

Physical Science

Quarter 1 – Module 9: Catalyst



Physical Science
Alternative Delivery Mode
Quarter 1 – Module 9: Catalyst
First Edition 2021

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Senior High School

Physical Science

Quarter 1 – Module 9:

Catalyst

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 your 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.



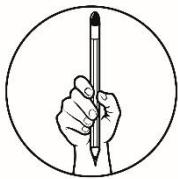
What I Need to Know

This module was designed and written with you in mind. It is here to help you to define catalyst and describe how it affects reaction rate. 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 contains discussion about catalyst as one of the factors affecting the reaction rate.

After going through this module, you are expected to:

1. describe the concept of catalyst;
2. present catalyst as an effective means of affecting the reaction rate; and
3. realize the importance of catalyst and how it affects your life.



What I Know

Pre-Assessment

Modified TRUE or FALSE.

Directions: On the space at the left, write **TRUE** if the statement is true. If the statement is **false**, change the italicized word to make it correct. Write your answer on a separate sheet of paper.

- _____ 1. A catalyst is a substance that can be added to a reaction to increase the reaction rate without getting consumed in the process.
- _____ 2. Heat is not a catalyst since it can't be taken out of the reaction in the same amount it was inputted into the reaction.
- _____ 3. Catalysts increase the rates of chemical reactions by raising the activation energy of the reactions.

- _____ 4. *Collisions only result in a reaction if the particles collide with a certain maximum energy called the activation energy of the reaction.*
- _____ 5. A chemical reaction may be energetically favorable (i.e. exothermic), and so if the activation barrier is high (i.e. the activation energy is high), the reaction rate may be extremely *slow*.
- _____ 6. *Decreasing* the concentration of reactants increases the collision frequency between reacting particles.
- _____ 7. *Increasing* the concentration of a substance increases the kinetic energy of the particles that make up the substance.
- _____ 8. *Raising* the temperature of a reaction increases the rate of the reaction by increasing the energy of the collisions between reacting particles.
- _____ 9. *Lowering* the surface area of a reactant increases the rate of the reaction.
- _____ 10. Catalysts permit reactions to proceed along a *higher* energy path.
- _____ 11. Smaller particle size allows for a *larger* surface area to be exposed for the reaction.
- _____ 12. *Temperature* is the measure of how much area of an object is exposed.
- _____ 13. Grains of sugar have a greater surface area than a solid cube of sugar of the same mass, and therefore will dissolve *quicker* in water.
- _____ 14. *Decreasing* 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.
- _____ 15. *Catalyst* describes the idea that atoms, ions, and molecules must collide in order to react.

Lesson 1

Catalyst

Reaction rates generally increase with increasing reactant concentration, increasing temperature, and the addition of a catalyst. Physical properties such as high solubility also increase reaction rates. Solvent polarity can either increase or decrease the rate of reaction, but increasing solvent viscosity generally decreases reaction rates.

This information is obtained by studying the chemical kinetics of a reaction, which depend on various factors: reactant concentrations, temperature, physical states and surface areas of reactants, and solvent and catalyst properties if either are present.



What's In

Activity 1 Word Search

Directions: Copy the table on a separate sheet of paper. Search and encircle to unlock the pool of words in the box then use them by filling in the blanks to complete the passage. Write your answer on another sheet of paper.

A	C	T	I	V	A	T	I	O	N	E	N	E	R	G	Y	M	G
B	W	D	N	B	M	L	Y	L	M	A	W	D	M	T	M	Q	Y
R	T	A	C	P	A	R	T	I	C	L	E	S	I	Z	E	Z	E
N	S	I	T	A	S	I	E	A	R	T	V	E	N	D	T	T	N
D	Y	T	R	N	R	R	M	Q	A	B	N	D	Q	G	R	M	Z
A	L	L	E	G	E	Y	P	T	M	O	V	K	Z	E	V	C	Y
C	A	C	J	M	S	M	E	X	I	D	C	L	I	O	V	Y	M
T	T	L	O	T	P	P	R	T	O	I	D	N	T	D	B	L	E
I	A	T	Q	M	I	E	A	C	M	T	H	Y	O	Y	L	R	S
V	C	O	N	C	E	N	T	R	A	T	I	O	N	D	B	B	P
A	N	Z	E	L	I	O	U	A	B	L	P	E	L	D	P	Q	L
I	K	R	D	X	Y	H	R	I	T	M	P	Z	R	W	M	T	R
I	P	Y	O	K	T	M	E	I	X	U	N	S	N	M	B	N	R

