10

Science

Learner's Material
Unit 4

This book was collaboratively developed and reviewed by educators from public and private schools, colleges, and/or universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@deped.gov.ph.

We value your feedback and recommendations.

Department of Education
Republic of the Philippines

Science – Grade 10
Learner's Material
First Edition 2015

Published by the Department of Education
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Undersecretary: Dina S. Ocampo, PhD

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Printed in the Philippines by REX Book Store, Inc.
Department of Education-Instructional Materials Council Secretariat (DepEd-IMCS)
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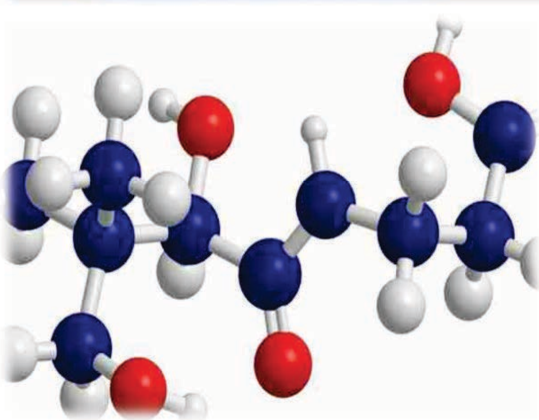
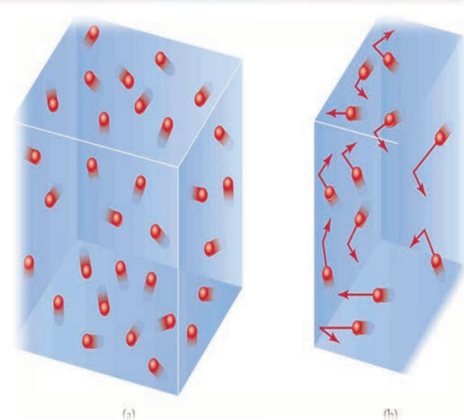




Unit 4: Matter and Its Interactions

Overview

In Grade 9, you have learned about chemical bonding and its various types. You have learned how chemical bonding occurs and how particles rearrange to form new substances. Basic mole concept was also introduced to you, relating mass and number of particles of substances. You were also able to analyze the bonding characteristics of carbon which results in the formation of large variety of compounds.

In Grade 10, you will learn that the rearrangement of particles happen when substances undergo chemical reaction. You will get to know how Law of Conservation of Mass applies to chemical reaction by analyzing masses and number of atoms of substances before and after a chemical reaction. Moving up from bonding characteristics of carbon, you will study about biomolecules such as carbohydrates, lipids, proteins, and nucleic acids.

Also in Grade 10 Chemistry, you will investigate how gases behave in different conditions based on knowledge of the motion of and distances between gas particles. You will be able to explain behaviour of gases using the assumptions in the Kinetic Molecular Theory. You will also learn the relationships between volume, temperature, and pressure using established gas laws.

Unit 4 is composed of the following modules:

Module 1: Behavior of Gases
Module 2: Chemical Reactions
Module 3: Biomolecules

Each module is filled with interesting and fun activities that will guide you in your journey to achieving optimum learning.

Let your journey begin…..

Unit 4
MODULE
1

Suggested time allotment: 14 hours

BEHAVIOR OF GASES

I. Introduction

This module offers interesting discussion about gases. You will have a chance to get to know important concepts that will make you appreciate the properties and the behavior of gases.

Most gases are invisible. We can name as many solids and liquids that we see around us but not gases. It is only the very few colored ones like the black smoke produced by smoke belchers that can be seen. Unseen gases are present, to name a few, in a bottle that seems to be empty, in the production of food by the plant, and even in playing our favorite sports. Can you play your favorite sports like volleyball and basketball without the ball sufficiently filled with air or gas? Even our very own existence requires the presence of unseen gases. We take in oxygen and we exhale carbon dioxide. Can we survive here on earth without the desirable gases which support life?

You learned in Grade 8 that like other solids and liquids, gases are also made up of molecules that behave differently. Most of the properties of gases can be attributed to the random and scattered arrangement of its molecules, which are located as far away as possible from each other because they have very weak intermolecular force of attraction.

II. Learning Competencies/Objectives

To keep you on track while you are studying this module, let's have the following learning competencies/objectives in mind:

- Investigate the relationship between:
    - o volume and pressure at constant temperature of a gas;
    - o volume and temperature at constant pressure of a gas.
- Explain the above mentioned relationships using the Kinetic Molecular Theory.

Before you engage yourself in studying this module, please answer the pre-assessment.

III. Pre-Assessment

Direction: Write the letter of the correct answer.

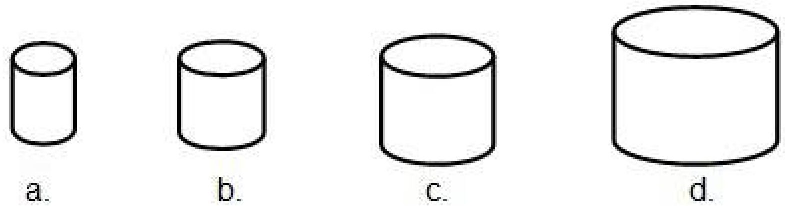
1. Which example has particles that can be drawn closer to occupy smaller volume?
   a. fruit juice b. block of wood
   c. air inside the syringe d. ice cube

2. Which of the following phenomena does NOT involve the application of gas pressure?
   a. burning fuels b. falling leaves
   c. vulcanizing tire d. rising hot air balloons

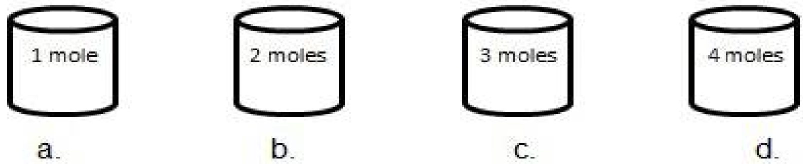
3. Last summer vacation, the Cruz family decided to go to Pagudpod, Ilocos Norte to have a beach party. On their way to Ilocos, all of them were surprised when the tire suddenly exploded. What is the probable explanation for the blown out tire during a long summer drive?
   a. High temperature causes a decrease in volume.
   b. The amount of the gases inside the tire is increased.
   c. The mass of the gases inside the tire increases causing a blown up tire.
   d. The volume of gases increases as the temperature increases, causing a blown up tire.

4. How can you possibly prove that gases have negligible mass?
   a. put a balloon in a digital balance before and after you fill it with air
   b. feel the weight of the samples on both hands
   c. ask two persons to hold a box filled with air
   d. support your claim of through equation

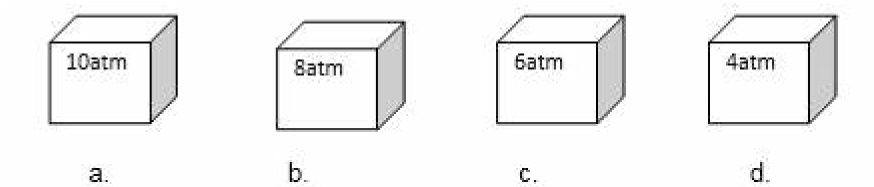
5. Each of the following containers is air tight and has the same number of gas molecules. Which container has the highest pressure?



6. Each of the following containers has the same size. Which of following containers has the most compressed gas molecules?



7. All the gas samples have the same temperature and mass. In which of the following conditions will the gas sample have the highest density?



8. What happens to the density of a gas as its volume decreases at constant pressure and temperature?
   a. decreases b. increases
   c. stays the same d. unpredictable

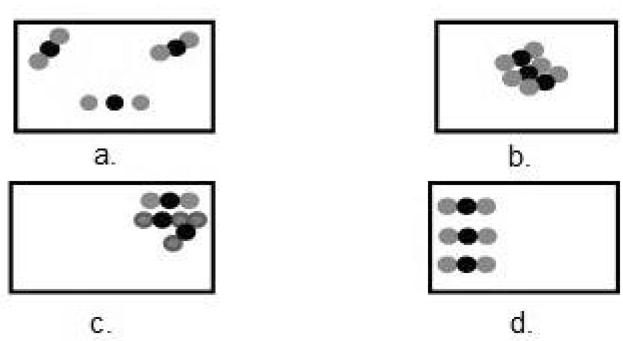
For numbers 9 to11, the choices are:
   a. Boyle's Law b. Charles' Law
   c. Combined Gas Law d. Ideal Gas Law

9. What law explains the mechanism of gas compressor?

10. What gas law best explains the explosion of the heated aerosol container?

11. What gas law explains the relationship among the volume, pressure, temperature, and the number of moles of gases?

12. How will you represent the molecules of carbon dioxide at 30°C?



13. What kind of movement is exhibited by gas molecules?
   a. vibrational movement
   b. rotational movement
   c. translational movement
   d. combination of a, b and c

14. How does the temperature affect the average kinetic energy of gas molecules?
   a. as the temperature decreases the average kinetic energy of gas molecules decreases
   b. as the temperature decreases the average kinetic energy of gas molecules increases
   c. as the temperature decreases the average kinetic energy of gas molecules remains the same
   d. as the temperature decreases the average kinetic energy of gas molecules fluctuates

15. What will happen to the gas pressure as the temperature increases, if the amount and volume of the gas are kept constant?
   a. the gas pressure remains the same
   b. the gas pressure decreases
   c. the gas pressure increases
   d. there is no significant effect

Have your answers checked and keep the result. You will learn about the explanations in your right and wrong answers as you study this module.

Are you familiar with the properties of gases? The first activity will give you ideas on the properties of gases.

IV. Reading Resources and Instructional Activities

Activity 1

Getting to Know Gases

Objective:

Prove that gases have the following properties: mass, volume, temperature, and pressure.

Materials:

For Activity A:

3 rubber balloons of the same kind
digital balance
balloon pump (optional)

For Activity B:

pipette and aspirator or syringe
100-mL graduated cylinder
200 mL water
20 mL cooking oil

For Activity C:

thermometer (360°C)
alcohol lamp
tripod
wire gauze
match
denatured alcohol
ice
500-mL beaker or any tin can

For Activity D:

Erlenmeyer flask
alcohol lamp
tripod
wire gauze
match
denatured alcohol

Procedure:

A. Gases and Its Mass

1. Measure the mass of the deflated balloon using a digital balance with a 0.01 precision (sensitive up to two decimal places).

2. Inflate the balloon using a balloon pump and seal the opening by securely twisting/looping the end.

3. Measure the mass of the inflated balloon using a digital balance.

4. Do three trials and record your data. **Note: Keep the inflated balloon to be used in procedure D.**

Table 1. Data for the Mass of Gas inside the Balloon

Trial	Mass of the deflated balloon (g)	Mass of the inflated balloon (g)	Difference in mass (Inflated-deflated) (g)
1			
2			
3			
Average			

Q1. Is the mass of the deflated balloon different from the mass of the inflated balloon?

Q2. Which is heavier, the inflated or the deflated balloon? Why?

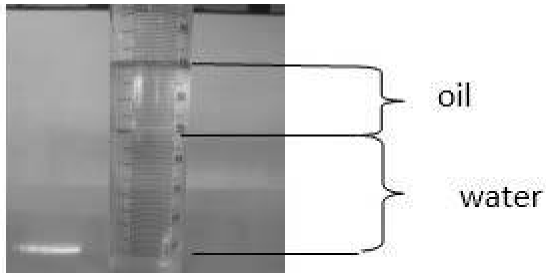
Q3. What can you infer in this activity?

Discover more about gases as you proceed to the next activities.

B. Gases and Its Volume

1. Put approximately 50.0 mL of water in the graduated cylinder.

2. Cover the water with cooking oil up to approximately 70.0 mL. Let the oil settle at the top of the water.



3. Dip the tip of the pipette in the water-oil mixture until it reaches the water portion of the mixture. Carefully press the aspirator at the other end of the pipette to introduce air in the mixture. A syringe can be used as a substitute for pipette.

4. Carefully remove the pipet from the water-oil mixture. Read the final volume after introducing air in the water-oil mixture.

   Note: If pipette and aspirator are not available, you may instead use syringe.

5. Perform three trials and write your data on Table 2.

Table 2. Data for the Volume of Air Trapped in the Water-Oil Mixture

Trial	Volume of water plus oil (mL)	Total volume when air was introduced (mL)	Difference in mass (Inflated-deflated) (mL)
1			
2			
3			
Average			

Q1. What happens to the volume reading of the water-oil mixture when air is introduced to it?

Q2. What does it indicate?

C. Gases and Its Temperature

1. Pour approximately 150 mL of water in a beaker or any tin can.

2. Measure the initial temperature of the air just above the water level.

3. Fill the beaker with crushed ice up to the water level. After 5 minutes, measure the temperature of the air just above the water level.

4. Assemble the wire gauze, tripod, and alcohol lamp. Set aside the iced water. Replace the content of the beaker with tap water. Place the beaker with water on the wire gauze.

5. Heat the water until it boils and get the temperature of the air just above the water level.

6. Perform three trials and write your data on Table 3.

Table 3. Temperature of Water Vapor

Trial	Temperature of the Air (°C)		
	Initial (room temperature)	Above the ice water	Above the boiling water
1			
2			
3			
Average			

Q1. Is there a difference in the temperature of air among the three set-ups?

Q2. Explain the difference in temperature of air.

Note: Use the boiling water for the next set-up.

D. Gases and Its Pressure

1. Transfer the hot water into the Erlenmeyer flask.

2. Carefully place the inflated balloon on the mouth of the Erlenmeyer flask with hot water. Observe what happens.

Q1. What happens to the inflated balloon?

Q2. What causes this phenomenon?

3. Remove the inflated balloon from the Erlenmeyer flask.

4. Get a deflated balloon and place it at the mouth of the Erlenmeyer flask.

5. Assemble the wire gauze, tripod, and alcohol lamp. Heat the Erlenmeyer flask with a deflated balloon.

Q3. What happens to the shape of the balloon?

Q4. What causes the balloon to change its shape and size?

Draw what happens to the balloon.

You have just observed that gases have volume, mass, temperature, and exert pressure. From your daily experiences, can you enumerate some instances where these properties are shown?

The warm temperature we are experiencing is from the heat trapped by the greenhouse gases (carbon dioxide, methane and water vapor to name a few).

The basketball is filled with air. So, it bounces while you are dribbling it. The same is true with the other kinds of ball.

When you open a can or bottle of softdrinks, it fizzes because of the escaping dissolved carbon dioxide due to change of pressure. When the wind blows, it exerts pressure too. There are a lot of manifestations of gases though we cannot see them.

Now that we have proven that gases have mass, volume, temperature, and pressure, let us now be familiar with the units being used to express these properties of gases. Can you identify whether a unit represents volume or pressure or temperature? Below is the list of these units. Start familiarizing yourself with them.

Table 4. Commonly Used Units for Volume and Pressure

Variable	SI Unit	Metric Unit	English Unit
Volume	cubic meter (m^3) cubic decimeter (dm^3) cubic centimeter (cm^3)	liter (L) milliliter (mL)	quart (qt) gallon (gal)
Pressure	Pascal (Pa)	atmosphere (atm) millimeters of mercury (mm Hg) centimeters of mercury (cm Hg)	torr lb/in^2 (psi)

Remembering these equivalents will also be of great help:

Volume units and their equivalents:

$1\ mL = 1\ cm^3$ $1\ L = 1\ dm^3$ $1\ m^3 = 1000\ L$

Source: http://www.metric-conversions.org/volume/cubic-meters-to-liters.htm

Pressure units and their equivalents:

1 atm = 760 mm Hg = 76 cm Hg = 760 torr = 101325 Pa = 14.6956 psi

Temperature units and their equivalents:

$0^{\circ}C = 273.15\ K$ $0^{\circ}C = 32^{\circ}F$

You will encounter most of these units as we go along. For the meantime, let us investigate if there are interrelationships among the properties of gases. Let us start with the effect of pressure to the volume of gases at constant temperature. Perform the next activity.

Activity 2

Boyle's Law

Objective:

- Investigate the relationship between volume and pressure of gases at constant temperature.

Materials:

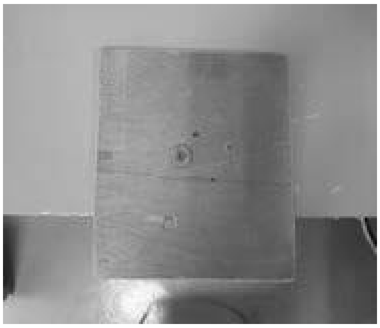
- 25 mL syringe
- set of weights
- ruler
- glue stick
- 5" by 3" illustration board
- 6" by 4" by 0.25" wood
- candle or glue gun
- match (if you opted to use candle)

Procedure:

1. Fill the syringe with air by pulling the plunger. See to it that the volume reading is at approximately 25.0 mL.

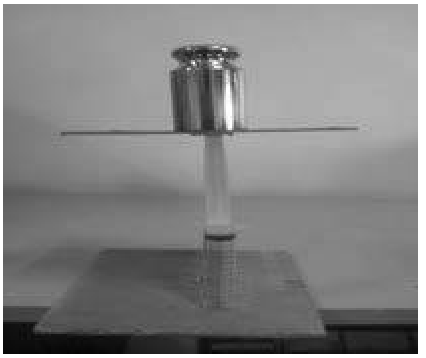
2. Seal the opening of the syringe with the melted glue stick.

3. Bore a hole that is very close to the size of the opening of the syringe in a 6” by 4” flat wood. Screw the wood on a stable object. Insert in an upright position the sealed part of the syringe in the hole of the wood, be sure it is sturdy.



4. Paste a 5” by 3” illustration board at the end of the plunger. This will serve as the holder of the weights. You have just prepared a Boyle’s Law Apparatus.

5. Carefully place a 200-gram weight on the holder and get the volume reading.



6. Place one at a time different weights to the plunger.
   If you do not have set of weights, you may use books of the same kind. Be sure to get the mass of each book.

7. Record the mass and volume reading using Table 5.

Table 5. Observation on Volume Changes

Trial	Volume (cm^3)	Mass (g)	Pressure (N/m^2)
Initial Reading			
1			
2			
3			
4			
5			

Note: ***P*** = Force/Area
Force = mass (kg) x acceleration due to gravity ($9.8 m/s^2$)
πr^2 = Surface Area of the syringe

Q1. What happens to the volume of the syringe as the set of weights is added on top of it?

Q2. What happens to the pressure on the syringe when the set of weights is added?

8. Plot a graph with the pressure at the y axis and volume at the x axis.

Q3. Describe the graph.

Q4. What is the relationship between volume and pressure of gases at constant temperature?

The activity you have performed enables you to observe Boyle's Law, which can be used to describe the relationship between the volume and pressure of gases at constant temperature. Based on the result of your activity, what can you infer?

