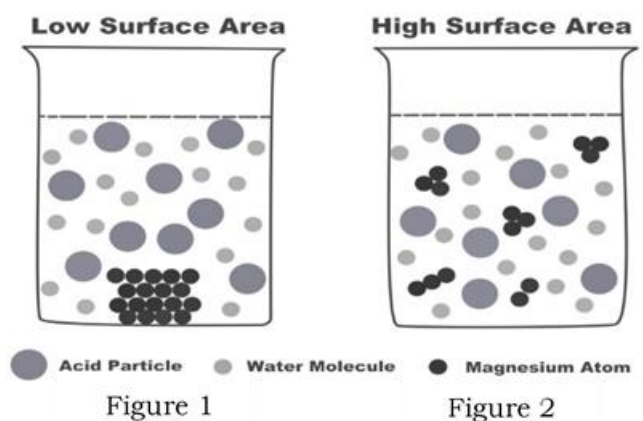
What can you deduce (conclude) about the effect of concentration on the rate of chemical reaction?

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#### 4. Surface Area and Particle Size

*Surface area* is the measure of how much exposed area a solid object has, expressed in square units. In a reaction between a solid and a liquid, the more finely divided a solid is, the faster is the rate of reaction. Likewise, as you powdered a solid, its surface area becomes greater, thus the particles have higher chance of colliding and faster reaction happens.

To understand this further, try to analyze the picture and answer the questions below:

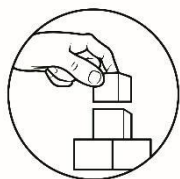


How many reactant particles can be seen on Figure 1? \_\_\_\_\_

Which do you think is the solid particle on Figure 1? \_\_\_\_\_

What have you observed to the reactant particles in Figure 2? \_\_\_\_\_

In which container will the solid particle dissolve faster and why?



### ***What's More***

#### **Activity 1.1 Factors affecting Reaction Rates**

The rate at which reactants are consumed and products are formed during chemical reactions vary greatly. In this part of the module, you will discover how the different factors, such as concentration, temperature and particle size affect the rate of chemical reactions.

The following video links are experiments that you will watch and observe before answering the “Activity Assessment.”

- A. Effects of concentration: [https://www.youtube.com/watch?v=o\\_TJEHzjBLM](https://www.youtube.com/watch?v=o_TJEHzjBLM)
- B. Effects of Temperature: <https://www.youtube.com/watch?v=izqJkdj1d4U>
- C. Effects of Particle Size: <https://www.youtube.com/watch?v=kQtKRBL3rJY>

### Activity 1.2 Guide Questions

**Directions:** Answer briefly and concisely the following questions.

#### PART A: Effects of Concentration

1. What evidence shows that reaction occurs?
- \_\_\_\_\_
- 2-3. Compare the rate of formation of Hydrogen gas in a tube A containing diluted Hydrochloric acid (HCl) with that of tube B containing concentrated Hydrochloric acid (HCl).
- \_\_\_\_\_
- \_\_\_\_\_
- 4-5. Explain the effects of concentration on the rate of chemical reaction.
- \_\_\_\_\_
- \_\_\_\_\_
6. Show the correct chemical equation for the reaction of Magnesium (Mg) ribbon And Hydrochloric (HCl) acid.
- \_\_\_\_\_
- \_\_\_\_\_

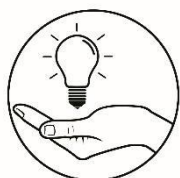
#### PART B: Effects of Temperature

7. In which temperature of Oxalic acid ( $C_2H_2O_4$ ) and Sulfuric acid ( $H_2SO_4$ ) mixture that Potassium Permanganate ( $KMnO_4$ ) dissolves faster?
- \_\_\_\_\_
- 8-9. What evidence shows that a fast reaction occurs?
- \_\_\_\_\_
- \_\_\_\_\_
- 10-11. How does temperature affect the rate of chemical reaction?
- \_\_\_\_\_
- \_\_\_\_\_

#### PART C: Effects of Particle Size

- 12-13. Compare the speed reaction of powdered Calcium Carbonate ( $CaCO_3$ ) with that of a lump of Calcium Carbonate placed in water?
- \_\_\_\_\_

14-15. How does particle size affect the rate of chemical reaction?



## ***What I Have Learned***

### **SENTENCE COMPLETION**

Directions: Complete the group of words to form relevant ideas about the lesson.