Factors Affecting the Rate of Reaction

Concentration Temperature	Activation energy Particle Size	Catalyst Enzyme
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Increasing the _____ of a system increases the average kinetic energy of its constituent particles. As the average kinetic energy increases, the particles move faster and collide more frequently per unit time and possess greater energy when they collide. When the _____ of all the reactants increases, more molecules or ions interact to form new compounds, and the rate of reaction increases. When solids and liquids react, increasing the surface area of the solid will increase the reaction rate. A decrease in _____ causes an increase in the solid's total surface area. Collisions only result in a reaction if the particles collide with a certain minimum energy called the _____ for the reaction. The position of activation energy can be determined on a Maxwell-Boltzmann distribution. To increase the rate of a reaction, the number of successful collisions must be increased. One possible way of doing this is to provide an alternative way for the reaction to happen which has a lower activation energy. Adding _____ has this effect on activation energy. It provides an alternative route for the reaction with a lower activation energy. Catalysts are everywhere! Many biochemical processes, such as the oxidation of glucose, are heavily dependent on _____, proteins that behave as catalysts.



Notes to the Teacher

A Word of Caution!

Care must be taken when discussing how a catalyst operates. A catalyst provides an *alternative* route for the reaction with a lower activation energy. It does not "lower the activation energy of the reaction". There is a subtle difference between the two statements with a simple analogy. Suppose there is a mountain between two valleys such that the only way for people to get from one valley to the other is over the mountain. Only the most active people will manage to get from one valley to the other.

Now suppose a tunnel is cut through the mountain. Many more people will now manage to get from one valley to the other by this easier route. It could be said that the tunnel route has a lower activation energy than going over the mountain, but the mountain itself is not lowered. The tunnel has provided an alternative route but has not lowered the original one. The original mountain is still there, and some people still choose to climb it. In chemical terms, if particles collide with enough energy, they can still react in exactly the same way as if the catalyst was not there; it is simply that the majority of particles will react via the easier catalyzed route.