In your Grade 9 lesson on living things and their environment, you made use of the lung model to explain the respiratory system. Do you still have the model with you? Try to use it again. What do you notice as you pull the bigger balloon that represents the diaphragm? Yes, the lungs expand! Let's try to explain it with the use of Boyle's Law. Pulling the rubber balloon represents inhaling. As you inhale, the lung cavity expands, causing the pressure inside the lungs to decrease and become lower than the outside pressure. As a result, air flows from the higher pressure area, which is outside the body, into the lungs. Exhaling is the opposite process; when you release the rubber which represents the diaphragm, the balloon representing the lungs decreases in volume. This phenomenon happens during exhaling. When the diaphragm contracts as you exhale, it results to a decrease in the lung volume, increasing the pressure inside the chest cavity and causing air to flow out of the lungs. Try to breath in and breath out and mindfully observe what happens to your lung cavity. Interestingly, as you inhale and exhale, approximately 500 mL of air gets in and out of your lungs.

Here is another thing that can happen which can be explained through Boyle's Law. Have you observed the air exhaled by the fishes in the aquarium? It gets bigger and bigger as it rises because the pressure at the bottom of the aquarium is higher than the pressure near the surface.

Where else do you see applications of the relationship between pressure and volume of gases?

Robert Boyle (1627-1691)

> The relationship between the volume and pressure of gases at constant temperature was first stated by Robert Boyle during the 16th century. He performed an experiment wherein he trapped a fixed amount of air in the J-tube, he changed the pressure and controlled the temperature and then, he observed its effect to the volume of the air inside the J-tube. He found out that as the pressure is increased, the volume decreases. He finally concluded that the volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.

Similarly, this is what you observed when you perform Activity 2.

Gas particles have a very weak intermolecular force of attraction, hence they move as far as possible from each other. They have the tendency to occupy all the spaces they are contained in. If the pressure is increased, the volume will be decreased forcing the gas particles to move closer to one another.

The observations in Activity 2 can be expressed in the Boyle's Law equation:

$$\mathbf{V \;\; \alpha \;\; \frac{1}{P} \quad \text{at constant T and n}}$$

Where:

V = volume, P = pressure, T = temperature and n = amount of the gas.

How will you read the above sited equation? It is read as: The volume of a gas is inversely proportional to its pressure, if temperature and amount of a gas are held constant.

It can also be read as: At constant temperature, the volume occupied by a fixed amount of gas is directly proportional to the reciprocal of pressure (1/P).

Let's take a look at the equation again and try to change the proportionality sign (**α**) with the equal sign (=).

$$V \ \alpha \ \frac{1}{P} \ \text{at constant } (k)$$

$$V = \frac{k}{P} \quad \text{Thus, } k = VP$$

The latter equation is simply read as:

The product of Pressure and Volume is constant.

What is the value of Vx P in Table 6?

Table 6. Data on Volume-Pressure Relationship

Trial	Volume (L)	Pressure (atm)	VxP
1	2.0	10.00	
2	4.0	5.00	
3	8.0	2.50	
4	16.0	1.25	

Were you able to verify the meaning of proportionality constant?

Let us apply the equation you learned about Boyle's Law. Since volume and pressure of the gas can be varied, let P_1 and V_1 be the initial pressure and volume respectively and P_2 and V_2 be the final pressure and volume respectively.

According to Boyle's Law, PV= k therefore:

$V_1P_1 = k$
$V_2P_2 = k$
then $V_1P_1 = V_2P_2$

You are now equipped with the fundamental knowledge to cope with the problem solving activities related to Boyle's Law.

Let's try to solve this problem:

The inflated balloon that slipped from the hand of Renn has a volume of 0.50 L at sea level (1.0 atm) and it reached a height of approximately 8 km where the atmospheric pressure is approximately 0.33 atm. Assuming that the temperature is constant, compute for the final volume of the balloon.

Source: http://regentsprep.org/Regents/math/algtrig/ATP8b/exponentialResource.htm

In analyzing the problem, it is important that you categorize the initial and final conditions of the variables:

Initial Conditions	Final Conditions
V_1 = 0.50 L	V_2 = ?
P_1 = 1.0 atm	P_2 = 0.33 atm

By applying Boyle's Law, can you predict what will happen to the final volume?

Yes, you're right! The final volume will increase. Let's compute for the numerical value of the final volume by substituting the given values to this equation.

$$\mathbf{V_1P_1 = V_2P_2}$$

$$\mathbf{V_2 = V_1P_1 / P_2}$$

$$\mathbf{V_2 = \frac{(0.50\ L)\ (1.0\ atm)}{(0.33\ atm)} = 1.5\ L}$$

Did you notice the decrease in pressure and how it affects the final volume? The pressure decreased by 1/3. That is why, the volume increased by 3-folds. Try to multiply V_1 by P_1 and V_2 by P_2. Does it have the same product? Isn't it amazing?

Answer the following problems for a better grasp of the lesson:

1. Oxygen gas inside a 1.5 L gas tank has a pressure of 0.95 atm. Provided that the temperature remains constant, how much pressure is needed to reduce its volume by ½?

2. A scuba diver needs a diving tank in order to provide breathing gas while he is underwater. How much pressure is needed for 6.00 liters of gas at 1.01 atmospheric pressure to be compressed in a 3.00 liter cylinder ?

3. A sample of fluorine gas occupies a volume of 500 mL at 760 torr. Given that the temperature remains the same, calculate the pressure required to reduce its volume by 1/3.

You have shown good mastery of the concepts on Boyle's Law, thus you can now proceed to the next activity. This time, we will find out if there is a relationship between volume and temperature at constant pressure.

Activity 3

Charles' Law

Objective:

Investigate the relationship between volume and temperature at constant pressure.

Materials:

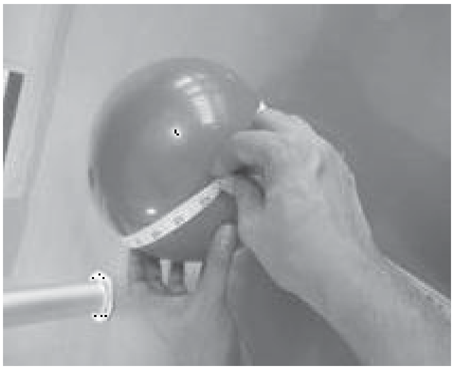
- rubber balloon
- tap water
- hot water
- ice
- thermometer
- alcohol lamp
- tape measure

Procedure:

1. Prepare 3 beakers (1 for ice water, 1 for tap water, and another one for hot water).

2. Inflate a balloon.

3. Measure the circumference of the balloon using a tape measure.



4. Get the temperature reading of the hot water.

5. Put the balloon in hot water for 2 minutes, then measure again its circumference.

6. Do three trials and get the average of the results.
7. Repeat procedures 3 to 6 using tap water.

8. Repeat procedures 3 to 6 . This time use ice water.

9. Record the results in the Table 7.

Table 7. Data on Determining the Size of the Balloon at Different Temperatures

Set-up	Average Temperature (°C)	Average Circumference of the Balloon (cm)		
		before	after	difference
Warm Water				
Tap Water				
Ice Water				

Q1. What happens to the size of the balloon as the temperature decreases?

Q2. How does the change in the temperature relate to the volume of gas in the balloon?

The learning experiences you have from Activity 3 focuses on the volume-temperature relationship. Can you enumerate familiar events you observe in your community and household which are related with the volume-temperature relationship in gases?

The sky lanterns we use in celebrating New Year, Christmas, weddings, and other important occasions operate on the concept of volume-temperature relationship. Have you tried releasing a sky lantern? It is like a mini-hot air balloon; as the temperature increases, the sky lantern obtains its full volume and rises in the atmosphere. It rises and rises as the temperature increases because the density of gases decreases as gases expand due to the increase in temperature. This explains that the increase in volume and decrease in density cause the sky lantern to float in the air!

Jacques Charles
(1746- 1823)

The volume - temperature relationship in gases ($k = V/T$) was determined by and named after Jacques Charles. In his experiment, Jacques Charles trapped a sample of gas in a cylinder with a movable piston in water bath at different temperatures. Jacques Charles found out that different gases decreased their volume by factors 1/273 per °C of cooling. With this rate of reduction, if gas will be cooled up to -273°C, it will have zero volume! Interesting, isn't it? Charles' Law states that at constant pressure, the volume of a fixed amount of gas is directly proportional to the Kelvin (K) temperature.

Mathematically, Charles' Law can be expressed as:

$$\mathbf{V \alpha T \text{ at constant } P}$$

Where: **V** = volume and
T = temperature expressed in Kelvin

Why is there a need to convert °C to K? Kelvin is the basic unit for measuring temperature in the International System (SI). "It denotes the absolute temperature scale whereby 0K or absolute zero is defined as the temperature when molecules will have the lowest energy."

Removing the proportionality symbol (α) and using the equality sign (=) the equation will be as follows:

$$V = kT \qquad \text{or} \qquad k = \frac{V}{T}$$

Thus, in a direct proportion, the quotient of the variable is constant.

If you are going to consider the initial and final conditions, you will arrive at the following equations:

$$\frac{V_1}{T_1} = k \qquad \text{and} \qquad \frac{V_2}{T_2} = k$$

Whereas, V_1 is the initial volume and V_2 is the final volume
T_1 is the initial temperature and T_2 is the final temperature

If the volume-temperature ratios are the same in the initial and final conditions, then we will arrive at this equation:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

To further illustrate the mathematical equations above, let us have the following:

A gas cylinder was measured to have different volumes at different temperature as shown in Table 8. Complete the table with the necessary information.

Table 8. Data on Volume-Temperature Relationship

Trial	Volume Reading (ml)	Temperature (°C)	Temperature (K)
1	25	2	
2	30	57	
3	35	102	
4	40	152	

Note: To convert **°C** to K, use this formula: **K = °C + 273.15**

Plot the data from Table 8 in a graph by placing the volume in the y axis and temperature at Kelvin scale in the x axis.

How is this graph different from the graph you obtained in Activity 2?

Let's apply Charles' Law in solving problems related to volume-temperature relationship in gases.

Sample Problem:

An inflated balloon with a volume of 0.75 L at 30°C was placed inside the freezer where the temperature is -10°C. Find out what will happen to the volume of the balloon if the pressure remains constant. Support your answer with computation.

Just like what we did before, let's start with the given variables:

Initial Conditions	Final Conditions
V_1 = 0.75L	V_2 = ?
T_1 = 30°C = 303K	T_2 = -10°C = 263K

Convert the temperature to Kelvin.

K = °C + 273 = 30 + 273 = 303K

Solve for the final volume.

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(0.75L)(263\cancel{K})}{303\cancel{K}} = \frac{197.25L}{303} = 0.65L$$

Were you able to predict it correctly? Try to divide V_1 by T_1 and V_2 by T_2. Did you obtain the same quotient? Amazing!

The volume decreases because the temperature decreases too. In this case, the volume between the gas molecules decreases because the kinetic energy is also affected by temperature. Do you realize the relationship of Charles' Law to Kinetic Molecular Theory? Gas molecules move slowly at low temperature, thus there is less collision and so it will occupy smaller space.

Answer the following Charles' Law problem to facilitate mastery of concepts on the volume-temperature relationship:

1. A cylinder with a movable piston contains 250 cm^3 air at 10°C. If the pressure is kept constant, at what temperature would you expect the volume to be 150 cm^3?

2. A tank (not rigid) contains 2.3 L of helium gas at 25°C. What will be the volume of the tank after heating it and its content to 40°C temperature at constant pressure?

3. At 20°C, the volume of chlorine gas is 15 dm^3. Compute for the resulting volume if the temperature is adjusted to 318K provided that the pressure remains the same.

Aside from Boyle's and Charles' laws, there is another gas law that you need to be familiar with. Have you ever wondered how temperature affects the pressure of the gas at constant volume?

The next activity will help you visualize the effect of increasing the pressure on the temperature of gases at constant volume.

Activity 4

Gay-Lussac's Law

Objective:

Investigate the relationship between temperature and pressure at constant volume.

Materials:

- 110°C thermometer
- Erlenmeyer flask/bottle
- cork or rubber stopper
- denatured alcohol
- Liquid dropper

Procedure:

1. Insert the thermometer into the stopper. **Precaution: Lubricate the thermometer with a small amount of grease before insertion.**

2. Put 5 drops of denatured alcohol in the Erlenmeyer flask.

3. Cover the Erlenmeyer flask with the stopper that you prepared in Procedure 1. The size of the stopper should fit the mouth of the Erlenmeyer flask. Wait for 2 minutes before measuring the temperature.

4. Shake the Erlenmeyer flask for 2 minutes and take the temperature reading.

CAUTION: Carefully hold the thermometer to avoid breakage.

5. Perform three trials and record the data.

Table 9. Data on Temperature of the Gas Before and After Shaking the Erlenmeyer flask

Trial	Temperature (C°)	
	Before Shaking	**After Shaking**
1		
2		
3		
Average		

Q1. What happens to the drops of denatured alcohol after 2 minutes? after another 2 minutes ?

Q2. Compare the pressure exerted by the denatured alcohol molecules before and after shaking?

Q3. How is the temperature of gas molecules affected by pressure or vice versa?

The previous activity revealed to us the temperature-pressure relationship at constant volume in gases. Can you think of some phenomena which can be explained by this relationship? Are you familiar with the pressure cooker? The pressure cooker is airtight, so pressure builds up inside the pressure cooker as the liquid inside comes to a boil. The resulting trapped steam causes the internal temperature to rise more than what it can normally do at normal atmospheric pressure. Thus, the cooking of hard meat and fibre is done at a short period of time.


Joseph Louis Gay-Lussac (1746- 1823)

The person who is credited with the determination of the temperature-pressure relationship in gases at constant volume is Joseph Louis Gay-Lussac. He deduced that the pressure of the gas is directly proportional to its temperature.

This means that when the temperature of gases increases its pressure also increases or vice versa. Hence, we can state the Gay-Lussac's Law as: At constant volume, the pressure of a fixed mass of gas is directly proportional to the absolute temperature.

Gay-Lussac's Law can be expressed mathematically as

$$P \alpha T \text{ at constant Volume}$$

It is can be written as:

$$P = k\,T \quad \text{or} \quad k = \frac{P}{T}$$

Since there is a direct proportionality between the pressure and temperature of gases at constant volume, it can be shown in this equation:

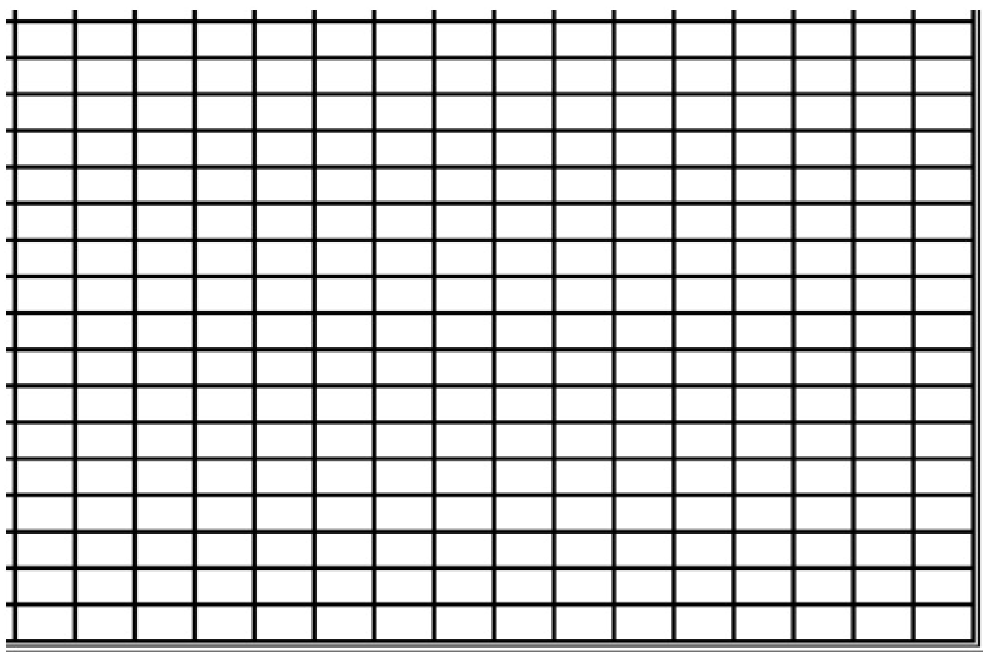
$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Consider this table:

Table 10. Data on Temperature-Pressure Relationship of Gases

Trial	Pressure (atm)	Temperature (K)	P/T
1	1.0	100	
2	2.0	200	
3	3.0	300	
4	4.0	400	

Plot a Temperature-Pressure graph using the data in the Table 10.



What kind of relationship is depicted in the graph?

Let us apply Gay-Lussac's Law in problem solving:

Sample Problem: The pressure of a nitrogen gas inside a rigid tank is 1.5 atmosphere at 30°C. What will be the resulting pressure if the tank is cooled to 0°C?

Identify the given:

Initial Conditions	Final Conditions
P_1 = 1.50 atm	P_2 = ?
T_1 = $30^{o}C$ = 303	T_2 = $0^{o}C$ = 273K

Convert the temperature to Kelvin.

K = °C + 273
K = 30° + 273 = 303K

Then substitute the given values to this equation.

$$P_1 / T_1 = P_2 / T_2$$

$$P_2 = P_1 T_2 / T_1$$

$$P_2 = (1.50 \text{ atm}) (273 \text{ K}) / 303 \text{ K} = \mathbf{1.35 \text{ atm}}$$

Were you able to determine correctly that there will be a decrease in the pressure of nitrogen gas? That's the beauty of understanding the relationship between temperature and pressure of gases.

Practice makes perfect! Answer the following problems on Gay-Lussac's Law to ensure mastery of concepts on the temperature-pressure relationship:

1. A certain light bulb containing argon has a pressure of 1.20 atm at 18°C. If it will be heated to 85°C at constant volume, what will be the resulting pressure? Is it enough to cause sudden breakage of the bulb?

2. At 20°C a confined ammonia gas has a pressure of 2.50 atm. At what temperature would its pressure be equal to 760 mmHg?

3. The helium tank has a pressure of 650 torr at 25°C. What will be the pressure if the temperature is tripled?

You have demonstrated pretty well your skills in problem solving. Good job!

Let's have a review:

Table 11. Gas Laws' Working Formula

Gas Law	Working Formula
Boyle's Law	$V_1P_1 = V_2P_2$
Charles' Law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Gay-Lussac's Law	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

The above cited laws show the relationship of two variables in gases. In the next activity, you will observe the interrelationship among the three variables of gases as to volume, temperature, and pressure.

Activity 5

Combined Gas Laws

Objective:

Determine the relationship among temperature, pressure, and volume of gases at constant number of moles.

Materials:

- liquid dropper
- cylindrical container with cover
- denatured alcohol
- match/candle
- ruler

Procedure:

1. Get a cylindrical container made of hard carton and bore a hole near its bottom.

2. Remove the cover of the cylindrical container and put 5 drops of denatured alcohol. **Caution: Denatured alcohol is toxic or poisonous. It can cause blindness. BE CAREFUL!**
3. Cover and hold the cylindrical container in such a way that your thumb is covering the hole near the base.

4. Shake the container vigorously for 1 minute.

5. Place the container on the table or arm rest. As quickly as possible, place a lighted match/candle near the hole. Observe what will happen. **Cautions: The container of the denatured alcohol should be placed as far as possible from your working area because it is flammable. Immediately wash your hands with plenty of water after this procedure.**

Q1. What happens to the cylindrical container when a source of heat is placed near the hole?

Q2. Why do you need to shake the container after putting 5 drops of denatured alcohol?