- 1-3. According to the collision theory, there are three (3) requirements for a reaction to occur these are \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.
- 4-7. The factors that can affect the rate of reaction are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.
8. Increasing the concentration of reactants in a solution \_\_\_\_\_ the frequency of collision of particles and the rate of reaction.
9. Increasing the concentration means, there is more of \_\_\_\_\_ in the solution.
10. Increasing the temperature \_\_\_\_\_ the collision of particles.
11. Increasing the temperature \_\_\_\_\_ the kinetic energy of particles.
12. The greater the size of particles, the \_\_\_\_\_ is the surface area.
13. The smaller the size of particles, the \_\_\_\_\_ is the surface area.
- 14-15. Remember, not all reactions happen at the same speed. Some are \_\_\_\_\_ while others are \_\_\_\_\_.





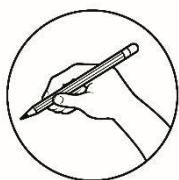
## What I Can Do

Create your own 5-minute experiment video by choosing one of the factors discussed in this lesson.

### Rubric for Grading

The video will be scored from 1 to 5, with 5 being the highest. The criteria for grading are as follows:

Criteria	Expectations
<b>Visuals</b>	The video is clear and engaging. Camera shots tell the story visually and no lighting problems.
<b>Audio</b>	Loudness and dialogue are balanced. Spoken words show confidence and are convincing.
<b>Content</b>	Delivery of content is precise and complete. Emphasis given should be based on the discussion.
<b>Timeliness</b>	The video should consume the required 5-minutes. For every less or added minute/s, points will be deducted.



## Assessment

### PART A. MODIFIED TRUE OR FALSE

Directions: Write the word **TRUE** if the statement is correct. If the statement is **FALSE**, change the *italicized* word to make the statement correct.

- \_\_\_\_\_ 1. *Decreasing* the concentration of the reactants increases the collision frequency between reacting particles.
- \_\_\_\_\_ 2. Increasing the *concentration* of a substance increases the kinetic energy of the particles that make up the substance.
- \_\_\_\_\_ 3. *Increasing* the surface area of the reactant, increases the rate of the reaction.
- \_\_\_\_\_ 4. Raising the temperature of the reaction increases the rate of the reaction by increasing the *energy* of the collisions between reacting particles.
- \_\_\_\_\_ 5. If the reactant particles collide with *less* than the activation energy, the particles bounce back, and no reaction will occur.

## PART B. IDENTIFICATION

Directions: Identify what factor affects the rate of chemical reaction in the following situations. Use the choices below by writing the correct letter before the number.

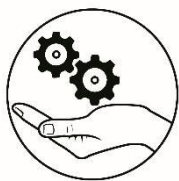
A. Temperature      B. Concentrations      C. Particle Size

- \_\_\_\_\_ 6. The food was refrigerated.
- \_\_\_\_\_ 7. A coal dust explosion happens in mines.
- \_\_\_\_\_ 8. Acid rain erodes marble fast.
- \_\_\_\_\_ 9. Two antacid tablets neutralize acids faster than one tablet.
- \_\_\_\_\_ 10. Kindling is used to start a fire.

## PART C. MULTIPLE CHOICE

Directions: Encircle the LETTER of the correct answer.

- 11. What conditions must be met in order for a chemical reaction to occur?
  - A. Collision with proper orientation
  - B. Sufficient activation energy
  - C. Adding more reactant particles
  - D. Both collision with proper orientation and sufficient energy
- 12. Which of the following would NOT increase the rate of reaction?
  - A. Increasing the temperature
  - B. Adding catalyst
  - C. Increasing the volume
  - D. Increasing the concentrations
- 13. Suppose you dissolve Zinc (Zn) in Hydrochloric acid (HCl) and add more acid than usual. Then drop pieces of Zinc. What factor does NOT affect the rate of the reaction?
  - A. Surface area of the Zinc
  - B. Concentration of the reactant
  - C. Temperature of the solution
  - D. Amount of Hydrochloric acid
- 14. Activation energy is the amount of energy required to \_\_\_\_\_.
  - A. break the bonds between the reacting molecules
  - B. make the reacting particles collide
  - C. form the bonds between the product molecules
  - D. convert the reactant to a single product
- 15. Why does a candle burn more rapidly when placed in an open jar than in air? What accounts for this reaction?
  - A. Higher Oxygen concentration
  - B. Greater surface area of the jar
  - C. Increasing the surrounding temperature
  - D. Length of the candle



## Additional Activities

Now is the time for you to explore your knowledge about collision theory and the factors affecting the rate of chemical reaction. Only short answers are needed.