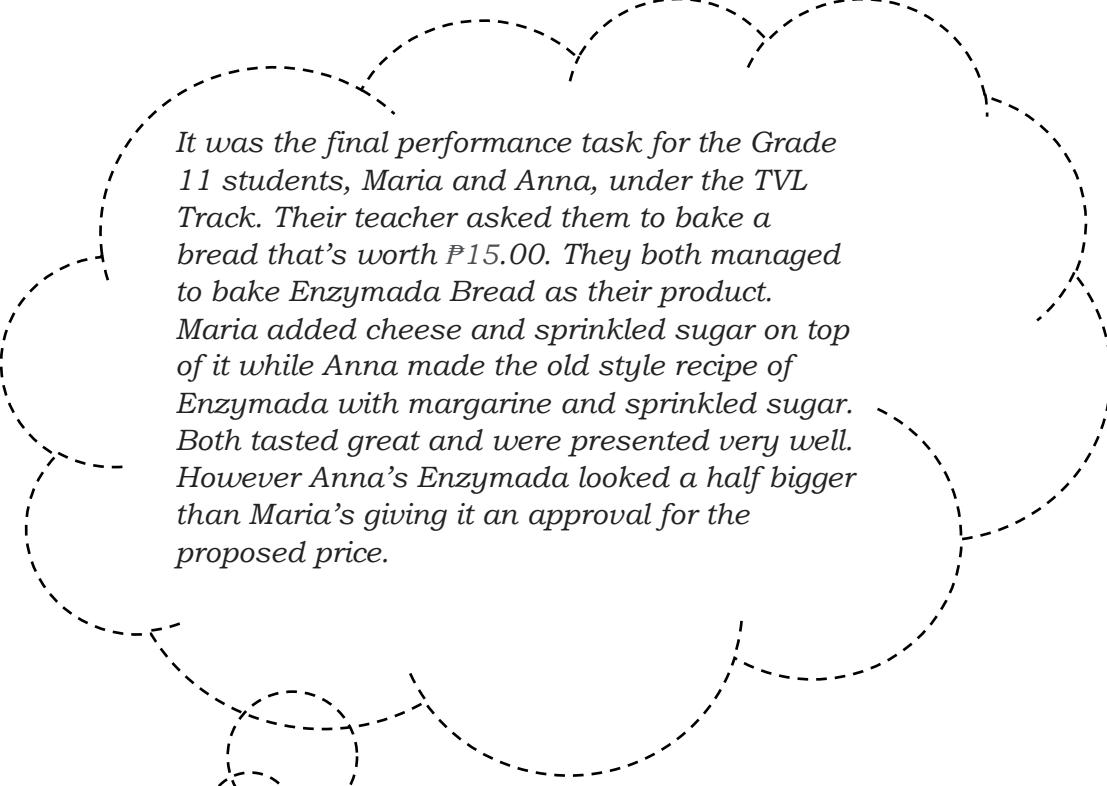
What's New

Excellent! You are good in analyzing information. As a reward, I will share a story with you.

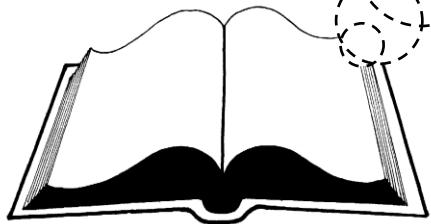


Wow, I do love hearing stories. Can't wait any longer Professor X.

I am more than glad and happy hearing that from you. I'll just get my book and read it for you.



It was the final performance task for the Grade 11 students, Maria and Anna, under the TVL Track. Their teacher asked them to bake a bread that's worth ₱15.00. They both managed to bake Enzymada Bread as their product. Maria added cheese and sprinkled sugar on top of it while Anna made the old style recipe of Enzymada with margarine and sprinkled sugar. Both tasted great and were presented very well. However Anna's Enzymada looked a half bigger than Maria's giving it an approval for the proposed price.



That sound's interesting and appetizing!

What makes their bread size different? In baking, Baker's yeast is the common name for the strains of yeast commonly used in baking bread and bakery products, serving as a leavening agent which causes the bread to rise (expand and become lighter and softer) by converting the fermentable sugars present in the dough into carbon dioxide and ethanol. The yeast act as the catalyst in the process. It increases the rate of reaction without itself being consumed. There are also some fruits that are affected by catalysts.

Activity 1.1

So, apples go brown when their flesh reacts with air. In the pictures below, which apple will go brown the quickest? Why? (Use a separate sheet of paper for your answer.)

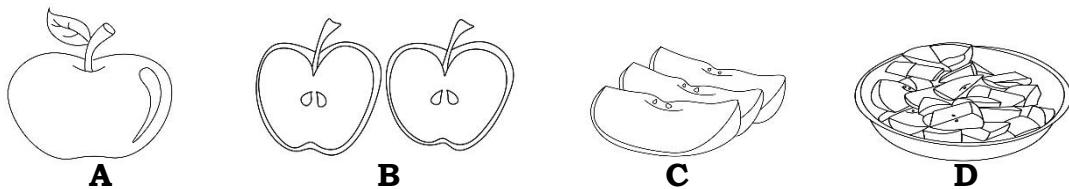


Figure 2: Apple set ups in different sizes.