Q3. How is the volume of the gases related to its temperature and pressure?

Can you think of applications involving combined gas law?

The weather balloon which carries instruments upward to be able to send back information on atmospheric pressure, humidity, temperature, and wind speed through radiosonde also applies Combined Gas Law. As the weather balloon rises up from the ground, it responds to three variable changes in the surroundings; volume, pressure, and temperature.

Have you ever notice the warning label in the aerosol container? What is the temperature requirement for its storage? Have you seen an explosion of a can of this kind? The explosion of this container is also an application of Combined Gas Law.“The exposure to high temperature increases the kinetic energy of the gases causing an increase in the pressure due to the increased collision of the gases on the walls. An increase in pressure would result in expansion of volume. But because the can is contained, thus the container explodes.”

No one is credited for the Combined Gas Law. Putting together Boyle’s Law and Charles’ Law together will result to this statement.

The pressure and volume of a gas are inversely proportional to each other, but are both directly proportional to the temperature of that gas.

Translating it to mathematical equation will give us the following:

$$T = \frac{VP}{K} \quad \text{or} \quad V = \frac{kT}{P} \quad \text{or} \quad P = \frac{kT}{V} \quad \text{or} \quad k = \frac{PV}{T}$$

The constant k in the equation above is known as the universal gas constant. It is the result of the combination of the proportionality constants in the three gas laws. Note that the formula is equal to a constant, thus it is possible to compute for the change in volume, temperature, or pressure using the following proportion:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Let's use the Combined Gas Law in determining change in the final volume, temperature, or pressure of gases.

Sample Problem: The oxygen tank manufacturer used to produce 5.0 L oxygen tanks at 2000 psi and 25°C . Statistics suggests that the 3.0 L oxygen tank at 1500 psi more marketable. What temperature requirement is needed to produce a 3 L oxygen tank at 1500 psi?

The given values are:

Initial Conditions	**Final Conditions**
V_1 = 5.0 L	V_2 = 3.0 L
T_1 = 25^{o}C = 298K	T_2 = ?
P_1 = 2000psi	P_2 = 1500 psi

Computing for temperature requirement:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$T_2 = \frac{T_1P_2V_2}{P_1V_1}$$

$$T_2 = \frac{(298K)\ ((1500\cancel{psi})\ (3.0\cancel{L})}{(2000\cancel{psi})\ (5.0\cancel{L})}$$

T_2 = 134K ≈ 130 K

Answer the following problems:

1. Helium gas has a volume of 250 mL at 0°C at 1.0 atm. What will be the final pressure if the volume is reduced to 100 mL at 45°C?

2. The volume of a gas at 27°C and 700.0 mmHg is 600.0 mL. What is the volume of the gas at -20.0°C and 500.0 mmHg?

3. A 2.5 L of nitrogen gas exerts a pressure of 760 mmHg at 473 K. What temperature is needed to reduce the volume to 1.75 L at 1140 torr?

It is really important to know how the properties of gases affect us and our environment. There is a lot more as you move on to the next activities.

Do you still remember the mole concept? Can you still recall what a mole means? The number of moles quantifies the amount of a substance. What could be the possible relationship of the amount of gas in a mole to its volume? Can you make a prediction about it?

Amedeo Avogadro
(1776-1856)

During the first half of the nineteenth century, Lorenzo Romano Amedeo Carlo Avogadro, Count of Quaregna and Cerreto, made important contributions in shedding light on reaction stoichiometry. He provided explanations as to why compounds reacted in definite ratios and on how the amount of gas affects its volume. Experimentally, the most convenient way of quantifying the amount of gas is through its mass. Avogadro played an important role in providing evidence of the existence of atoms. Eventually the number of molecules in a mole is named after him.

In 1811, Avogadro wrote in a paper that, “Equal volumes of all gases, kept at the same pressure and temperature, contain the same number of molecules.” Avogadro was the first to suggest that the volume of a gas is directly proportional to the number of moles of gas present at a given temperature and pressure.

If the volume of gases is directly proportional to the number of mole whose symbol is n, what will be the mathematical equation for the volume-mole relationship? Can you still recall the way we represent the relationship in a mathematical equation?

Using the proportionality symbol, we can express the proportionality between the volume and the number of mole of a gas as:

$$V \propto n \quad \text{at constant T and P}$$

Mathematically, the Avogadro's Hypothesis can be expressed as:

$$\frac{V}{n} = k$$

where V is the volume of gas
n is the amount of gas in moles and
k is a proportionality constant

This can also be expressed as:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} \quad \text{or} \quad V_1 n_2 = V_2 n_1$$

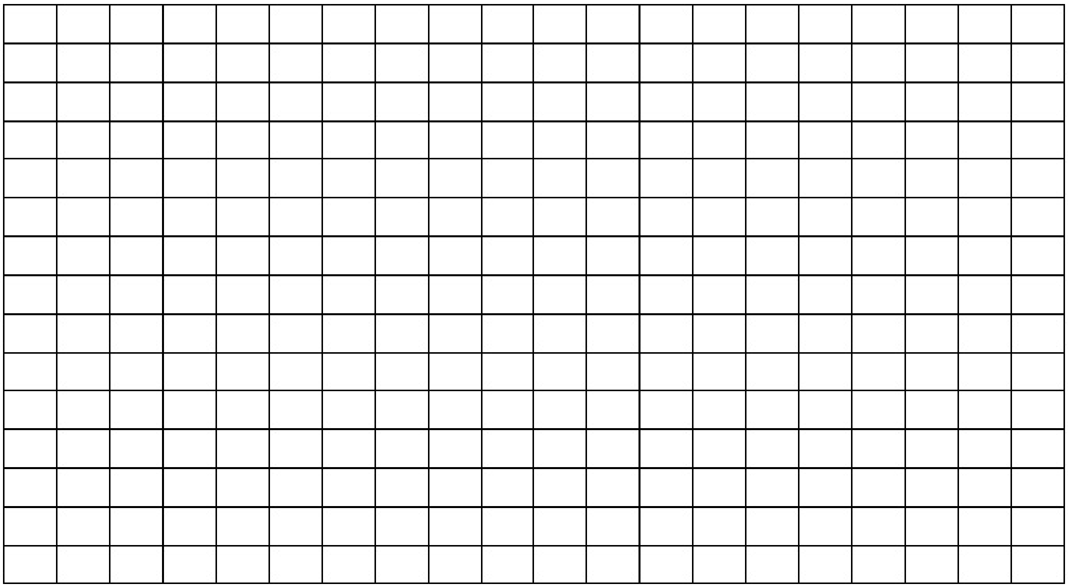
Let's have this table:

Table 12. Data on Avogadro's Hypothesis

Volume (L)	No. of moles (mol)	V/n (L/mol)
2.50	0.50	
5.00	1.0	
7.50	1.5	
10.00	2.0	
12.50	2.5	

Did you obtain a constant value for V/n ?

Predict how the Volume-Mole graph would look like. Verify your prediction, plot a graph.



Let's apply Avogadro's Hypothesis in solving this problem.

What will be the final volume of a 5.00 L He gas which contains 0.965 mole of at 30°C and 1.00 atmosphere, if the amount of this gas is increased to 1.80 moles provided that temperature and pressure remains unchanged?

As we have done in the past lessons, let's start analysing the problem by identifying the initial and final conditions:

Initial Conditions	**Final Conditions**
V_1 = 5.0 L	V_2 = ?
n_1 = 0.965 mol	n_2 = 1.80 mol
P_1 = 1.00atm	P_2 = 1.00atm
T_1 = 30^{o}C	T_2 = 30^{o}C

Since the temperature and pressure are held constant, we will use this formula:

$$V_2 = \frac{V_1 n_2}{n_1}$$

$$= \frac{(5.0L)\ (1.80\cancel{mol})}{0.965\ \cancel{mol}} = 9.3L$$

Let's have more problem sets!

1. A 7.25 L sample of nitrogen gas is determined to contain 0.75 mole of nitrogen. How many moles of nitrogen gas would there be in a 20 L sample provided the temperature and pressure remains the same.

2. Consider the following chemical equation:

$2NO_2$ (g) N_2O_4 (g)

If 50.0 mL of NO_2 gas is completely converted to N_2O_4 gas, under the same conditions, what volume will the N_2O_4 occupy?

Can we observe Avogadro's Hypothesis in real life scenarios?

Try to observe the baking of bread or cake at the nearest bakery in your place. How can you explain the phenomenon of having a bigger bread or cake compared with the dough?

Can you also use this law to explain the production of balloons and the way vulcanizing shop deals with flat tires?

Activity 6

Squashing the Bottle

Adopted from Apex

Objective:

Show the relationship among volume, temperature, pressure and number of moles.

Materials:

- two empty, plastic, 1.5-litre bottles with cover
- hot water
- ice cubes
- hammer
- plastic bag

Procedure for Activity A:

1. Fill one-third of the bottle with hot water.

2. After a few seconds, empty the bottle and put the cover at once.

Q1. What happened when you covered the bottle?

Q2. What caused it to happen?

Procedure for Activity B:

1. Put some ice cubes in a plastic bag. Crush the cubes with a hammer.

2. Put the crushed ice cubes in the bottle. Put the cover on.

3. Shake the bottle so that the inner portion is thoroughly chilled. Observe the bottle.

Q4. What happened to the bottle?

Q5. Explain the phenomenon.

Let’s us now recall the previous gas laws that we have learned in this module.

The different gas laws are:

Boyle’s Law: $V \alpha \frac{1}{P}$ *(n and T are constant)*

Charles’ Law: $V \alpha T$ *(n and P are constant)*

Avogadro’s Law: $V \alpha n$ *(P and T are constant)*

Combining the three laws, you will get:

$$V \alpha = \frac{nT}{P}$$

Using the sign of equality will result to this equation:

$$V = \frac{RnT}{P} \quad \text{or} \quad PV = nRT$$

where:

V = volume in liters
P = pressure in atmosphere
n = moles
T = temperature in Kelvin
R = universal gas constant, $\frac{0.0821 \text{ L. atm}}{\text{mol. K}}$

Do you have an idea on how we arrived at the value of proportionality constant (R)?

Based on the equation above, can you state the ideal gas law in your own words?

The Ideal Gas Equation is useful in illustrating the relationship among the pressure, volume, temperature, and number of moles of a gas. This equation is used to describe gases that behave ideally.

Do gases behave ideally? Discuss among your group members and prove your answer. Validate your answer by consulting Science Teachers, reading books, and internet search to name a few.

Let's apply the ideal gas law equation in this problem:

> What is the volume of a container that can hold 0.50 mole of gas at 25.0°C and 1.25atm?

The given are:

Pressure: 1.25 atm
Temperature: 25.0°C + 273 = 298 K
No. of moles: 0.50 mole

We are asked to calculate for the volume so let's substitute the given values to this equation:

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$= \frac{(0.50\ \cancel{mole})\ (0.0821\ L\ \cancel{atm}/\cancel{mol}.\ \cancel{K})\ (298\cancel{K})}{1.25\ \cancel{atm}}$$

$$= 9.8L$$

Let's use the ideal gas equation in the following problems:

1. Calculate the pressure exerted by a 0.25 mole sulfur hexafluoride in a steel vessel having a capacity of 1250 mL at 70.0°C.
2. Fermentation of glucose produce gas in the form of carbon dioxide, how many moles of carbon dioxide is produced if 0.78 L of carbon dioxide at 20.1°C and 1.00 atm was collected during the process?
3. A sample of liquid acetone is placed in a 25.0 mL flask and vaporized by the heating to 75°C at 1.02 atm. The vapor weighs 5.87 g. Calculate the number of moles of the acetone.

Having enough information about the behaviour of gases you are now ready to explain the Kinetic Molecular Theory.

Activity 7

A Gaseous Outlook

Adopted from Apex

Objective:

Determine the application of gas laws in daily occurrences.

Materials:

Activity A
- string
- sticky tape
- medium-sized balloon
- drinking straw

Activity B
- glass bottle
- medium-sized balloon
- sink with hot and cold water

Activity C
- bowl
- drinking glass
- water

A. Jet-Propelled Balloon
1. Thread a string through the straw and tie its ends tightly between two points at equal heights in a room (e.g., handles or hooks).
2. Inflate the balloon and keep the neck closed between your fingers.
3. Fix the balloon underneath the drinking straw with the sticky tape and pull the balloon along to one end of the string.
4. Pull your fingers against the mouth of the balloon then let go.

Q1. Explain why the balloon shoots along the thread at a speed using the concept of the gas laws.

Q2. What does this prove regarding the compressibility of gases?

B. The Rising Water
1. Put the glass into the water upside down.

2. Lift the glass up, but without the rim going above the surface of the water. Observe what happens.

Q1. What happened to the level of the water inside the glass?

Q2. What caused this to happen?

Q3. If the rim of the glass was raised above the surface of the water what might have happened?

Let us try to make ourselves familiar with the Kinetic Molecular Theory and try to relate the above mentioned concepts with the said theory.

Kinetic Molecular Theory states that:

a. Gases are composed of molecules. The distances from one molecule to another molecule are far greater than the molecules' dimensions. These molecules can be considered as spherical bodies which possess negligible mass and volume.

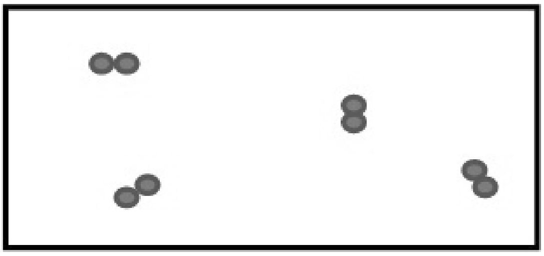


Figure 1. Molecules of Gases

b. Gas molecules are always in constant random motion and they frequently collide with one another and with the walls of the container. Collision among molecules are perfectly elastic, that is, energy may transfer from molecule to molecule as the result of collision but the total energy of all the molecules in the system remains the same/constant.

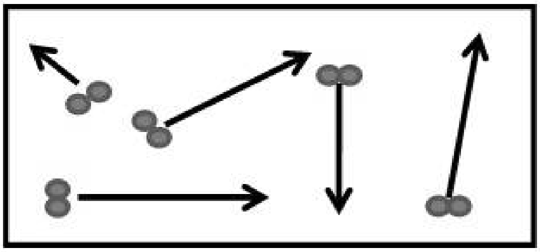
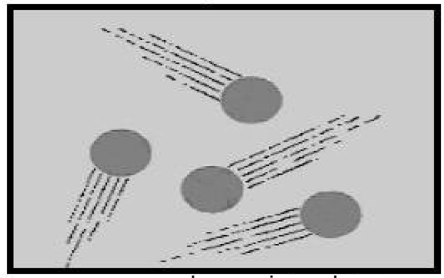


Figure 2. Molecules of Gases in Random Motion

c. There is a neither attractive nor repulsive force between or among gas molecules.

d. Movement of gas molecules is affected by temperature. The average kinetic of the molecules is directly related to the temperature of gas.



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The Kinetic Molecular Theory (KMT) explains the properties of gases and describes the behavior of gases. You can relate the early discussions that we had with this theory.

So far, you have learned that gases have mass, volume, temperature and it exerts pressure. The pressure exerted by gas molecules is due to collision among gas molecules and with the walls of the container. The frequency of collision is affected by temperature because gas molecules move faster at high temperature, on the other hand, they move slowly at low temperature. The faster the movement of the molecules, the more frequent the collision, causing an increase in pressure.

Let's check whether you understand the Kinetic Molecular Theory. Try to answer the following:

Direction: Identify and underline the possible weakness or flaws in the postulates. Write TRUE if the postulate is accurate and FALSE if the postulate is flawed.

Postulates

1. A gas consists of a collection of small particles traveling in straight line motion and obeying Newton's Laws.

2. The molecules in a gas occupy negligible volume.

3. Collisions between molecules are perfectly elastic (that is, no energy is gained nor lost during the collision).

4. There are negligible, attractive, or repulsive forces between molecules.

5. The average kinetic energy of a molecule is constant.

Lifted from "Applied Academics for Excellence" (APEX)

IV. Summary/Synthesis/Feedback

- Gas is one of the phases of matter. It has no definite shape and size. It can be compressed easily.
- Properties of gases include mass, volume, temperature, and pressure.
    - o The amount of a gas or its mass could be expressed in moles or grams. The mass of gases is negligible.
    - o The volume of a gas is the amount of space occupied by the gases. Gases have the tendency to occupy all the spaces of the container that they are confined. They have weak intermolecular force of attraction; hence they are arranged as far away as possible from each other. The common units used in expressing the volume of a gas are liter (L) and milliliter (mL).
    - o The temperature of a gas is the measure of the hotness or coldness of an object. It is proportional to the average kinetic energy of its molecules. It can be measured in Celsius or Kelvin. Kelvin is the absolute scale.
    - o The pressure of a confined gas is the average effect of the forces of the colliding molecules. It can be measured in atmosphere, torr, psi, cmHg or mmHg. It can be quantified using this equation:

$$P = F/A$$

Where: P= pressure, F = force, and A= area

$$F = ma$$

Where: F = force, m = mass and a = acceleration

- The properties of gases can affect one another. They are related to each other.
    - o The volume of a gas is directly related to its temperature at constant pressure.
    - o The pressure of a gas is directly related to its temperature at constant temperature.
    - o The volume of a gas is inversely related to its pressure at constant temperature.

- The amount of a gas in a mole is directly related to its volume at constant pressure and temperature.

- The properties of gases can be varied. The relationships of these properties can be quantified experimentally with the aid of the different laboratory apparatus or by using the different gas laws as follows:

  - Boyle's Law $\mathbf{V_1P_1 = V_2P_2}$
  - Charles' Law $\mathbf{V_1 / T_1 = V_2 / T_2}$
  - Gay-Lussac's Law $\mathbf{P_1 / T_1 = P_2 / T_2}$
  - Avogadro's Law $\mathbf{V_1n_2 = V_2n_1}$
  - Combined Gas Law $\mathbf{V_1P_1 T_2 = V_2P_2 T_1}$
  - Ideal Gas Law **PV=nRT**

  Where V= volume,
  P = pressure,
  T = temperature,
  n = amount of gas in moles
  R = 0.0821 L.atm./mol.K
  1= used as a subscript,means initial condition
  2= used as a subscript,means final condition

- Not all gases behave ideally. Most of the gases found in nature conform to the principles of Boyle's Law, Charles' Law, Gay-Lussac's Law, Avogadro's Law, and Combined Gas Law.

- The following conversion factors are useful in solving gas law related problems:

  α. For volume
  1 mL = 1 cm^3 1 L = 1 dm^3 1 m^3 = 1000 L

  http://www.metric-conversions.org/volume/cubic-meters-to-liters.htm

  β. For pressure
  1 atm = 760 mmHg = 76 cmHg = 760 torr = 101,325 Pa = 14.6956 psi

  χ. For temperature

  0˚C = 273.15K   0˚C = 32 ˚F

- The behavior of the gas molecules can be explained by the Kinetic Molecular Theory. It states that:

  a. Gases are composed of molecules. The distances from molecule to molecule are far greater than the molecules' dimensions. These molecules can be considered as spherical bodies which possess negligible mass and volume

  b. Gas molecules are always in constant random motion and they frequently collide with each other and with the walls of the container. Collisions among molecules are perfectly elastic, that is, energy may transfer from molecule to molecule as the result of collision, but the total energy of all the molecules in the system remains the same/constant.

  c. There is a negligible attractive or repulsive force between or among gas molecules.