1. Use the collision theory to explain why a lump of sugar is better to use in hot cup of tea, but granulated sugar is better to use in iced tea.

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2. Suppose you held a lighted match to a solid piece of wood and another match to a pile of wood shavings. Which form of wood would catch fire more easily and why?

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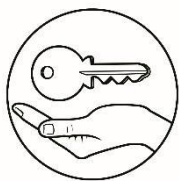
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### WORD SEARCH ACTIVITY

**Directions:** Find and encircle the missing words hidden in the grid. The words may be hidden in any direction.



activation    collision    energy    particle size    product  
reactant    reaction    solute    temperature    theory



## Answer Key

<p><b>What I Know</b></p> <p>C B D D B D D C A C B C D</p>	<p><b>What's In</b></p> <p>Chemical Physical Physical Chemical</p>	<p><b>What's New</b></p> <p>Change of color, Presence of mold, wrinkled skin, drying, rotting There is combining of two or more elements to form a compound. A bond was formed between elements</p>
<p><b>What Is It</b></p> <p><b>Activation Energy</b>- a cyclist going up a steep road. Or any activity that requires exerting energy and force. <b>Temperature</b>- Hot water – 1; Tap water -2; Cold water - 3 <b>Concentration</b>-the particle on the left side has more spaces between them so there is less collision between particles <b>Concentration</b>- When there is a greater number of solute/particles, there is a greater chance of collision causing the increase rate of reaction.</p>	<p><b>What Is it (continuation)</b></p> <p><b>Size of particle/surface area</b> 3 Magnesium atom they are broken into smaller pieces Figure 2 because the particles are smaller which increases the surface area</p>	<p><b>What's More</b></p> <p><b>Activity 1.2</b> <b>Effects of Concentration</b> Formation of gas bubbles. 2-3. The rate of formation of Hydrogen gas is higher in the boiling tube B containing concentrated Hydrochloric acid than in tube A containing diluted Hydrochloric acid. 4-5. The rate of reaction increases with increase of concentration of the reactants</p>

<p><b>What I Have Learned</b></p> <p>Collision of particles, Activation and Activation Energy, Temperature, Concentration and Particle Size/Surface Area Increases Solute Increases Increases Smaller Greater Slow/Slower, Fast/Faster</p>	<p><b>Additional Activities</b></p> <p>In hot tea, the lump of sugar dissolves faster because of the temperature. Reaction rate is increased with increase in temperature making the particles collide faster, gaining more energy. Granulated sugar increases the dissolving rate because more particles are exposed to water.</p>	
<p><b>Assessment</b></p> <p>11. D increasing 12. C True 13. D True 14. B True 15. A True</p> <p>A C B B C</p>	<p><b>What's More</b></p> <p><b>Activity 1.2 (continuation)</b></p> <p>6. <math>\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2</math></p> <p><b>Effects of Temperature</b></p> <p>In hot or in high temperatures. The pink color disappears fast. The rate of reaction increases with high temperature.</p>	<p><b>What's More</b></p> <p><b>Activity 1.2 (continuation)</b></p> <p><b>Effects of Particle Size</b></p> <p>Powdered Calcium Carbonate (<math>\text{CaCO}_3</math>) dissolves faster than a lump of <math>\text{CaCO}_3</math>. When particle size decreases, the total surface area exposed to reacting particles increases thus increasing the speed of chemical reaction. The smaller the size of the reacting particles the faster the rate of reaction.</p>

**Additional Activities (cont.)**

Wood shavings will catch fire more easily because more particles are exposed to other reactant creating greater collision and increasing the rate of chemical reactions.

## Additional Activities (cont.)

### WORD SEARCH

С	И	Σ	λ	λ	W	О	Н	W	В	Σ	Е
М	О	Σ	О	Г	U	Т	Е	Е	Г	Е	Σ
И	В	Г	К	О	К	Г	А	W	В	С	І
О	О	Σ	Г	Г	Д	С	Е	U	Г	λ	Σ
І	О	Г	В	І	Т	А	Т	Е	С	Т	Е
С	І	Σ	И	В	В	І	Е	Е	λ	Σ	С
А	Е	Т	Х	Е	λ	И	О	В	λ	W	І
Е	В	Σ	В	В	Е	В	С	И	λ	В	Т
В	О	W	Т	W	λ	W	Д	В	Е	U	В
Т	Е	В	В	О	Д	U	С	Т	Σ	Н	А
Т	А	С	Т	І	λ	А	Т	І	О	И	В

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