What is It

Key Terms

- **Activation energy:** the minimum energy required for a reaction to occur.
- **Catalysis:** the increase in the rate of a chemical reaction by lowering its activation energy.
- **Transition state:** an intermediate state during a chemical reaction that has a higher energy than the reactants or the products.
- **Maxwell-Boltzmann Distribution:** a probability distribution used for describing the speeds of various particles within a stationary container at a specific temperature. The distribution is often represented with a graph, with the y-axis defined as the number of molecules and the x-axis defined as the speed.

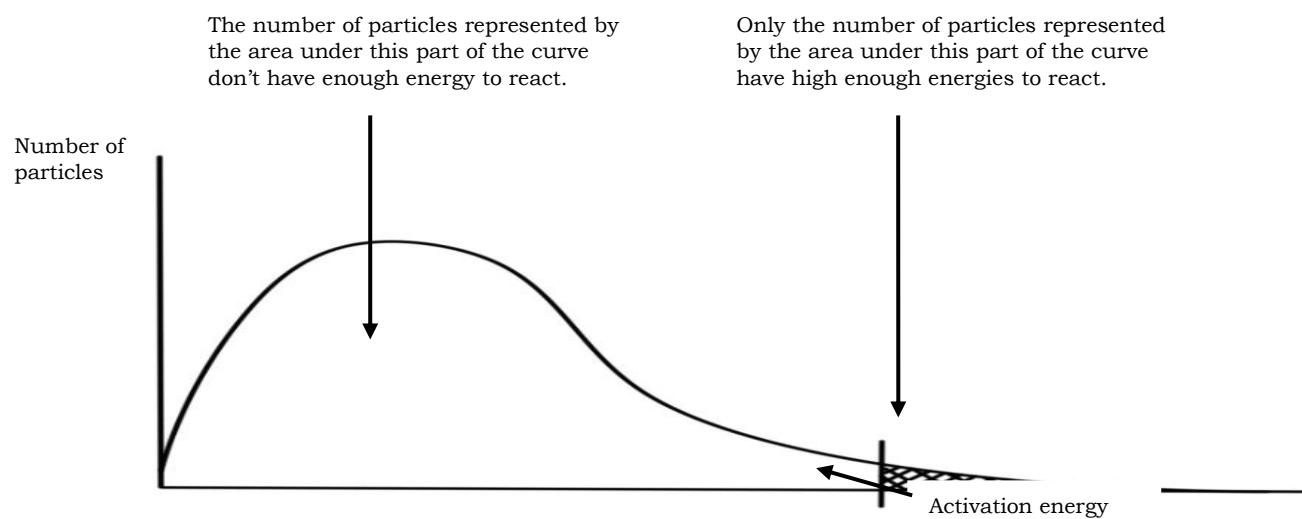
The Effect of a Catalyst on Rate of Reaction

This part explains how adding a catalyst affects the rate of reaction. It assumes familiarity with basic concepts in the collision theory of reaction rates, and with the **Maxwell-Boltzmann distribution** of molecular energies in a gas. A *catalyst* is a substance which speeds up a reaction, but is chemically unchanged at its end. When the reaction has finished, the mass of catalyst is the same as at the beginning. Several examples of catalyzed reactions and their respective catalysts are given below:

Reaction	Catalyst
Decomposition of hydrogen peroxide	manganese(IV) oxide, MnO ₂
Nitration of benzene	concentrated sulfuric acid
Manufacture of ammonia by the Haber Process	iron
Conversion of SO ₂ into SO ₃ during the Contact Process to make sulfuric acid	vanadium(V) oxide, V ₂ O ₅
Hydrogenation of a C=C double bond	nickel