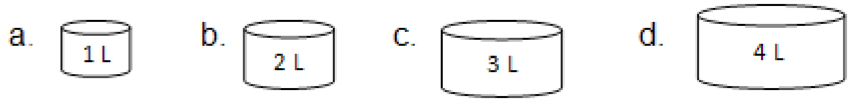
  d. Movement of gas molecules is affected by temperature. The average kinetic of the molecules is directly related to the temperature of gas.

V. Summative Assessment

1. Jane can still pump air in the party balloon even though it is already inflated. What explains this phenomenon?
   a. balloons look better if its size is bigger
   b. balloons are made up of plastic
   c. the air inside the balloon is hot
   d. air molecules can be compressed

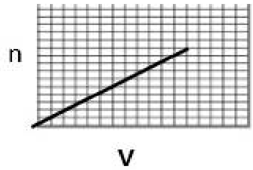
2. What is most likely to happen when an aerosol can is heated?
   a. the can will be deformed
   b. the can will stay the same
   c. the can will eventually explode
   d. the can will tarnish

3. Each container with varying volume has 1.0 mole of oxygen gas at 30.0°C. In which container will pressure be the lowest?

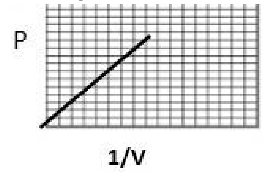


4. Which of the following phenomena best illustrates Charles' Law?
   a. carbon dioxide being dissolved in water
   b. expansion of the balloon as it is being submerged in hot water
   c. breathing apparatus being used by a patient
   d. leavening agent causing the fluffiness of cake products

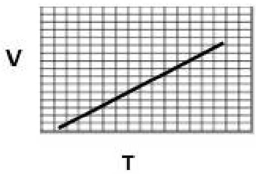
5. Which of the following pair/s is/are correctly matched?



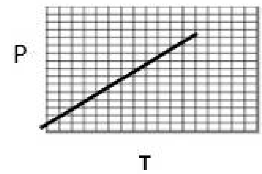
I. Avogadro's Law



II. Boyle's Law



III. Charles' Law



IV. Gay Lussac's Law

a. I & II   b. III & IV   c. I, III, & IV   d. I, II, III, & IV

6. Which of the following samples is highly compressible at high pressure and expandable at high temperature?
   a. oxygen gas   b. aluminium sheet   c. water   d. ice

7. Records show that the incident of tire explosion is high during summer season. Which of the following gives the best explanation for this observation?
   a. there are more travellers during summer vacation
   b. high temperature during summer season causes the air inside the tire to expand
   c. vehicles' tires are not well maintained
   d. there is too much air inside the tires

8. Which is most likely to happen when a closed vessel filled with gas is shaken for 2 minutes?
   a. the temperature inside the vessel increases
   b. the pressure inside the vessel increase
   c. the temperature and pressure inside the vessel increase
   d. both the temperature and pressure inside the vessel increase

9. Determine what will happen to the temperature of a confined gas as the pressure decreases.
   a. the gas temperature stays the same
   b. the gas temperature decreases
   c. the gas temperature increases
   d. there is no enough data

10. Gab wants to have a portable oxygen tank. A 5.00 liter oxygen gas exerts a pressure of 1.00 atmosphere. How much pressure is needed for this gas to be compressed in a 2.00 liter cylinder, provided there is no temperature change?
   a. 3.0 atm   b. 2.5 atm   c. 2.0 atm   d. 1.5 atm

11. The temperature of nitrogen gas contained in a not rigid vessel is reduced from 100°C to 5.0°C? Which of the following describes the resulting behavior of nitrogen gas molecules?

I. The average kinetic energy suddenly increases, thus the pressure increases

II. The average kinetic energy suddenly decreases, thus the pressure decreases

III. The volume occupied by the gas molecules suddenly increases, thus the container expand

IV. The volume occupied by the gas molecules suddenly decreases, thus the container shrink

a. I & III b. II & IV c. I & IV d. II & II

12. A balloon with a volume of 200 mL at 30°C is submerged in hot water to obtain a temperature of 50°C. Find out what will happen to the volume of the balloon, provided the pressure remains the same.

a. the volume of the balloon will become higher than 200 mL
b. the volume of the balloon will become lower than 200 mL
c. the volume of the balloon will stay the same
d. there is no enough data

13. A 2.0 g (approximately 0.045 mole) sample of dry ice (solid carbon dioxide) is placed in an evacuated 3.5 L vessel at 30°C. Compute for the pressure inside the vessel after all the dry ice has been converted to carbon dioxide gas. (R=0.0821 L. atm/mol.K)

a. 0.32 atm b. 0.45 atm c. 0.67 atm d. 1.0 atm

14. What is the explanation to your answer in item number 13?

a. the gaseous form of dry ice exerts the same pressure with its environment because it adopts the atmospheric pressure
b. the gaseous form of dry ice exerts lower pressure due to the bigger volume that results to lesser collisions of the gas particles.
c. the gaseous form of dry ice will have the same pressure because its composition remains the same
d. the gaseous form of dry ice will either have high or low pressure

15. What do you expect to happen to the volume of a gas if its pressure is doubled and its temperature is reduced to half?

a. its volume is increased
b. its volume is doubled
c. its volume remains unchanged
d. its volume is decreased

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Photos by: Francis E.Ansing and Ma. Victoria G. Senase

Unit 4
MODULE
2

Suggested time allotment: 12 hours

CHEMICAL REACTION

I. Introduction

From the time we get up in the morning to the time that we sleep at night, chemical changes are taking place, within us and outside of us. Plants grow through photosynthesis, foods that we eat are digested by the body, metals corrode, raw materials are being converted to useful products, new medicines are being developed, more versatile and cost effective materials are being made.

Various chemical changes that occur around us have significant effects to our environment and consequently to our health. Chemical changes occurring in industries result to products that are useful to us. The wastes we throw continue to undergo chemical changes and this has an impact on our well-being as well. The irresponsible use of fertilizers, herbicides and pesticides have negatively affected plants and aquatic life. We continue to pollute the atmosphere with vehicle and industrial gas emissions.

In your lower grade levels, you were exposed to some chemical reactions, you've tested the reactivity of some metals and you've seen the color changes of an indicator when tested with acids and bases. You have also learned in chemical bonding, that atoms gain stability by losing or gaining electron/s.

In this module , you will further understand how a chemical change proceeds, how bonds are broken and new bonds are formed, and how chemical reactions are translated into chemical equations, where rearrangements of atoms causes the formation of new substance/s. A lot of these chemical changes made the quality of our lives better.

This module contains the following lessons and activities:

1. Identifying chemical change
   Evidences of chemical reactions
   Chemical equation
2. Types of chemical reactions
3. Law of conservation of mass
4. Factors affecting reaction rate

How do chemical reactions take place?
What is the significance of studying the rates of reaction?

II. Learning Competencies/Objectives

The learner should be able to:

1. Write chemical equations;
2. Apply the principles of conservation of mass to chemical reactions;
3. Classify reactions according to the different types;
4. Identify the factors that affect reaction rates and explain them according to collision theory; and
5. Explain how the factors affecting rates of chemical reactions are applied in food preservation and materials production, fire control, pollution, and corrosion.

III. Pre-Assessment

1 -5 Multiple Choice. Choose the correct answer.

1. During a chemical reaction,
   a. atoms are destroyed
   b. atoms are rearranged
   c. elements are destroyed
   d. new elements are produced

2. A chemical reaction is a process in which
   a. all reactants change state
   b. products change into reactants
   c. the law of conservation of mass applies
   d. all of these

3. What determines an atom's ability to undergo chemical reactions?
   a. protons
   b. neutrons
   c. innermost electrons
   d. outermost electrons

4. How is a chemical equation is balanced?
   a. changing subscripts
   b. erasing elements as necessary
   c. adding coefficients
   d. adding elements as necessary

5. What are the products in the equation below?
   $Zn + CuSO_4 \text{ -----> } ZnSO_4 + Cu$
   a. Zn and Cu
   b. Zn and $CuSO_4$
   c. $ZnSO_4$ and Cu
   d. Zn only

6 -10 Write true if the statement is correct and false if incorrect, and change the underlined word/s to make the statement correct.

6. Generally, the higher the concentration of the reacting substances, the faster is the reaction.
7. At lower temperature, chemical reactions occur at slower rates.
8. The bigger the surface area of the reactants, the faster the rate of reaction.
9. Catalysts increase the rate of reaction by providing a reaction pathway with a higher activation energy.
10. The minimum energy required to start a reaction is called bond energy.

11 - 12 Balance the following chemical equations, then classify the reaction according to its type

	Chemical Equation	Type of Reaction
11.	$CaCO_3 = HCI \text{ ---> } CaCI_2 + H_2CO_3$	
12.	$AqNO_3 = Zn \text{ ---> } Zn\ (NO_3)_2 + Ag$	

13-15 Explain in concise and brief sentences.

13. What is the function of MnO_2 in the production of oxygen from hydrogen peroxide in this reaction:

$$H_2O_2 \xrightarrow[MnO_2]{} H_2O + O_2$$

14. Why would iron fillings rust faster than an iron nail?

15. Enzymes are in molds and bacteria that spoil food. Explain, using your knowledge of factors affecting the rate of reaction, why food doesn't spoil as fast when it is refrigerated as it would at room temperature.

IV. Reading Resources and Instructional Activities

How do you know if a certain change that has taken place involves a chemical reaction? What indicators/ evidences should be present to consider it a chemical reaction?

Activity 1 will help you identify those indicators/evidences of chemical reactions.

Activity 1

Everything has changed

Objectives:

- Perform a laboratory activity involving chemical reactions;
- Distinguish evidences of chemical reactions.

Materials:

- Mg ribbon (Mg)
- Iron nail (Fe)
- 30 volumes Agua oxigenada
- Hydrogen peroxide (H_2O_2)
- Manganese dioxide (MnO_2)
- 10% copper sulfate ($CuSO_4$) solution
- 10% sodium hydroxide (NaOH) solution
- Denatured alcohol
- Vinegar
- Baking soda
- Matches
- Alcohol lamp
- Tripod
- Crucible tong
- Beakers or small transparent bottles
- Test tubes
- Test tube rack
- Thermometer
- Forceps or crucible tong
- Iron nail/shoe tack
- spatula or small teaspoon

Precautions

1. Wear goggles.
2. Be careful with the use of matches.
3. Do not touch substances, it may cause skin irritation.

Procedure A. Iron Nail-Copper Sulfate Reaction

1. Fill a test tube with 10 mL of copper sulfate solution.
2. Drop the nail gently into the solution.
3. Place the test tube in the test tube rack for a few minutes.

(You may proceed to the next procedure while waiting for any change.)

Table 1. Iron Nail-Copper Sulfate Reaction

Materials	Color Before Mixing	Color After Mixing
Copper solution		
Nail		

Q1. What happened to the color of the copper sulfate solution?

Q2. What happened to the color of the nail?

Procedure B. Magnesium Ribbon Reaction

1. Cut about 10 cm of magnesium ribbon.
2. Light the alcohol lamp.
3. Hold the magnesium ribbon with a crucible tong or forceps.
4. Place the magnesium ribbon over the flame.

Q3. What happened to the magnesium ribbon when you directly burned it?

Q4. What substance in the air could have reacted with magnesium during burning?

Q5. Describe the appearance of the product formed.

Table 2. Magnesium Ribbon Reaction

Materials	Before Burning		During Burning	
	Color	Appearance	Color	Appearance
Magnesium				

Procedure C. Hydrogen Peroxide (Agua Oxigenada) Reaction

This procedure should be done fast.

1. Pour 20 mL of agua oxigenada in a small beaker.
2. Using a spatula add a pinch of manganese dioxide (MnO_2) to the beaker.

Q6. What happened to the mixture?

3. Place a lighted match on top of the beaker near the bubbles. (Figure 1)
4. Observe what happens to the flame.

Q7. Describe the change you observe in the flame.

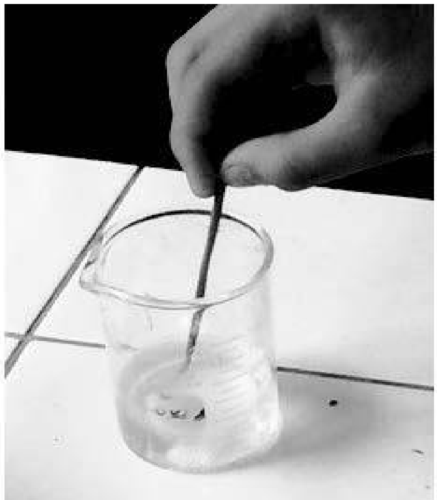


Figure 1

Table 3. Hydrogen Peroxide (Agua Oxigenada) Reaction

Material	Before Reaction	With addition of MnO_2
Agua oxigenada		

Procedure D. Vinegar and Baking Soda Reaction

This procedure should be done swiftly

1. Pour 20 mL of vinegar in a small beaker.
2. Get the temperature of vinegar.
3. Add a tablespoon of baking soda to the beaker.

Figure 2

Q8. What do you observe in the mixture?

1. Place a lighted match on top of the beaker near the bubbles. (Figure 2)
2. Observe what happens to the flame.

Q9. Describe what you observe in the flame.

Table 4. Vinegar and Baking Soda Reaction

	OBSERVATION	
Material	**Before Reaction**	**During Reaction**
vinegar		
baking soda		

Procedure E. Copper Sulfate-Sodium Hydroxide Reaction

1. Pour 5 mL of aqueous copper solution in one test tube.
2. Pour 5 mL of aqueous sodium hydroxide in another test tube.
3. Slowly combine the two solutions.
4. Observe what happens.

Q10. What did you observe at the bottom of the test tube?

5. Shake the mixture.
6. Observe what happens.

Q11. Compare the appearance before and after shaking

Table 5. Copper Sulfate-Sodium Hydroxide Reaction

APPEARANCE		
Materials	**Before Reaction**	**After Reaction (copper sulfate + sodium hydroxide)**
Copper sulfate solution		
hydroxide solution		

You have learned in your Grade 9 Chemistry that substances undergo chemical bonding so that atoms can become more stable. Chemical bonding results to breaking of bonds and formation of new bonds, thus new substances are formed. Formation of new substances means a chemical reaction has taken place.

KEY CONCEPTS:
When a physical change occurs there is no breaking and forming of bonds. There are certain things that will help us identify if a chemical reaction has taken place. We call these evidences of chemical reactions.

1. Production of light
2. Evolution of gas
3. Temperature change
4. Change in intrinsic properties (color, odor)
5. Formation of precipitate

Oxygen is vital to life. One interesting reaction which involves oxygen is the production of fire.

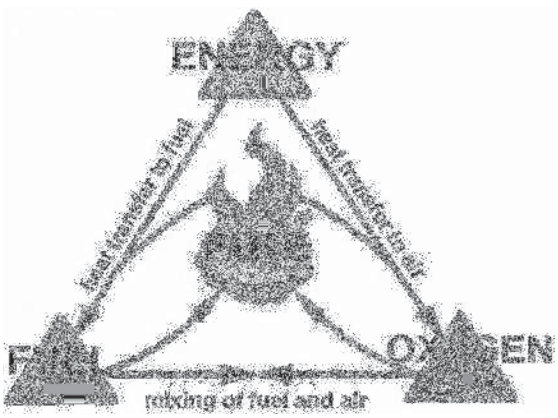
Fire has fascinated people for so long, that the ancient people even regarded it as one of the earliest elements. Fire was so important to them and they described it as an element that changes everything. The earliest theory about burning was the Phlogiston Theory. This theory by George Ernst Stahl in the 17th century stated that when a material burns, it releases a substance known as phlogiston, and this theory was accepted for a very long time.

Figure 3

Antoine Lavoisier through his careful observations from his experiments, debunked the phlogiston theory as he discovered that instead of releasing a substance (phlogiston) a material accurately burns as it reacts (uses) with oxygen. This is now known as the Theory of Oxidation, and this is accepted up to this day.

For burning to occur, 3 factors should be present in proper conditions and proportions.

1. Fuel
2. Oxygen
3. Heat



http://pslc.ws/fire/howwhy/triangle.htm
(accessed: (Mar.4, 2014)
Figure 4

In our country, we are reminded that March is a Fire Prevention month, as this month signals the start of summer, the season when countless fires break out all over the country, "An ounce of prevention is better than a pound of cure" is a motto we all need to remember.

Various materials acts as fuel to sustain fire, so various fire prevention and control measures are

Later as you progress in your lessons, you will get to learn more chemical reactions which may bring benefit or harm to life as well as to the environment.

In the next activity you will learn how chemical reactions can be presented in a shorter way. It is through this presentation that chemical reactions will later be analyzed for classification.

Activity 2

"What's in a Reaction?"

Objectives:

- Distinguish between reactants and products.
- Write a chemical equation.

A. Reactants and Products.

Reactants are substances that are used up to form new substances in a chemical reaction.

The following chemical reactions took place in Activity 1 procedure A to E.

1. Iron reacts with copper sulfate ($CuSO_4$) and forms iron (II) sulfate ($FeSO_4$) and copper.
2. Magnesium combines with oxygen gas (O_2) to produce magnesium oxide
3. Hydrogen peroxide (H_2O_2) in the presence of manganese dioxide (MnO_2) produces water and oxygen gas.
4. Acetic acid (CH_3COOH) and sodium bicarbonate ($NaHCO_3$) produce sodium acetate with the release of carbon dioxide (CO_2) gas and water.
5. Copper sulfate ($CuSO_4$) reacts with sodium hydroxide (NaOH) to produce insoluble copper (II) hydroxide $Cu(OH)_2$ and sodium sulfate (Na_2SO_4) solution.

Fill in the table below with the Reactants and Products from the chemical reactions above. Below each number, write the symbol or formula of the reactant and product.

Table 6. Reactants and Products

Reaction	Reactants	Products
1		
2		
3		
4		
5		

B. Symbols used in Chemical Equation

There are other symbols used in writing a chemical equations:

Table 7. Symbols and their Meanings

Symbol	Meaning
$+$	to show combination of reactants or products
$\longrightarrow$	To produce; to form; to yield
(s), (l), (g), (aq)	(s)-solid (l)-liquid (g)-gas (aq)-aqueous (substance is dissolved in water)
$\rightleftarrows$	Reversible reaction
$\xrightarrow{\text{Heat}}$ $\xrightarrow{\Delta}$	Indicates that heat is supplied to the reaction
$\xrightarrow[\text{Pt}]{}$	A formula written above or below the yield sign indicates its use as a catalyst or solvent

Using the symbols and formulas in Table 6 and the symbols in Table 7, write the chemical reaction using these symbols to complete chemical equation.

Table 8 Chemical Equation

Reaction	Chemical Equation
1	
2	
3	
4	
5	

KEY CONCEPTS:
A chemical equation is a chemist's shorthand for a chemical reaction. The equation distinguishes between the reactants, which are the starting materials and the products which are the resulting substance/s. It shows the symbols or formulas of the reactants and products, the phases (solid, liquid, gas) of these substances, and the ratio of the substances as they react.

In the next activity you will classify the chemical reactions you encountered in the laboratory activity "Everything has changed".

Activity 3

We Simply Click Together

Objectives:

- Classify reactions according to their types, based on how atoms are grouped or regrouped.
- Classify chemical reactions.

Materials:

- Activity Guide
- Students tabulated data from activity 2 “What’s in a Reaction?”

Procedure:

1. Bring out your filled up (answered) table from activity 2 ”What’s in a Reaction?”

Guide Questions:

Q12. In the second chemical reaction, how many reactants are used? How many product/s is/are formed?

Q13. In the third chemical reaction, how many reactants are used? How many product/s is/are formed?

Q14. In the first chemical reaction, what changes did copper and iron undergo during the reaction? What can you conclude about iron?

Q15. In the 4th chemical reactions, how many reactants and products are involved? What kind of substance are they?

Q16. In the fifth chemical reaction, both the reactants and products are compounds made up of positive and negative ions, what did you notice with the pairing of the positive and negative ions in the reactant and product side?

2. Refer to the guide card in classifying these six chemical reactions.

GUIDE CARD

A. COMBINATION (Synthesis) REACTION: A reaction when 2 or more reactants combine to form a single product.

The general formula for this reaction is :

$$A + B \longrightarrow AB$$

B. DECOMPOSITION REACTION: In this reaction, a single reactant breaks down into simpler ones. (2 or more products). This is the reverse of combination reaction.

The general formula for this reaction is:

$$AB \longrightarrow A + B$$

C. SINGLE DISPLACEMENT (Replacement) REACTION: This is when one element replaces another element from a compound. The more active element takes the place of the less active element in a compound.

The general formula for this reaction is:

$$A + BC \longrightarrow AC + B$$

D. DOUBLE DISPLACEMENT REACTION (Metathesis): This is when the positive ions (cations) and negative ions (anions) of different compounds switch places, forming two entirely different compounds.

The general formula for this reaction is:

$$AB + CD \longrightarrow AD + CB$$

E. COMBUSTION (Burning) REACTION: This is when oxygen combines with a hydrocarbon (compound containing hydrogen and carbon) to form a water and carbon dioxide. Example of which is the burning of butane gas

$$C_4H_{10} + O_2 \longrightarrow CO_2 + H_2O$$

F. ACID-BASE REACTION: This is a speacial kind of double displacement reaction that takes place when an acid and base react with each other. The H+ of the acid reacts with the OH- of the base forming water. The other product is salt. Example of which is:

$$HCl + NaOH \longrightarrow NaCl = H_2O$$

Table 9. Types of Chemical Reactions

Reaction	Chemical Equation	Type of Chemical Reaction
1		
2		
3		
4		
5		

KEY CONCEPTS:

Chemical reactions can be classified according to the following types:

A. COMBINATION REACTION: Reactants combine to form a single product. The general formula for this reaction is:

A + B ------→ AB

B. DECOMPOSITION REACTION: In this reaction, a single reactant breaks down into simpler ones. (2 or more products). This is the reverse of combination reaction. The general formula for this reaction is

: AB ------→ A + B

C. SINGLE DISPLACEMENT (Replacement) REACTION. This is when one element replaces another element from a compound. The more active element takes the place of the less active element in a compound. The general formula for this reaction is:

A + BC ------→ AC + B

D. DOUBLE DISPLACEMENT REACTION (Metathesis). This is when the positive ions (cations) and negative ions (anions) of different compounds switch places, froming two entirely different compounds. The general formula for this reaction is:

AB + CD → AD + CB

E. COMBUSTION (Burning) REACTION This when oxygen combines with a hydrocarbon to form water and carbon dioxide.

F. ACID-BASE REACTION: This is a special kind of double displacement that takes place when an acid and base react with each other.

HCl + NaOH ----→ NaCl + H2O

ENRICHMENT:
Classify the following unbalanced chemical equations according to the six types of chemical reactions.

A. Combination
B. Decomposition
C. Single displacement
D. Double displacement
E. Combustion
F. Acid-base

1. $NaOH + KNO_3 \rightarrow NaNO_3 + KOH$
2. $CH_4 + O_2 \rightarrow CO_2 + 2 H_2O$
3. $Fe + NaBr \rightarrow FeBr_3 + Na$
4. $CaSO_4 + Mg(OH)_2 \rightarrow Ca(OH)_2 + MgSO_4$
5. $NH_4OH + HBr \rightarrow H_2O + NH_4Br$
6. $P_4 + O_2 \rightarrow P_2O_5$
7. $NaNO_3 \rightarrow NaNO_2 + O_2$
8. $C_{18}H_{18} + O_2 \rightarrow CO_2 + H_2O$
9. $H_2SO_4 + NaOH \rightarrow NaSO_4 + H_2O$
10. $NiSO_4 + Li_3PO_4 \rightarrow Ni_3(PO_4)_2 + Li_2SO_4$

In the next activity, you will see how mass is conserved during a chemical reaction and how this is explained by the Law of Conservation of Mass.

Activity 4

How much can you take?

Objective:

- Perform an activity that illustrates Law of Conservation of Mass.

Part 1. Laboratory Activity on Law of Conservation of Mass

Materials:

- Steel wool
- 10% $CuSO_4$ solution
- Test tube
- Rubber/cork stopper
- Test tube holder
- Beaker
- Alcohol burner
- Wire gauze
- Tripod
- Matches

Procedure:

1. Place a dry and clean test tube and a rubber/ cork stopper in a dry and clean 100 mL-beaker.
2. Get the total mass of the dry and clean test tube and the stopper, and the 100 mL-beaker. Record it in Table 10.

3. Place a small portion of steel wool in the test tube.
4. Add 10 mL $CuSO_4$ solution.
5. Cover the mouth of the test tube with the rubber/ cork stopper .
6. Get the mass of the set-up using the same 100mL-beaker. Record the mass in Table 10.
7. Heat the lower part of the test tube gently for 2 minutes while moving it to and fro. Make sure that the rubber/ cork stopper covers the mouth of the test tube and the test tube is held with a test tube holder in a slanted position.

Q17. Describe the appearance of the steel wool.

Q18. What is the evidence that a chemical change happened?

8. Allow the test tube to cool completely in the 100-mL beaker.
9. Get the mass of the set-up again. Record your observation in Table 10.

Table 10. Law of Conservation of Mass

BEFORE HEATING	**Mass (g)**
(a) Mass of the test tube, stopper, and beaker	
(b) Mass of the test tube, stopper, and beaker and Mass of the Steel wool + $CuSO_4$ solution	
(c) Mass of the Steel wool + $CuSO_4$ solution [(b)+(a)]	Total Mass of Reactants:
AFTER HEATING	
(d) Mass of the test tube, stopper, and beaker and Mass of the Steel wool + $CuSO_4$	
(e) Mass of the Steel wool + $CuSO_4$ solution [(d)-(a)]	

Q19. Why is it important for the test tube to be sealed?

Q20. How will you compare the total mass before and after the reaction ?

Part 2. Paper Clip Reaction Model

Materials:
- 1 box of different colored paper clips
- Periodic table

Procedure:

1. Sort out your paper clips according to color. Designate a color for each element.

Element	Color of paper clip
Hydrogen (H)	White
Nitrogen (N)	Blue
Oxygen (O)	Red

2. By connecting paper clips together (follow the color coding in number (1), make model representations for these molecules :

   a. $\mathbf{O_2}$, $\mathbf{H_2}$, $\mathbf{H_2O}$ Prepare at least 3 sets of each molecule as shown in the figure below.

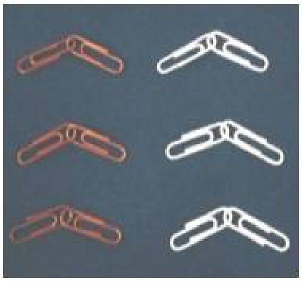


Figure 5.1

Figure 5.2

   b. $\mathbf{N_2}$, $\mathbf{H_2}$, $\mathbf{NH_3}$ Prepare at least 4 sets of each molecule

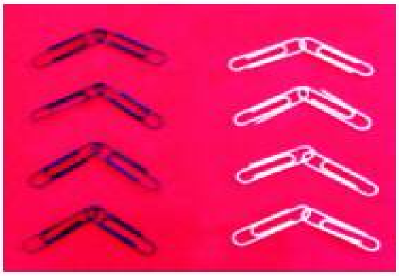


Figure 6.1

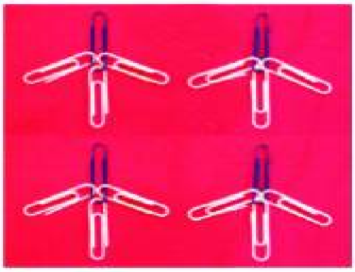


Figure 6.2

3. You will be working on balancing 2 chemical equations.
   a. $\mathbf{H_2 + O_2 \rightarrow H_2O}$
   b. $\mathbf{N_2 + H_2 \rightarrow NH_3}$

4. Starting with the first equation:
   a. Break up one set of $\mathbf{O_2}$ **since $\mathbf{H_2O}$ has only 1 Oxygen.**
   b. Connect this single O atom to the one set of H_2 you have prepared to form 1 set of H_2O
   c. Get another set of H_2 and connect to the single O atom left to form a new set of H_2O.

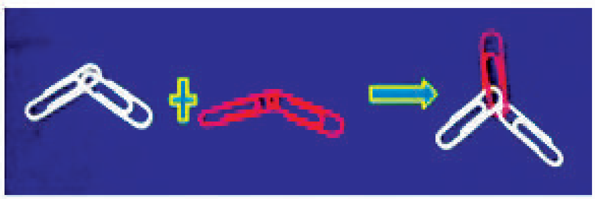
Guide Questions:

Q21. How many set/s of H_2 have you used? ______

Q22. How many set/s of O_2 have you used? ______

Q23. How many set/s of H_2O have you created? ______
These number of set/s represent **coefficient** which is the whole number placed before the formula of the reactants and products.

Q24. Write the corresponding coefficients in the chemical equation.



_____ H_2 + _____ O_2 > _____ H_2O

Figure 7

NOTE: If there is only one set, we do not write 1 anymore.

5. Do the same with the second equation

____ N_2 + ____ H_2 → ____ NH_3

NOTE: You can use more than 2 sets.

Guide Questions:

Q25. How many set/s of **N_2** have you used? ______

Q26. How many set/s of **H_2** have you used? ______

Q27. How many set/s of **NH_3** have you created? ______

Q28. Write the corresponding coefficients in the chemical equation.

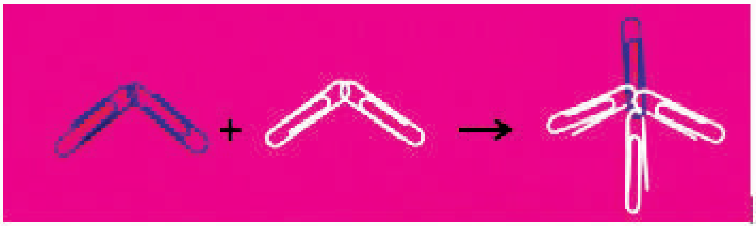
____ N_2 + ____ H_2 → ____ NH_3

NOTE: If there is only one set , we do not write 1 anymore.

6. Get the molar mass of N_2, H_2, and NH_3, multiply their masses by their coefficient, then get the total mass of the reactants and compare to the total mass of the products. The first equation is done for you.
molar mass (g/mol) : H=1 O=16 N=14

$2\ H_2$	**+**	**O_2**	$\rightarrow$	**$2\ H_2O$**
2(2 x1g/mol)	+	(2 x 16g/mol)	$\rightarrow$	2 [(2x 1g/mol) + 16g/mol]
4 g/mol	+	32 g/mol	$\rightarrow$	2 (18 g/mol)
		36g	$\rightarrow$	**36g**

Q29. Do the same with the second equation



_____N_2 + _____H_2 > _____NH_3

Figure 8

Q30. How will you compare the total mass of the reactants and the total mass of the products?

This now follows the Law of Conservation of Mass.

KEY CONCEPTS:
Law of Conservation of Mass states that mass is conserved in a chemical reaction. The total mass of the reactants is equal to the total mass of the products. No new atoms are created or destroyed, there was only grouping or regrouping (rearrangement) of atoms.

The next activity reinforces your knowledge of Law of Conservation of Mass by balancing the chemical equations, involving the chemical reactions in the previous activity you performed.

Activity 5

Balancing Act

Objectives:

- Recognize that the number of atoms of each element is conserved in a chemical reaction as atoms in the reactants only rearrange themselves to form the products
- Apply the concept of Law of Conservation of Mass in balancing chemical equations

Material:

Table 11. Types of Chemical Reactions

Reaction	Chemical Equation	Type of Chemical Reaction
1		
2		
3		
4		
5		

Procedure:

1. Analyze the informations that can be gathered in the chemical equation :

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

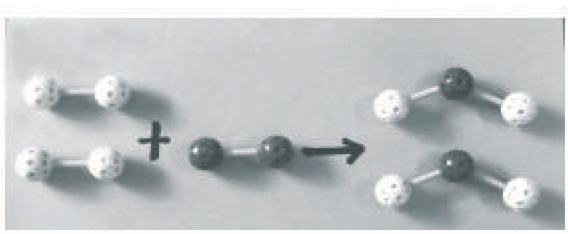


Figure 9

2 molecules of H_2 + 1 molecule of O_2 → 2 molecules of H_2O
2 moles of H_2 + 1 mole of O_2 → 2 moles of H_2O
4 atoms of H + 2 atoms of O → 4 atoms of H and 2 atoms of O

Note that the **coefficient** (number) placed before the formulas indicate the number of molecules or moles.

Determining the correct coefficients balances the number of atoms in the reactant and in the product side, allowing it to follow the Law of Conservation of Mass.

2. Bring out your data on Table 9 Types of Chemical Reactions, balance the chemical equations guided by the steps in balancing equations below this table.

Table 11. Balanced Chemical Equations

Reaction	Chemical Equation	Type of Chemical Reaction
1		
2		
3		
4		
5		

Steps in Balancing Equations:

Write the unbalanced chemical equation, make sure you have followed correctly the rules in writing formulas of compounds.

- Take note of the elements present in the reactant and product side.
- Count the number of atom/s of each element present in the reactant and product side.
- Apply the Law of Conservation of Mass to get the same number of atoms of every element on each side of the equation.Balance chemical equations by placing the appropriate coefficients before the symbol or formula. Do not change the subscripts of the formula in an attempt to balance the equation as it will change the identity of the components.

KEY CONCEPTS:

- For a chemical equation to conform to the Law of Conservation of Mass, it has to be balanced.
- Chemical equations are balanced by placing the appropriate coefficients before the symbols or formulas of reactants and products.
- Certain steps are observed in balancing reactions.

ENRICHMENT:

Balance the following chemical equations, making sure to apply the principle of the Law of Conservation of Mass.

1. $Zn + HCl \rightarrow ZnCl_2 + H_2$
2. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
3. $Fe + NaBr \rightarrow FeBr_3 + Na$
4. $SiCl_4 + H_2O \rightarrow SiO_2 + HCl$
5. $N_2 + O_2 + H_2O \rightarrow HNO_3$
6. $P_4 + O_2 \rightarrow P_2O_5$
7. $NaNO_3 \rightarrow NaNO_2 + O_2$
8. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$
9. $Fe + H_2O \rightarrow H_2 + Fe_3O_4$
10. $Al + O_2 \rightarrow Al_2O_3$

A burning vehicle and a puppy are undergoing a similar kind of chemical reaction. What reaction could this be?

In the next activity you will learn why chemical reactions occur and why they occur at different rates.

Activity 6

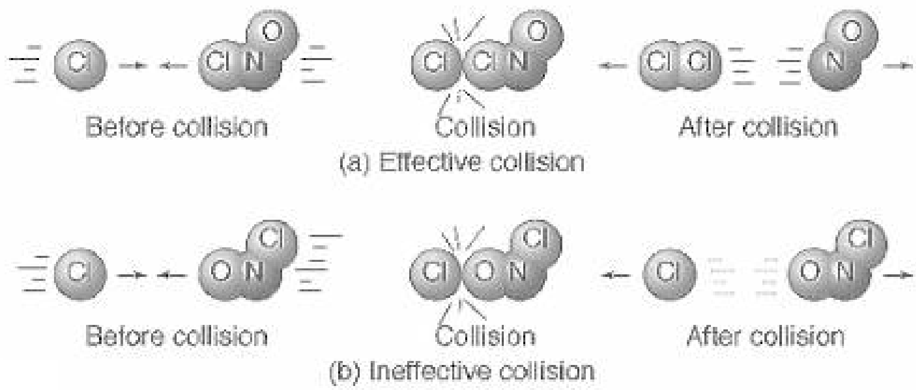
Race to the Finish Line

Objectives:

- explain how the factors affecting rates of chemical reactions are applied in food preservation, control of fire, pollution, corrosion and materials production
- recognize the importance of controlling rates of reactions in technology

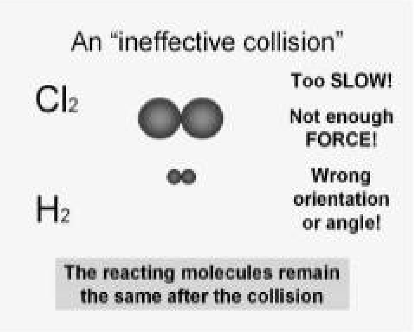
Part 1. Collision Theory

Task: Analysis of molecular representation of collision theory.



Source: http://wps.prenhall.com/wps/media/objects/3082/3156859/blb1404/bl14fg16.jpg (accessed: Oct.29, 2014)

Figure 10



Source: http://i.ytimg.com/vi/OkGzaSOkyf4/maxresdefault.jpg (accessed: Oct.29, 2014)

Figure 11

The illustrations above show the effective and ineffective collision of molecules to effect a chemical reaction.

Guide Questions:

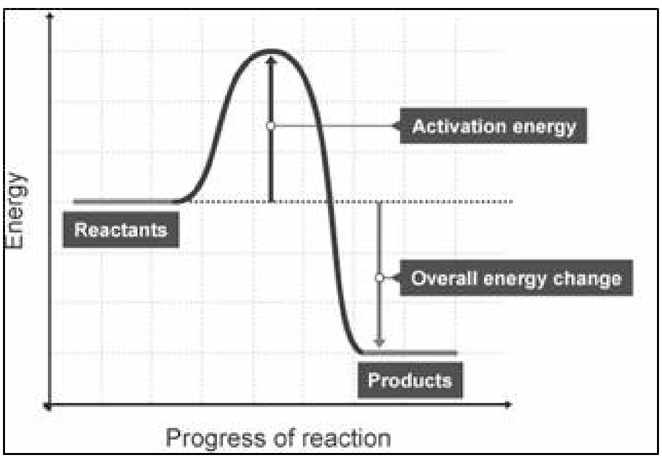
Q31. What causes a chemical reaction?

Q32. What must happen for a chemical reaction to take place?

Q33. Describe fruitful / effective collision resulting to formation of products.