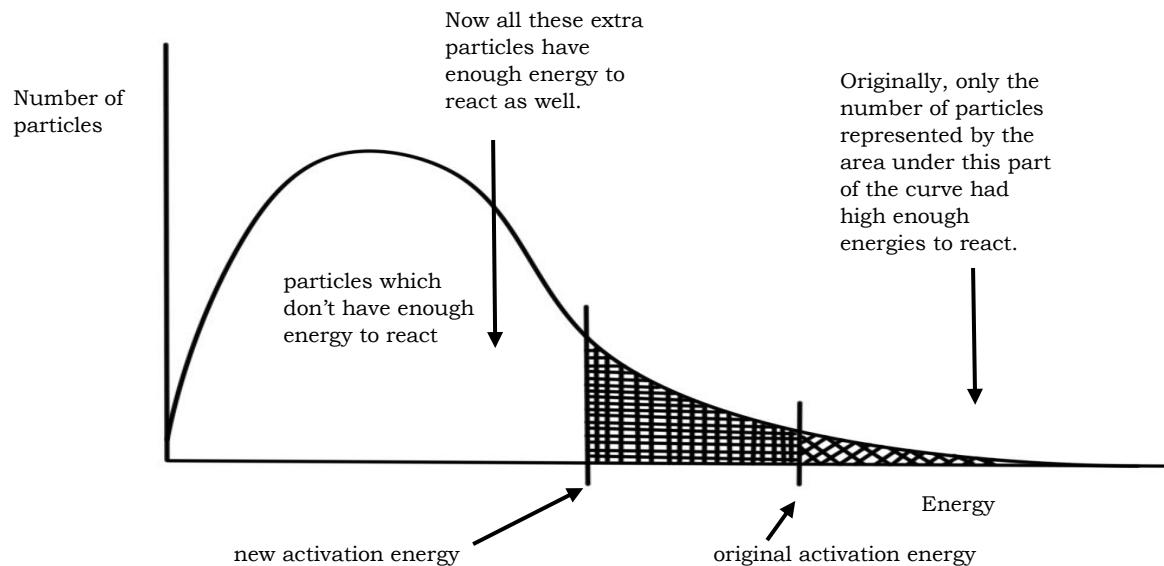
The Importance of Activation Energy

Collisions only result in a reaction if the particles collide with a certain minimum energy called the *activation energy* for the reaction. The position of activation energy can be determined on a **Maxwell-Boltzmann distribution**:

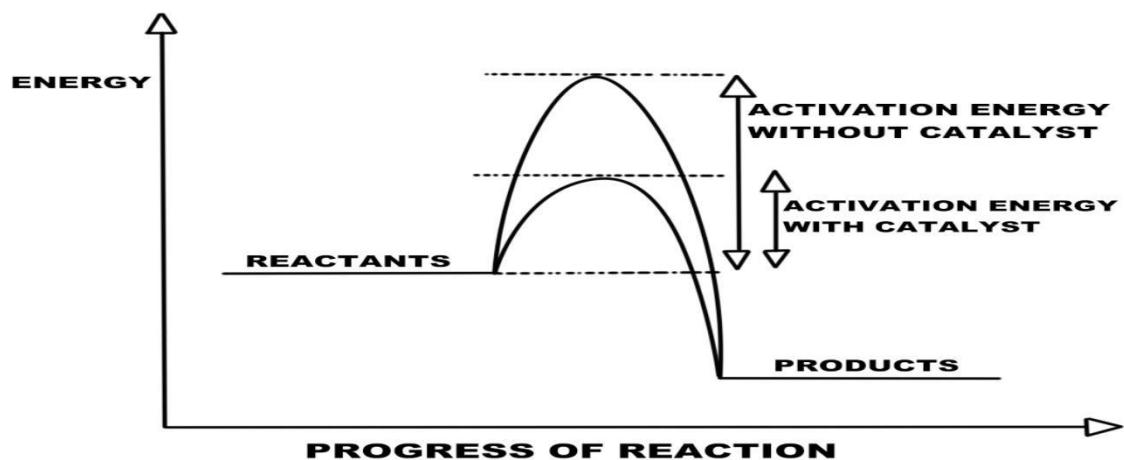


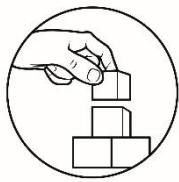
Only those particles represented by the area to the right of the activation energy will react when they collide. The majority do not have enough energy, and will simply bounce apart.

To increase the rate of a reaction, the number of successful collisions must be increased. One possible way of doing this is to provide an alternative way for the reaction to happen which has a lower activation energy. In other words, to move the activation energy to the left on the graph:



Adding a catalyst has this effect on activation energy. A catalyst provides an alternative route for the reaction with a lower activation energy. This is illustrated on the following energy profile:





What's More

Activity 1.2 Guide Questions

Catalyst is one of the factors that can affect the rate of reaction along with concentration, temperature, and size of the particles as discussed on the previous module.

The video links below show a simple experiment and a discussion on how catalyst react with substances, hence affecting its rate.

Answer the guide questions below after watching each video.

Link 1:

“What Are Catalysts? | Reactions | Chemistry | FuseSchool”. Accessed May 23, 2020, https://www.youtube.com/watch?v=m_9bpZep1QM&t=41s

Link 2:

“Demonstration of a Catalyst | Experiment”. Accessed May 23, 2020, <https://www.youtube.com/watch?v=5JpGbhAP3ZE>

Link 1: Guide Questions

1. What is a catalyst?
2. How does catalyst work?
3. In the video, where are catalysts used in everyday life?

Link 2: Guide Questions

1. What substance in the experiment contains catalyst that helps in the reaction?
2. What happens when the yeast is added to the hydrogen peroxide?
3. What enzyme catalyst was produced by the substance?
4. How would you differentiate catalyst from temperature as a factor affecting the rate of reaction?
5. What is the significance of putting flame on the solution in the experiment?

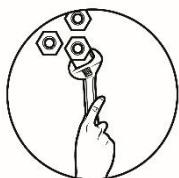


What I Have Learned

Activity 1.3 Critical Thinking

Complete the group of words to form relevant ideas about the lesson. Do this in a separate sheet of paper.

- A catalyst is...
- An enzyme...
- Activation energy is related to rate of reaction because...
- Without catalyst, life is



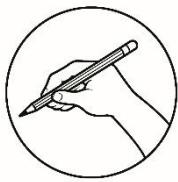
What I Can Do

Activity 1.4 Acrostic Poem

Now that you have learned the nature of catalyst, make an acrostic poem using the word CATALYST. In making the poem you may also write the importance of catalyst in our daily life. Do this in a separate sheet of paper.



C-
A-
T-
A-
L-
Y-
S-
T-



Assessment

Post-Test

Multiple Choice

Directions: Choose the letter of the correct answer. Write it on a separate sheet of paper.

1. How does a catalyst work in speeding up a reaction?
 - a. by lowering the activation energy or reaction.
 - b. by giving them more energy.
 - c. by making them more available.
 - d. none of these.

2. What is the name given to a catalyst in the human body?

a. Biology	c. Catalyst
b. Chemical	d. Enzyme

3. How is catalyst different from a reactant?
 - a. Adding more catalyst speeds up the rate of reaction.
 - b. Adding more catalyst slows down the rate of reaction.
 - c. The catalyst is not used up in the reaction.
 - d. The catalyst increases the activation energy of the reaction.

4. The rate of a chemical reaction is NOT affected by which of the following?

a. Temperature	c. Concentration
b. Particle size	d. All of these affect reaction rate

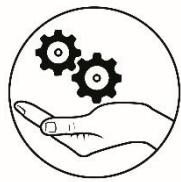
5. Which of the following will lower the rate of reaction?
 - a. Adding an enzyme to the reaction.
 - b. Decreasing the temperature from 40°C to 10°C.
 - c. Breaking a chunk of calcium up into smaller pieces.
 - d. Increasing the amount of solute dissolved in solution.

6. Which of the following is not a characteristic of a catalyst?

a. It participates in the reaction.	c. It enhances the equilibrium rate.
b. It activates equilibrium.	d. It initializes the reaction.

7. What must happen before a chemical reaction can begin?
 - a. The activation energy must be exceeded.
 - b. The activation energy must be reached.
 - c. The concentration of reactant molecules must be reduced.
 - d. The concentrations of products and reactants must be equal.