In 1888 Svante Arrhenius suggested that particles must possess a certain minimum amount of kinetic energy in order to react. The energy diagram is shown below.

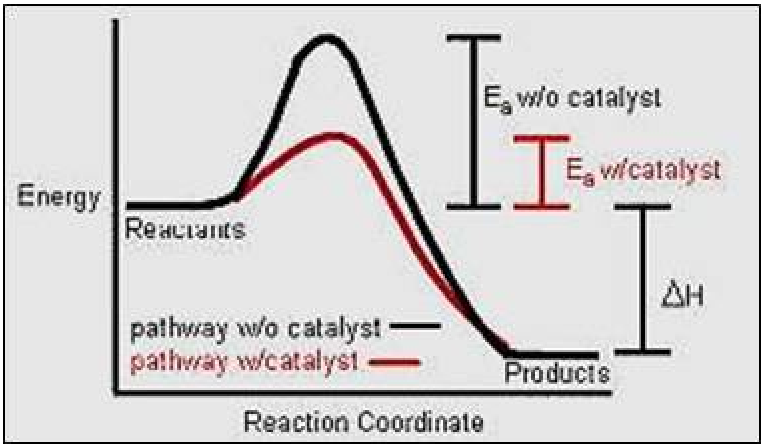
Energy diagrams are used to analyze the changes in energy that occur during a chemical reaction. The energy of the reactants must be raised up over an energy barrier.



Activation energy is the energy required to initiate a reaction and force the reactants to form an activated complex.The activated complex is located at the peak of the energy diagram for a reaction.

Source: http://www.bing.com/images/search?q=Activation+enegy&go=&qs=n&form=QBIR&pq=activation+energy&sc=8-17&sp=- (1&sk=#view=detail&id=C4330FFCC22298D71798C4462372111054F635D6&selectedIndex=96 (Accessed: July 4, 2014)

Figure 11.1



Source: https://www.chem.tamu.edu/class/majors/tutorialnotefiles/factors.htm (accessed: July 4, 2014)

Figure 11.2

Q34. What is the effect of a catalyst on the activation energy?

COLLISION THEORY:

Collision theory explains how collision between reactant molecules may or may not result in a successful chemical reaction.

Based this theory, not all collisions between the molecules result in the formation of products. Effective collisions between molecules, which result in the formation of products, only occur when the following two conditions are met:

(a) the colliding molecules should possess a minimum kinetic energy, known as activation energy, to start a chemical reaction.

(b) the reactant molecules should be in correct orientation when they collide.

Activation energy is needed to break the bond between reactant molecules to form new bonds leading to formation of the products.

KEY CONCEPTS:
COLLISION THEORY: Reactions can only happen when the reactant particles collide, but most collisions are NOT successful in forming product molecules despite the high rate of collisions. Reactants should have sufficient energy, and their molecules should be in proper orientation for a successful collision to happen.
The minimum kinetic energy required for reaction is known as the activation energy.

PART 2: Factors Affecting Reaction Rates
In this experiment, students will study the effect that temperature, reactant concentration, particle size, catalysts and surface area have on chemical reaction rates.

Equipments:
- 7 clear plastic cups
- mortar and pestle
- 2 medium sized test tubes
- 2 test tube holders

Reagents:
- 20 volume hydrogen peroxide (Agua oxigenada)
- Manganese dioxide
- water
- 4 seltzer tablets or denture cleaner in tablet form
- 3 5cm x 5cm colored crepe paper/ Japanese paper
- 25% household bleach solution
- 50% household bleach solution
- 75% household bleach solution

A. Effect of Particle Size or Surface Area on Reaction Rate

Procedure:

1. Get 2 clear plastic cups, half fill each plastic cups with water.

2. Obtain two denture cleaner tablets. Powderize one tablet using mortar and pestle.
3. Simultaneously drop the whole tablet and powderized tablet in the 2 separate plastic cups.
4. Observe the reactions for several minutes and record the time it takes for each tablet to stop fizzing .

Table 12. Effect of Particle Size or Surface Area on Reaction Rate

Effect of Particle Size of Surface Area on Reaction Rate	
Reaction Condition	**Reaction Rate** **Time (sec)**
denture cleaner (whole) in water	
denture cleaner (powderized) in water	

Guide Questions:

Q35. a. Which tablet fizzed for a longer period of time?
b. How might you explain any difference ?

Q36. a. Describe in your own words the effect of particle size or surface area on the rate of a reaction.

B. Effect of Temperature on Reaction Rate

Procedure

5. Fill one glass with cold water and another glass with hot water.
6. Drop a denture cleaner tablet into each glass.
7. Observe the reactions that occur. Record the time it takes for each tablet to stop fizzing .

Q37. Is there any noticeable difference between the two reactions?
Q38. What is the effect of temperature on reaction rate?

Table 13. Effect of Temperature on Reaction Rate

Effect of Particle Size of Surface Area on Reaction Rate	
Reaction Condition	**Reaction Rate** **Time (sec)**
denture tablet in cold water	
denture tablet in hot water	

C. Effect of a Catalyst on Reaction Rate

Figure 12

8. Place 10mL of hydrogen peroxide (H_2O_2) in 2 separate test tubes. Place one test tube in a hot water bath.
   Note the rate bubbles form.
9. Add a pinch of manganese dioxide in the second test tube.
   Note the rate bubbles form.

Q39. How will you compare the rate at which bubbles were produced?

Q40. Study the chemical equation below.

Chemical Equation: $H_2O_{2\,(l)} \xrightarrow[MnO_2]{} H_2O_{(l)} + O_{2\,(g)}$

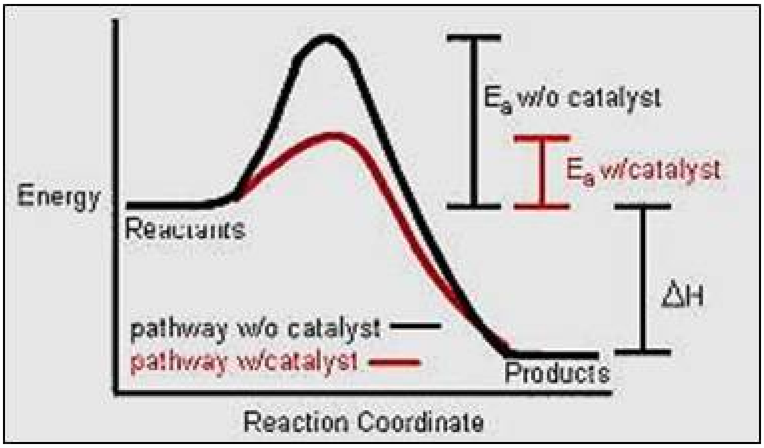
Notice the reactants and resulting products.

Q41. Where is the MnO_2 written in the equation?

Q42. Do you think the MnO_2 reacted with H_2O_2 ?

Q43. MnO_2 only acted as a catalyst. What role do you think a catalyst play in a chemical reaction?

Going back to the diagram below, recall the effect of catalyst on activation energy .



D. Effect of Concentration on Reaction Rate

Caution: Wear a mask while performing this experiment.

Procedure:

10. Prepare in separate plastic cups, different concentrations of household bleach solution
    - 100% (no water added)
    - 50% (half part bleach solution- half part water)
    - 25% (1/4 part bleach solution – ¾ part water) .

11. Prepare 3 pieces of 5cm x 5cm sized brightly colored crepe paper or Japanese paper.

12. Drop the pieces of crepe paper into the 3 plastic cups simultaneously.

13. Compare the rate of discolorization of the papers in the 3 beakers. Record your observation in the table below.

Table 14. Effect of Concentration on Reaction Rate

Concentration	Reaction Rate
25% solution	
50% solution	
100% solution	

Q44. Did you get the same rate of reaction?

Q45. Describe in your own words the effect of concentration on the rates of reaction.

Q46. How will you explain using the Collision theory the factors affecting reaction :

a. Surface area of reactants
b. Temperature
c. Catalyst
d. Concentration

KEY CONCEPTS:

The rate of chemical reaction is affected by the following factors: temperature, surface area of reactants, presence of catalyst, concentration of reactants.

Every factor that affects reaction rate can be understood relative to collision theory.

ENRICHMENT:

Write TRUE on the space provided if the statement is correct.

Rewrite the statement, if the statement is false.

1. Catalysts speed up chemical reactions but are not changed by them.
2. Heat, light, or change in odor can indicate a physical change.
3. Activation energy is the minimum energy required for reactions to start.
4. Low temperature speeds up reaction rates.
5. A low concentration of chemical slows reaction rate.

The following activity, will deepen your understanding of the benefits and harm posed by some chemical reactions, and will guide you in exploring why rate of some chemical reactions need to be controlled.

Activity 7

Making Connections

Objectives:

- Explain how factors affecting the rate of chemical reactions are applied in food preparation, control of fire, corrosion prevention, etc.
- Analyze effect of chemical reactions on life and the environment through visual presentation.

PART 1.

1. Analysis of set of pictures linking to acid rain :

What effect does acid rain has on limestone/ marble statues?

http://www.petersommer.com/blog/category/news/exhibitions/

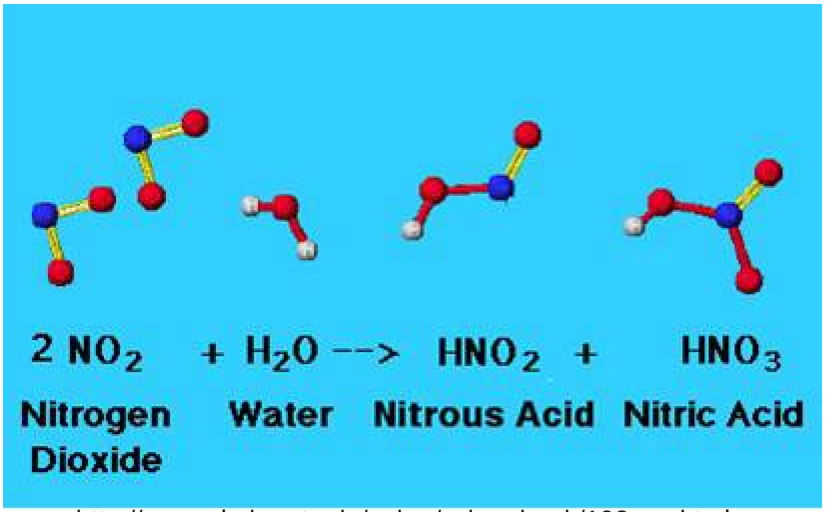
Figure 13. Effect of Acid Rain on Marble

What effect does acid rain has on plant growth?

http://www.connecticutvalleybiological.com/acid-rain-and-the-environment-acidity-and-plant-growth-p-15860.html

Figure 14. Effect of Acid Ran oon Plant Growth

Nitric oxide NO_2, a product of combustion of gasoline in automobiles is one of the culprits in the formation of acid rain. Referring to Fig. 15, analyze how NO_2 is converted to nitric acid HNO_3



http://www.elmhurst.edu/~chm/vchembook/193nox.html

Figure 15. Reaction of Nitrogen Dioxide with Water

From Figure 16, identify other problems posed by acid rain.

http://envis.tropmet.res.in/menu/ENVIS_Acid_Rain/images/acidImage/Acid_Rain_Arriving.png

Figure 16

2. Discussion on acid rain, a chemical reaction that has environmental issues.

An example of a chemical reaction that has an environmental concern is the acid rain.

Acid rain has been the leading significant cause of destruction in our environment. In infrastructure, it is the cause of corrosion of metals in alloys like steel in buildings, bridges, and transport vehicles. This is due to the displacement reaction of active metals with hydrogen in acids.

Materials with historical and cultural values such as monuments and statues are also destroyed by acid rain. They are mostly made up of limestone and marble which like metals form a chemical reaction with acids, lead to their dissolution.

Marine life is also affected by acid rain. It causes the pH of bodies of water to decrease; this change in pH will increase marine life mortality, retard fish growth, decrease egg production and embryo survival.

Acid rain also tends to dissolve vital minerals in the soil. Crops grown in these depleted soils give poor yields, if they grow at all.

In areas of high automobile traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere can be quite significant. In urban areas, the main source of acid rain is from automobiles. Other sources are thermal power plants and coal mining industries. Gas emissions like CO2, CO, SO2, NO2, and NO from these sources react with water vapor in the air producing acids. Rain contaminated with these acids are what we know now as acid rain.

Removing the offending oxides from exhaust and using alternate energy sources are much preferred courses of action at the present time. One of the most important means of reducing sulfur emissions is the swith to low sulfur fuels. Another is the scrubbing of stack gases before they are released to the atmosphere. In this process, the stack gases percolate through a solution that absorbs the oxides of sulfur. The solution is renewed frequently, and waste sulfur can be recovered from the spent solution.

Analyzing the issue:

Q47. What natural processes can contribute to acid rain?

Q48. How is acid rain produced?

Q49. What adverse effect can acid rain pose on living organisms and its environment?

Q50. Who should be responsible for cleaning up the pollution problem?

Q51. What measures are taken to address the problem?

PART 2 : Visual presentation (any form of media) of the effects of chemical reactions on life and the environment

Group Activity

1. Using any form of media, prepare a visual presentation of a chemical reaction involved in:
    a. Food processing and preservation
    b. Fire control
    c. Corrosion Control
    d. Photochemical Smog
    e. Haber Process
    f. Catalytic Converter
    g. Car air bag
    h. formation of ozone layer in the stratosphere
    i. formation of acid rain

2. Research on how a specific chemical reaction poses useful or harmful effects to life and the environment.

3. Present to class your visual presentation

- During your planning session, be reminded to follow the **GRASP Task Design Prompts** to assist you in the organization of your activity.

Goal

Your task is to create a visual presentation of benefits/ harm posed by a particular chemical reaction using any form of media.

Role

You have been asked to gather/ collect researches on chemical reaction assigned to your group.

Your job is to understand fully the concepts and issues involved.

Audience

The target audience is the whole class and a local public official (e.g., barangay chairman) or a member of your community who may be involved in your assigned topic. You need to encourage/ convince your audience to draw pledges/ policies that will help mitigate the problem/ promote the benefits in your topic.

Situation

The challenge has to do with preparation of the visual presentation: choosing and documenting appropriate resources, summarizing and making the research coherent.

Product, Performance and Purpose

You will create a visual presentation supported by research in order to better understand and appreciate the principles involved in chemical reactions.

Standards and Criteria for Success

Your performance needs to meet the following criteria:

- Creative (visual presentation is clear/visually appealing)
- Meaningful (giving importance to the understanding of the benefits and harm posed)
- Illustrative (discussing thoroughly how these reactions may cause harm or how we can benefit from them)

Though this is a group task, you will individually assess your performance using the Critical Thinking Rubric below.

Critical Thinking Rubric:

	4	3	2	1
Identifying the important information	I determine what concepts and relationships are important in a complex system of abstract and concrete information.	I can usually tell what concepts and relationships are important in a system.	Sometimes, I have trouble telling the difference between important and unimportant concepts and relationships in a system.	I often get important and unimportant information mixed up.
Making Inferences	I use what I know about the subject along with my personal experiences and knowledge to make reasonable inferences. I use my inferences to draw conclusions about information.	I analyze new information and make reasonable inferences.	With help, I can make inferences, but sometimes my inferences are not based on good reasons.	I usually cannot make inferences about what I am learning.

	4	3	2	1
Evaluating Sources	I use several strategies for evaluating the reliability of a variety of different kinds of sources.	I use some strategies for evaluating sources.	Sometimes, I am fooled by information that is not reliable.	I often cannot tell the difference between reliable and false information.
Learning Independently	I do whatever I need to do to learn more about ideas and concepts that are new to me.	I make an effort to learn more about ideas and concepts that are new to me.	If someone reminds me, I learn more about ideas and concepts that are new to me.	I am usually happy with what I already know about information, and I do not bother to find out more.
Communicating	I can clearly and thoroughly explain my opinions by giving good reasons for them, orally and in writing.	I can explain my opinions by giving good reasons for them, orally and in writing.	With prompting and guidance, I can explain my opinions orally and in writing.	I cannot explain my opinions so that they make sense.

IV. Summary/Synthesis/Feedback

- **<u>Reactants</u>** are the substances that enter into a chemical reaction, and **<u>products</u>** are the resulting substances. Substances that undergo a chemical reaction experience a change in their physical and chemical properties.
- When a physical change occurs there is no breaking and forming of bonds. There are certain things that will help us identify if a chemical reaction has taken place. We call these <u>evidences of chemical reactions</u>. These are: production of light, evolution of gas, temperature change, color change, and formation of precipitate.
- A **chemical equation** is a chemist's shorthand for a chemical reaction. The equation distinguishes between the **reactants**, which are the starting materials and the **products** which are the resulting substance/s. It shows the symbols or formulas of the reactants and products, the phases (solid, liquid, gas) of these substances, the ratio of the substances as they react.
- Chemical reactions are classified in to the following types:

  combination: $A + B \rightarrow AB$

  decomposition: $AB \rightarrow A + B$

  single displacement: $A + BC \rightarrow AC + B$

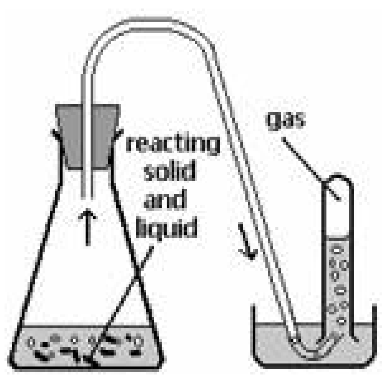
  double displacement: $AB + CD \rightarrow AD + CB$

  combustion (reaction with oxygen producing carbon dioxide and water),

  acid-base: reaction between acid and base
- **COLLISION THEORY**: Reactions can only happen when the reactant particles collide. Reactants should have sufficient energy, and their molecules should be in proper orientation for a successful collision to happen.
- Activation Energy, Ea, is the minimum amount of energy needed for a reaction to occur.
- The rate of chemical reaction is affected by the following factors: temperature, surface area of reactants, presence of catalyst, concentration of reactants.
- Every factor that affects reaction rate can be understood relative to Collision theory.

V. Summative Assessment

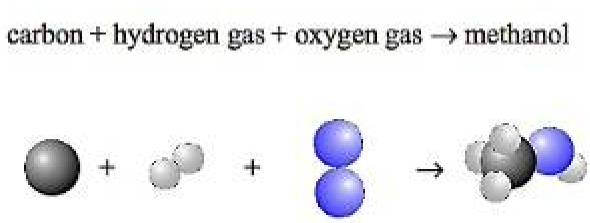
I. Multiple Choice: Choose the correct answer.



1. Analyze the diagram on the left, what evidence shows that the reaction's product is a gas?
   a. bubbles are forming and collected
   b. the gas is not soluble in water
   c. acids always produce gases when they react with a solid
   d. there is no filter funnel and paper to remove unreacted solid.

2-3 Refer to the illustration below:

The following depicts the formation of methanol (CH_3OH).



2. What would be the skeleton equation for this reaction?
   a. $C + Cl_2 + O_2 \rightarrow CH_3ClH$
   b. $C + H_2 + O_2 \rightarrow CH_3OH$
   c. $C_2 + H_2 + O_2 \rightarrow CH_3OH$
   d. $C + H + O \rightarrow CH_3OH$

3. If the formula for methanol is CH_3OH, what would be the balanced chemical equation for this reaction?
   a. $C_3 + 2H_2 + O_2 \rightarrow 2CH_3OH$
   b. $2C + 4H_2 + O_2 \rightarrow 2CH_3OH$
   c. $2C + 2H_2 + O_2 \rightarrow 2CH_3OH$
   d. $C + H + O \rightarrow CH_3OH$

4. Which of the following is the correct balanced reaction?
   a. $2\ C_3H_8 + 10O_2 \rightarrow 6CO_2 + 8H_2O$
   b. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$
   c. $C_3H_8 + O_2 \rightarrow 3CO_2 + 2H_2O$
   d. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

5. Quicklime (CaO) is used as a drying agent. When water is added to this, slaked lime $Ca(OH)_2$ is formed. What type of reaction is this?
   a. combination
   b. single displacement
   c. decomposition
   d. double displacement

6. Fresh fish and meat that are not stored in a refrigerator show signs of spoilage in less than a day. What has caused this spoilage?
   a. temperature changes
   b. presence of microorganisms
   c. oxygen in air
   d. all of the above

7. The rate of reaction increases as the temperature increases. Which of the following statements provides the best explanation for this?
   a. At lower temperatures the particles do not collide with each other.
   b. At higher temperatures the particles have more energy, move faster, and collide more often.
   c. Higher temperature has higher activation energy.
   d. Increasing the temperature increases the number of particles, so they collide more often.

8. Which of the following statements about collisions is correct?
   a. Reaction will occur even without collision of molecules.
   b. All colliding particles have the same amount of energy.
   c. Only fast-moving particles collide with each other.
   d. Reactions can happen if the colliding particles have enough energy.

9. Reactions eventually stop. What is generally the reason for this?
   a. The catalyst has been used up.
   b. The particles have run out of energy.
   c. One or more of the reactants has been used up.
   d. Wrong catalyst was used.

10. In a reaction with hydrochloric acid, why does powdered magnesium reacts faster than the same mass of magnesium ribbon?

a. The powdered magnesium contains more atoms than the magnesium ribbon.
b. The powdered magnesium is hotter than the magnesium ribbon.
c. The powdered magnesium has a bigger surface area than the magnesium ribbon.
d. The powdered magnesium has a smaller surface area than the magnesium ribbon.

11. Marble reacts with hydrochloric acid to produce calcium chloride, water and carbon dioxide. In which of these mixtures is the rate of reaction likely to be the greatest?

a. 1 g of marble chips in 100 cm^3 of hydrochloric acid at 20°C.
b. 1 g of powdered marble in 100 cm^3 of hydrochloric acid at 30°C.
c. 1 g of powdered marble in 100 cm^3 of hydrochloric acid at 20°C.
d. 1 g of marble chips in 100cm^3 of hydrochloric acid at 30°C.

12. Manganese dioxide is a black powder that catalyzes the breakdown of hydrogen peroxide to water and oxygen. Which of the following statements is correct?

a. The mass of manganese dioxide will stay the same during the reaction.
b. The catalyzed reaction will produce more oxygen than the uncatalyzed reaction.
c. The particles in the catalyzed reaction will have more energy than in the uncatalyzed reaction.
d. Manganese dioxide will cause production of more water.

13-15 Explain briefly.

13-15 Based on your knowledge of factors affecting the rate of reaction, why is there a danger of explosion in places like coal mines where there are large quantities of powdered, combustible materials?

Glossary of Terms

Acid-base reaction	Reaction between an acid and a base producing salt and water.
Activated complex	The specie temporarily formed by the reactant molecules as a result of collision before they form the product.
Activation energy	The minimum amount of energy required to start a chemical reaction.
Catalyst	A substance that hastens a chemical reaction without itself being consumed.
Chemical equation	An equation that uses chemical symbols and formulas to represent a chemical reaction
Chemical reaction	A process in which a substance is changed into one or more new substance/s.
Coefficient	The number placed before the formulas, used to balance a chemical equation.
Collision Theory	Reactions can only happen when the reactant particles collide.
Combination reaction	Two or more reactants form a single product.
Combustion reaction	Reaction with oxygen producing water and carbon dioxide.
Decomposition reaction	A single reactant breaks down into 2 or more products.
Double displacement reaction	This is when the positive ions (cations) and negative ions (anions) of different compounds switch places, forming two entirely new compounds.
Inhibitor	Substance that slows down or retards a chemical reaction.
Precipitate	An insoluble solid that separates from the solution.
Product	The resulting substance after a chemical reaction.
Reactant	The substance entering a chemical reaction.
Single displacement reaction	A more active element replaces another element from a compound.
Smog	Coined from the words smoke and fog, an environmental pollutant.

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Unit 4
MODULE
3

Suggested time allotment: 12 hours

BIOMOLECULES

I. Introduction

Think about the food you eat everyday. Different types of food give you different nutrients for energy, growth and repair. These were introduced to you when you were at the elementary grades. Also, in Grade 9, you have learned that the bonding characteristics of carbon result in the formation of larger variety of compounds.

In this module, you will learn more about compounds which are essential to life. These compounds belong to four main classes of biomolecules: carbohydrates, lipids, proteins, and nucleic acids. Carbohydrates and lipids are generally made up of carbon, hydrogen and oxygen. Proteins and nucleic acids and some derivatives of carbohydrates and lipids also contain nitrogen. You will also have the opportunity to test food for the presence of biomolecules.

At the end of Module 3, you will be able to answer the following key question.

- What differentiates the biomolecules from each other?

II. Learning Competencies/Objectives

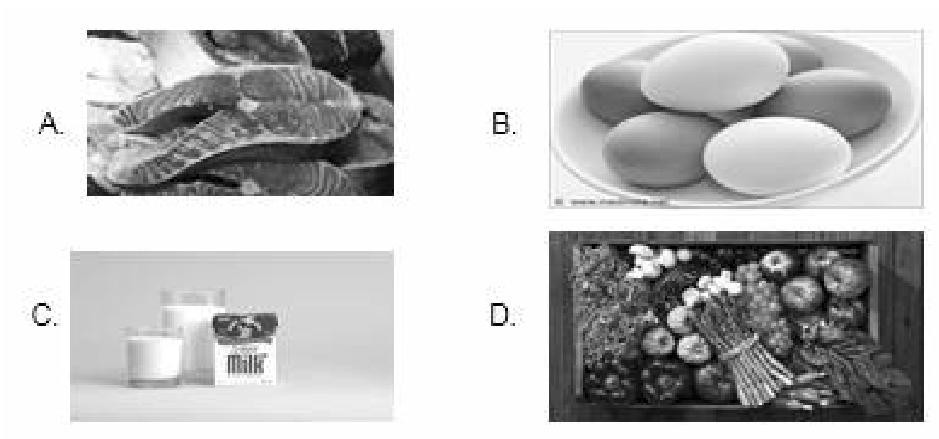
At the end of this module, the learners are expected to:

- Recognize the major categories of biomolecules such as carbohydrates, lipids, proteins and nucleic acids;
- Differentiate the biomolecules from each other in terms of their structure and function.

III. Pre-Assessment

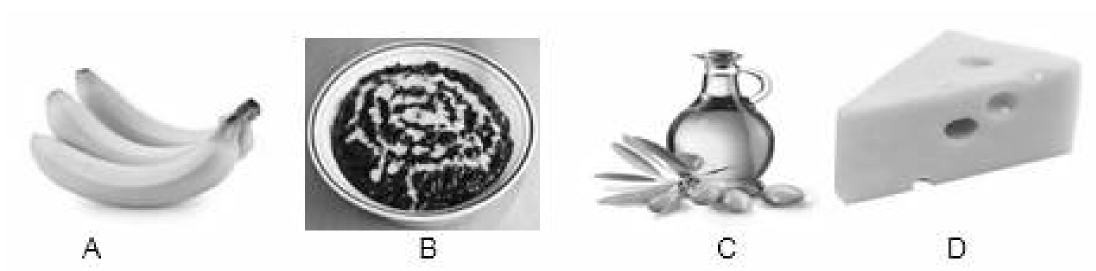
Direction: Analyze each question carefully then choose the letter of the correct answer.

1. Which of the following is NOT a major source of protein?



A. fish B. egg C. milk D. vegetable

2. Which of the following contains the most lipids?



A. banana B. champorado C. olive oil D. cheese

3. Which of the following is a correct pair?
   A. glucose: disaccharide
   B. sucrose: monosaccharide
   C. starch: polysaccharide
   D. triglyceride: polysaccharide

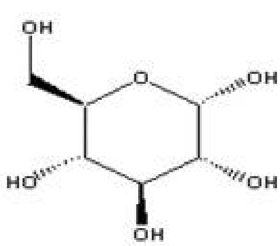
4. Which is a correct pair of an example of protein and its function?
   A. enzymes: speed up reactions in the body and eventually used up in the process.
   B. collagen: provides strength and flexibility to connective tissues.
   C. actin and myosin: supplies amino acids to baby mammals
   D. hemoglobin: helps regulate blood sugar levels

5. Maria wanted to determine what types of biomolecules are present in the three unknown substances that her teacher gave her. The following table shows her results.

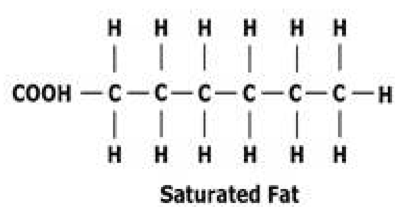
Substance	**Iodine Test**	**Biuret Test**	**Benedict's Test**
A	Black solution (+)	(-)	(-)
B	(-)	(+)	(-)
C	(-)	(-)	(+)

Which of the following statements is TRUE?
   A. Substances A and B are proteins while substance C is a lipid.
   B. Substance A contains starch and substance B and C contain nucleic acid
   C. Substances A and C are carbohydrates where A is an amylose in starch and B is a protein and C maybe a simple sugar
   D. Substance B is a carbohydrate and substances A and C are lipids

For numbers 6 to 9 please refer to the structures below:

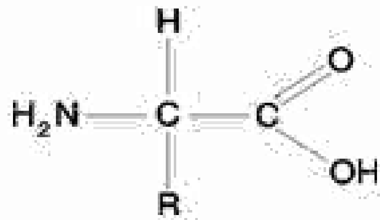


A



B

C



D

6. Which of the given structures (A, B, C, or D) represents molecules that provide energy and are very soluble in water?

7. Which of the given structures (A, B, C, or D) represents hydrophobic molecule that is used as storage of energy?

8. Which of the given structures (A, B, C, or D) represent the molecules that store the hereditary traits of humans?

9. Which of the given structures (A, B, C, or D) represent the building blocks of bigger molecules necessary for structural integrity of organisms?

10. Which of the biomolecules contain other elements aside from carbon, hydrogen, and oxygen?
    A. carbohydrates, lipids
    B. proteins, lipids
    C. nucleic acids, proteins
    D. nucleic acids, lipids

IV. Reading Resources and Instructional Activities

Figure 1. These are foods rich in carbohydrates and lipids

Look at the pictures above. Which food can be classified as carbohydrates or lipids? In order to find out between carbohydrates and lipids, you can perform Activity 1.

Activity 1

Test for Carbohydrates and Lipids

Objective:

- To detect the presence of carbohydrates and lipids in food samples using chemical tests.

Materials:

- Iodine solution or tincture of iodine
- Benedict's solution
- food samples for testing carbohydrates (cooked pasta, cracker,
- cooked rice, corn syrup, table sugar, pineapple)
- food samples for testing lipids (oil, peanut butter, egg, fried chicken,
- butter, milk, burger)
- 6 pcs.small test tubes or vials per group
- 6 pcs. test tube holders per group
- 2 pcs.droppers per group
- mortar & pestle per group
- 1 spot plate per group

Procedure:

A. Carbohydrates

Iodine Test for Starch

1. Place ½ teaspoon of each food sample on the well of a spot plate. Make sure that the food samples are far from each other.
2. Add 3 drops of Lugol's Iodine solution or tincture of iodine on each food sample.
3. Note that Lugol's iodine solution or tincture of iodine changes from yellow to blue or black in the presence of starch.
4. Write your observation in Table A.

B. Benedict's Test for Reducing Sugar

1. Place a pinch of the food samples to be tested into a test tube.
2. Add 1 full dropper of Benedict's solution to each test tube.
3. Gently shake the test tube or vial.
4. Place the test tubes in the hot water bath for 2-3 minutes. After 2-3 minutes, return the test tubes to the test tube racks. If the substance in your test tube contains sugar, Benedict solution will change color.

Positive Test: Benedict's solution changes from blue to green (very small amount of reducing sugar), to yellow (higher amount of reducing sugar) to orange or brick red (highest amount of reducing sugar). The change in color is due to the formation of the brick red precipitate, Cu_2O.

CAUTION: Always use a test tube holder to handle hot test tubes.

5. Observe your test tube (using white paper as a background). Record the amount of sugar present in Table 1.

Amount of Sugar in Food	0 None	+ Trace	++ Little Sugar	+++ Moderate Sugar	++++ Much Sugar
Color	Blue	Blue green	Green	Yellow	Orange/Red

C. Ethanol Emulsion Test for Fats and Oils

Adapted:http://brilliantbiologystudent.weebly.com/ethanol-emulsion-test-for-lipids.html
(accessed: July 15, 2014)

Solid sample:

1. Crush a pinch of food sample and place in a dry test tube.
2. Add ethanol to about 2 cm^3 above the level of the sample and shake thoroughly.
3. Allow the solid to **settle for** about 3 minutes and decant the ethanol into another test tube.
4. Add 2 cm^3 of **distilled water** to the test tube.
5. Write observations in Table 2.

Liquid sample:

1. Add a **few drops** of the liquid food sample to a dry test tube.
2. Add 2 cm^3 **ethanol** and shake it thoroughly
3. Add 2 cm^3 of **distilled water**.
4. Write observations in Table 3.

Test for Carbohydrates and Lipids

Table 2. Results of Carbohydrate Test

Food Sample	Test for Simple/ Reducing Sugars/ Benedict's Test	Iodine Test
Cooked pasta		
Cracker		
Cooked rice		
Corn syrup		
Table sugar		
Pineapple		

Table 3. Results of the Ethanol Emulsion Test for Lipids

Food Sample	Colorless	Layer of Cloudy White Suspension
Oil		
Peanut Butter		
Egg		
Fried Chicken		
Butter		
Milk		
Burger		
Mashed potato		

Q1. Which of the foods samples tested would your body use for a quick burst of energy?
Which could be used for energy when no carbohydrates are available?

Q2. Why it is that Benedict's test gives a negative (-) result with sucrose or table sugar?

Q3. What kind of foods rich in fats should be taken in moderation? Why?

Carbohydrates

Since food is always a part of our lives it is important that we know the nutrients found in the food we eat. The following discussions will give you a clearer avenue to understand carbohydrates.

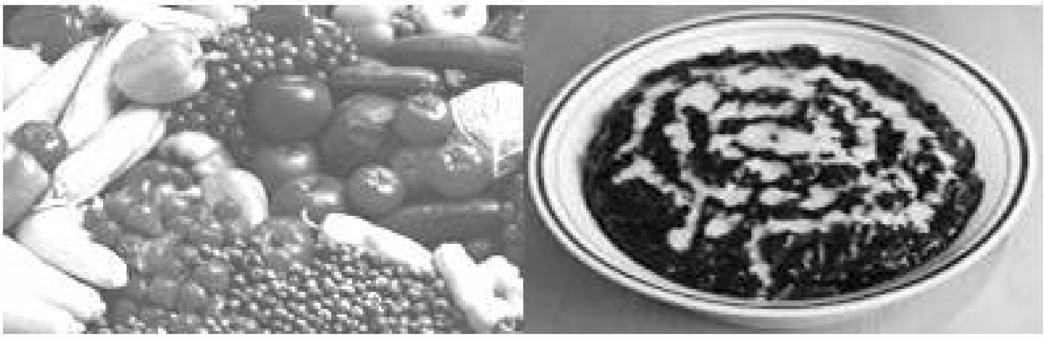
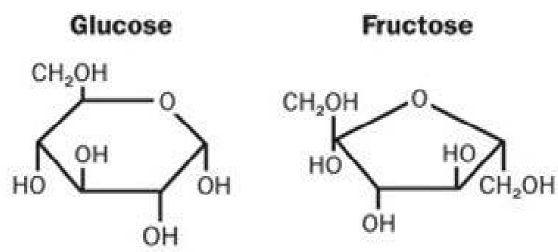


Figure 2. Foods rich in carbohydrates

Figure 2 shows some foods that are rich in carbohydrates. Carbohydrates are the major source of energy for the body. These are simple sugar, starch and cellulose. All carbohydrates contain carbon, hydrogen, and oxygen. They may be classified into the following:

Monosaccharides

From the prefix "mono" which means one, monosaccharide is the simplest sugar and the basic subunit of a carbohydrate.These compounds are white solids at room temperature. Because they have polar, hydroxyl (-OH) groups in their molecular structures, they are very soluble in water. The most common monosaccharides are **glucose** (also called dextrose) and **fructose**.



http://joelbergerdc.com/tag/glucose-vs-fructose/
Figure 3. Structure of Glucose and Fructose

Although both of these monosaccharides have the formula $C_6H_{12}O_6$, their structural formulas differ. As figure 3 shows, glucose in water solution forms a ring made up of five carbon atoms and one oxygen atom, and fructose in a water solution forms a ring made up of four carbon atoms and one oxygen atom. Both compounds have five-OH groups in their structures.

Compounds with the same molecular formulas are called **isomers.** So, glucose and fructose are isomers. Though they have the same molecular formula, these sugars cannot be used in the same way by cells in the body. The arrangement of the C, H, and O atoms determines the shape and properties of each sugar.

In Grade 8, you have learned about how carbohydrates and proteins are broken down in digestion. For fats and lipids, their digestion is completed in the small intestine and is broken down primarily into fatty acids and glycerol.

During digestion, carbohydrates are broken down into monosaccharide which is absorbed into the blood and transported to the cells providing “instant” energy to perform our activities. Sometimes we eat too much, especially when we are tired, the excess glucose is stored in the liver as **glycogen** for later use. It is very important to have a steady supply of glucose in the blood to maintain body functions. As what they say, too much or too little of anything may lead to some diseases. When too much glucose is in the blood, the pancreas secrete a hormone called insulin which stimulates cells in the liver, muscles and fat to absorb glucose and transform it into glycogen or fats, which can be stored for a period of time. When blood glucose drops, the pancreas secretes glucagon, which causes the liver, muscles and fat to convert glycogen back to glucose.

Fruits like grapes, apple or atis contain a monosaccharide called fructose or fruit sugar.It is considered the sweetest naturally occurring sugar.Due to its sweetness, fructose is sometimes used as a low calorie sweetener because less fructose is needed to produce the same sweetness that table sugar does. Starchy food that we eat is widely distributed in the plant world.Thus, its main constituent glucose is found in all plants and in the sap of trees.However, glucose is also found in glycogen that is produced in animal cells.