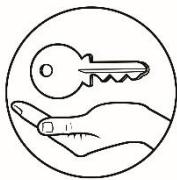
8. Which factor/s help/s explain why so many collisions fail to produce products? Choose all that apply.
- a. Number of collisions
 - b. Activation energy
 - c. Orientation
 - d. Energy released by reaction
9. Which of the following is a/are way/s to increase the speed of reaction? Choose all that apply.
- a. Raise the temperature.
 - b. Add more reactants.
 - c. Add a catalyst.
 - d. Add more products.
10. Pick two (2) options that will INCREASE the rate of reaction.
- a. reducing heat
 - b. adding heat
 - c. adding catalyst
 - d. removing catalyst
11. The minimum amount of energy needed for colliding particles to react is called the
- a. Activation Energy
 - b. Chemical Energy
 - c. Kinetic Energy
 - d. Potential Energy
12. A substance that increases the rate of a reaction without being used up during the reaction is called a
- a. Catalyst
 - b. Product
 - c. Reactant
 - d. Solute
13. Catalysts permit reactions to proceed along a _____ energy path.
- a. higher
 - b. lower
 - c. restricted
 - d. none of these.
14. Products will form faster if _____.
- a. the particle size of the reactants are larger.
 - b. temperature is decreased.
 - c. concentration of the reactants are increased.
 - d. the reaction is not stirred.
15. Smaller particle size allows for a _____ surface area to be exposed for the reaction.
- a. larger
 - b. rectangular
 - c. Smaller
 - d. Spherical



Additional Activities

Activity 1.5

In your daily living, list (five) 5 activities and its acting catalysts that you observe affecting the reaction rate. It can be present when you are eating, washing clothes and others. Do this in a separate sheet of paper.



Answer Key

- | Words Search | Passage |
|----------------------|---|
| 1. TRUE | Y O M T M D W A M G Y J M B N D W B |
| 2. TRUE | C M Y Q R E N E N O I T A V I T C A |
| 3. Lowering | Y D M T M D W A M G Y J M B N D W B |
| 4. Minimum | E E S E S I S A T T I S N |
| 5. TRUE | N T T D N E V T A |
| 6. Increasing | Z M B C S O D N B A O M K A R N A T Y D |
| 7. TRUE | M Y A L E C S K L O M T |
| 8. TRUE | M E M S M L C A C |
| 9. TRUE | D T N D I O T T A I |
| 10. lower | A E E I M S T A I |
| 11. TRUE | B T N D I O T A B T A I |
| 12. Surface area | G T M M B Z q M T I |
| 13. TRUE | B H Y X D B K I |
| 14. Increasing | B H Y X D B K I |
| 15. Collision theory | A N B M N S I U X I |

What I Know

III S 2011

Link 1:

1. Apple D will go brown the quickest. Since apple's flesh reacts to air, it speeds up the reaction but not used up in the reaction.
2. It provides an alternative pathway for the reaction to occur. This has a lower activation energy.
3. Used in the haber process, contact process and catalytic converters.

Link 2:

 1. It is the yeast. The one with the reaction, it will be affected by factors affecting the rate of reaction, it will be the yeast.
 2. It produces bubbles as a result of the release of oxygen.
 3. Catalase
 4. It is not consumed during the reaction.
 5. To test if combustion is possible due to the presence of oxygen.

What's New

What's More

**CO_Q1_Physical Science SHS
Module 9**

- Assessment**
- What I Have Learned**
1. A catalyst is a substance that speeds up a chemical reaction, but it is not consumed by the reaction; hence a catalyst can be recovered chemically unchanged at the end of the reaction. **A**
 2. Enzymes are biological molecules (typically proteins) that significantly speed up the rate of virtually all of the chemical reactions that take place within cells. **B**
 3. The activation energy of a chemical reaction is closely related to its rate. Specifically, the higher the activation energy, the slower the reaction will be. This is because molecules can only complete the reaction once they have reached the top of the activation energy barrier. **C**
 4. Answers may vary.
11. A
 12. A
 13. B
 14. C
 15. A

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