Disaccharides

In the morning, Aaron Jay’s mother prepares his coffee; he always adds half a teaspoon of table sugar. He remembered his TLE (Technology and Livelihood Education) teacher who mentioned one time in their class that the sugar we use to sweeten coffee is a disaccharide. It is also called sucrose with the molecular formula $C_{12}H_{22}O_{11}$. He wondered how sucrose, which is disaccharide, is formed. In their chemistry class, their teacher explained that the formation and breakdown of sucrose to glucose involves two reactions.

Condensation reaction is a reaction in which two molecules or parts of the same molecule combine. During the condensation of monosaccharides to form disaccharides, one molecule of water is lost.When two glucose molecules are combined, maltose is formed and water is lost during the process. A **Hydrolysis reaction** occurs when the bond between monosaccharides is broken with the addition of a water molecule.

Q1. What is the name of the dissacharide found in cheese and other milk products?

After he finished doing his homework, Aaron Jay drinks his milk. When he is about to jump into his bed to have a good night sleep, he has this bloated feeling along with a build up of intestinal gas.He feels uneasy and cannot sleep. He swears he will never drink milk again! The following morning in his chemistry class, his teacher discussed another important disaccharide- Lactose or milk sugar. Lactose is made up of a sugar called **galactose** and **glucose**. In our body, a specific enzyme, **lactase** is necessary to help break the bond between the two monosaccharides when lactose is digested.

People who cannot digest milk products are called “lactose intolerant” because they do not produce the enzyme (lactase) necessary to break the bond between glucose and galactose. Since lactose molecules are too large to be absorbed into the circulatory system, they continue through the digestive system, where they are eventually broken down by bacteria in the large intestine. These bacteria digest monosaccharides, producing carbon dioxide gas in the process. As a result, a common symptom of lactose intolerance is a build up of intestinal gas along with a bloated feeling, and more often the passing out of undigested lactose as diarrhea. After the discussion, he concluded that he maybe “lactose intolerant.”

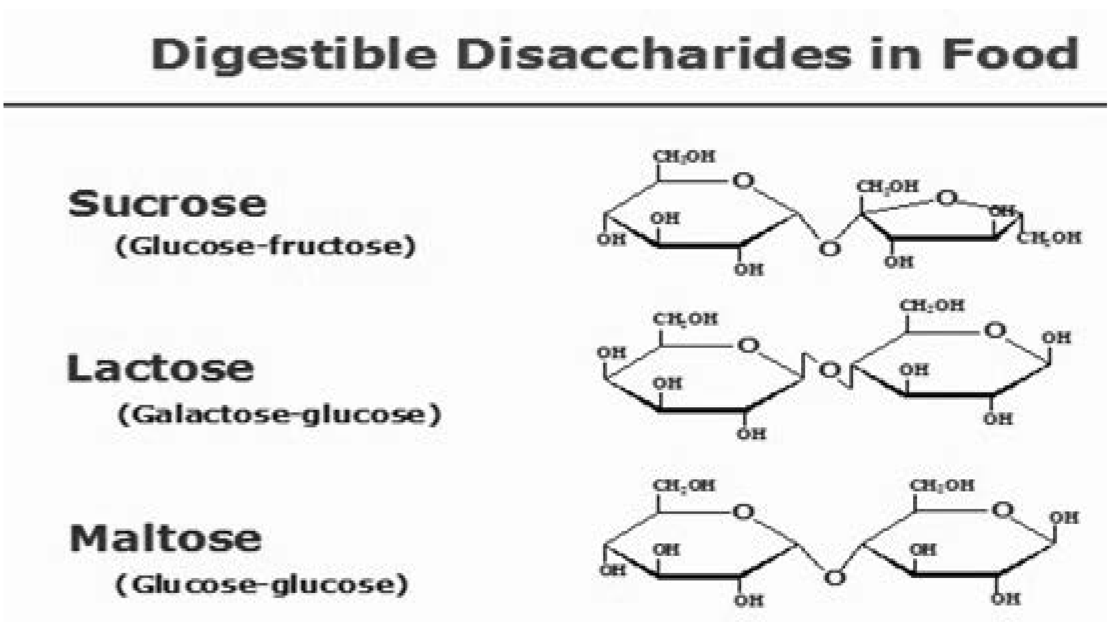


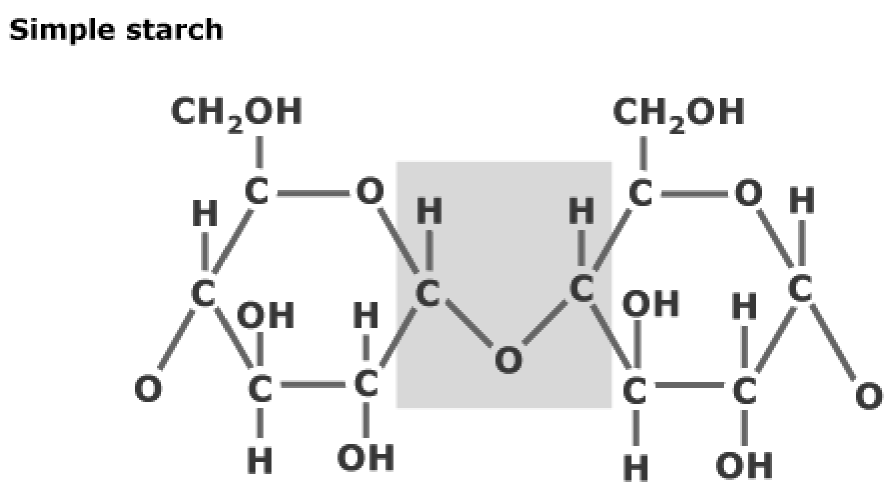
Figure 4. Structure of Disaccharides

Figure 4 shows that when two monosaccharides join together by combination reaction, a glycosidic bond will be formed between the two monosaccharide molecules. The reaction produces water as a side product.

Polysaccharides

In the evening, he did not drink milk anymore. Instead he ate fruits before going to bed. The following morning he had the same routine-ate his breakfast and went to school. As the bell rang, Aaron Jay rushed to the canteen to eat his lunch. It included local tubers like sweet potato or camote and green, leafy vegetables like *malungay* and *kangkong*. Again, he remembered the result of their activity no.1 wherein the food samples like sweet potato and ripe banana turned blue-black when stained with iodine solution. In their class discussion, these foods contain polysaccharides (the prefix poly means many) or complex carbohydrates. They are large molecules that are made up of many smaller units that are joined together.The reason why these foods turn blue-black is because they contain starchy components. After lunch, he returned to their classroom.Their discussion was about the three common polysaccharides- **starch**, **glycogen,** and **cellulose**.

The breakdown of **starch** requires a water molecule to provide a hydrogen atom and a hydroxyl group to the site where the bond is broken. With the help of enzymes in the digestive system, the glucose units can be separated from one another. When a glucose molecule is separated from the rest of the starch polymer; it can be absorbed and used as fuel by your cells. Since it takes time for glucose to be separated from the polysaccharide, it is released to the cells gradually. Thus, the glucose from starch reaches muscle cells over a period of time providing energy as it is needed. For this reason, athletes often eat meals rich in complex carbohydrates before an athletic event.

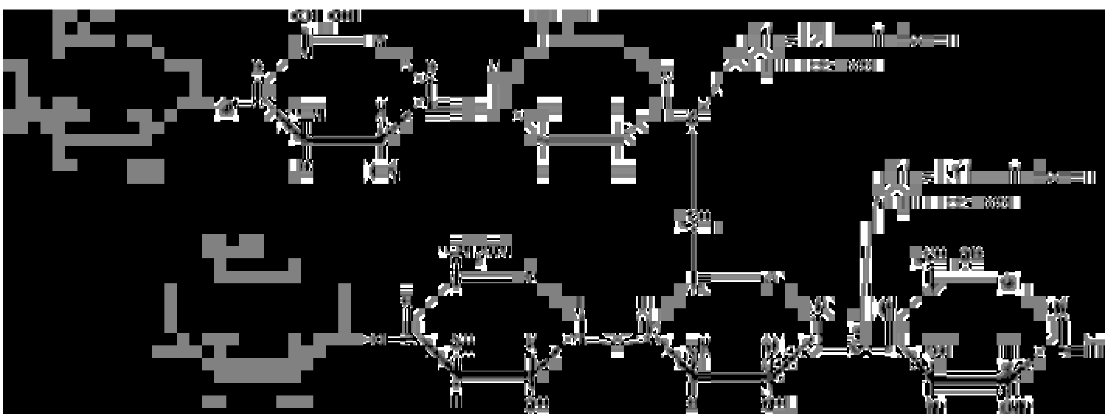


https://courses.ecampus.oregonstate.edu/ans312/one/carbs_story.htm
Figure 5. Structure of Starch

Starch is the chief storage form of carbohydrates in plants and the most important source of carbohydrate in human nutrition. A starch molecule is a polysaccharide assembled from the simple sugar **glucose;** it can contain anywhere from five hundred to several hundred thousand glucose molecules joined by **covalent bonds** into a single structure. Starch is made up of two types of polysaccharides: amylose, which is a coiled or helical structure, and amylopectin, which is branched. Plants make starch.

All individuals whose intake of glucose is excessive will store the excess glucose as fat for long term storage and some are converted to another polysaccharide **glycogen**. Glycogen is a polysaccharide that is similar to starch because it is also composed of alpha glucose units. It differs from starch since glycogen shows a higher degree of branching and is a polysaccharide that is made by animal.

On the other hand, starch contains both straight chain and branched polysaccharides with much less branching than that of glycogen, and is made only by plant.

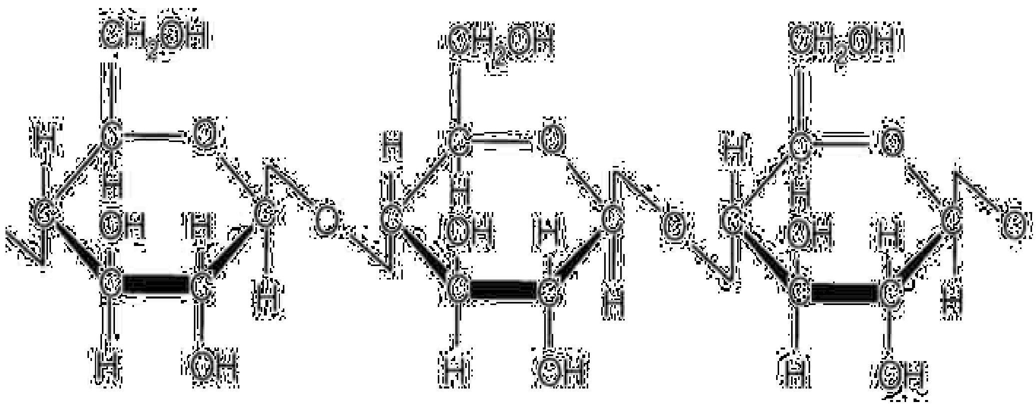


http://www.natuurlijkerwijs.com/english/Glycogen_metabolism.htm

Figure 6. Structure of Glycogen

Figure 6 shows the structure of glycogen which consists of long polymer chains of glucose units connected by an **alpha glycosidic** linkage.It is a multibranched polysaccharide of glucose that serves as a form of energy storage in animals. The polysaccharide structure represents the main storage form of glucose in the body

Glycogen is the readily available energy stored in liver and muscles and the one that is easily metabolized. Fats are stored in adipose tissues but unlike glycogen, are not as readily metabolized. They are used during prolonged exercise or activity.



https://myorganicchemistry.wikispaces.com/
Cellulose?responseToken=1a9131f668de1a94603bbdfb79f69128

Figure 7. Structure of Cellulose

The glucose molecules in **cellulose** chains (refer to Figure 7) are arranged in such a way that hydrogen bonds link hydroxyl groups of adjacent glucose molecules to form insoluble fibrous sheets. These sheets of cellulose are the basic component of plant. People cannot digest cellulose, but when we eat foods rich in fiber, which is cellulose, it speeds the movement of food through the digestive tracts. It is a food for herbivorous animals like cows, carabaos, goats, and horses. These animals have microorganisms in their digestive tracts that can digest cellulose. They have a special stomach chamber that holds the plants they eat for a long period of time, during which these microorganisms can break down the cellulose into glucose. The protozoans in the gut of insects such as termites also digest cellulose.

Being of great economic importance, cellulose is processed to produce papers and fibres, and is chemically modified to yield substances used in the manufacture of items such as plastics, photographic films, and rayon. Other cellulose derivatives are used as adhesives, explosives, thickening agents for foods, and in moisture-proof coatings.

Likewise, starch has many industrial applications in addition to its importance in human nutrition. It is used in the manufacture of paper, textiles, pharmaceuticals, and biodegradable polymers, and as an additive in foods.

Formulative Assessment:

Q2. Why do you think marathon runners eat a meal rich in carbohydrates the day before the race?

After the discussion, Aaron Jay was amazed at how carbohydrates contribute to energy production and the manufacture of important products for human consumption.

Lipids

In the previous lesson, you have learned that carbohydrates are important in providing “instant” energy for cells. There is another class of biomolecules called **lipids** that have the “job” of storing energy for later use. Lipids are also found in hormones and cell membrane components.

Foods rich in lipids

Lipids have different structural types such as carboxylic acids or fatty acids, triglycerides or neutral fats, steroids, and waxes, to name a few. Naturally occuring esters are lipids that contain one or more long-chain carboxylic acids called **fatty acids**. These are insoluble in water but soluble in nonpolar solvents.

When Aaron Jay accidentally mixed oil and water he observed that they do not mix. He was late in his Chemistry class the following morning but he was able to catch up the discussion of his teacher on lipids. His teacher explained that oil and water do not mix because they do not have the same polarity. Also, oils are composed primarily of long hydrocarbon chains. They are formed reaction between an alcohol and one or more long–chain carboxylic acids.

The most abundant of the lipids are the **fats** and **oils**, also called triglycerides. Table 4 below shows the structures of common fatty acids. The presence of double bonds in the fatty acids lowers its melting point. At room temperature, lauric acid is solid while linoleic acid is liquid.

Table 4. Structures of Some Common Fatty Acids

Name	Structural Formula	Melting Point (°C)
Lauric	$CH_3(CH_2)_{10}COOH$	44
Myristic	$CH_3(CH_2)_{12}COOH$	53
Palmitic	$CH_3(CH_2)_{14}COOH$	63
Stearic	$CH_3(CH_2)_{16}COOH$	70
Oleic	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	16
Linoleic*	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	-5
Linolenic*	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	-11
Arachidonic*	$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COOH$	-50

Source: Padolina, M.C.D., Antero, E.S., Alumaga, M.J.B & Estanilla, L.C. (2004). Conceptual and Functional Chemistry

Fats are solids at room temperature and contain saturated fatty acids. Aaron Jay still remembered that all saturated hydrocarbons contain single bonds and they are produced only by animals. Examples of animal fats are lard and butter.

Oils are liquids at room temperature and contain unsaturated fatty acids. Again, he recalled that unsaturated hydrocarbons contain one or more double bonds. Most oils, such as vegetable oil, corn oil, and olive oil are produced by plants. Table 5 gives the fatty acid content of some glycerides.

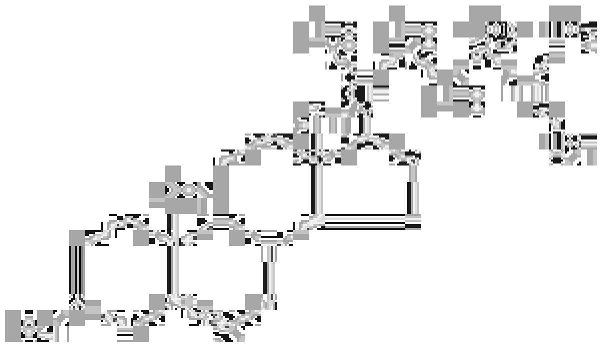
Table 5. Fatty Acid Content of Some Triglycerides

Source		Saturated			Unsaturated		Others
		Myristic	Palmitic	Stearic	Oleic	Linoleic	
Animal Fat	Butter	10	29	9	27	4	31
	Lard	2	30	18	41	6	5
	Beef	3	32	25	38	3	2
Plant Oil	Corn	1	10	4	34	48	4
	Soybean	-	7	3	25	56	9
	Peanut	-	7	5	60	21	7
	Olive	1	6	4	83	7	-

Sometimes we prefer to buy a product in solid form rather than in liquid. Which do you prefer? Spreading margarine on a pandesal or pouring oil on it? Of course, margarine is more acceptable to consumers when it is solid because it looks more like butter. However, margarine is made from vegetable oils that are liquid at room temperature. The oils can be processed to form solid margarine. How is this done?

Can we consider fats good or bad? It depends. If you eat in moderation, fats are good sources of body fuel.They are considered good emergency food and are efficient energy storage system. However, an excess quantity of fats is not good for the heart. The reason why fats are not good for the heart is because they tend to clog arteries and overwork the heart.While carbohydrates are the main source of energy in your body, your system turns it to fat as a backup energy source when carbohydrates are not available. Vitamins A, D, E, and K cannot function without adequate daily fat intake since they are fat soluble vitamins. If you don’t meet your daily fat intake or follow a low fat diet, absorption of these vitamins may be limited resulting in impaired functioning.

Steroids are another class of lipids whose molecules are composed of fused rings of atoms. The most important steroid is **cholesterol.** It is a sterol because of the presence of alcohol or the hydroxyl functional group.It is found mainly in animal cells although cell membranes of plants may contain small quantities of cholesterol as well as its major derivatives, sitosterol.



http://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/PH709_BasicCellBiology/PH709_BasicCellBiology24.html
Figure 11. Structure of Cholesterol

Figure 11 shows the unique structure of cholesterol which consists of four linked hydrocarbon rings forming the bulky steroid structure. There is a hydrocarbon tail linked to one end of the steroid and a hydroxyl group linked to the other end. Cholesterol is known as a “sterol” because it contains an alcohol functional group-OH. Cholesterol is present in most animal membranes with varying amounts but is absent in prokaryotes.

Cholesterol plays an important role in eukaryotes and especially abundant in cell membranes of animal cells. Small amount of cholesterol can also be found in the membrane of some organelles inside the cells, such as the mitochondrion and the endoplasmic reticulum. It is not only abundant in cell membrane, but also in brain tissues of the nervous system. An important nerve cell, myelin, covers nerve axons to help conduct the electrical impulses that make movement, sensation, thinking, learning, and remembering possible. Studies have shown that cholesterol was found to be the most important factor in the formation of synapses, which greatly affect our memory and learning ability. Animals are able to use cholesterol to synthesize other steroids like cortisone, testosterone, and estrogen. These hormones are already discussed in Grade 9. Although cholesterol is an essential lipid for humans, excessive levels of cholesterol in the blood can lead to deposits in the arteries of the heart. These arterial deposits are a leading cause of heart disease. (LeMay Jr, 2000)

Aaron Jay's journey to the world of carbohydrates and lipids gave him a clearer view of the importance of these biomolecules in providing the body with energy. However, he still wants to know which type of molecule has the higher calorie content.

His teacher explained that a calorie is actually a unit of heat energy. We think of calories as something that are present in food and all food have calories. However, your body sees calories as energy in the form of heat. Heat energy is what really fuels our body in the same way that gasoline fuels your car's energy.

Now all foods have calories and different foods have different amounts of calories. Calories are provided by fats, carbohydrates, and proteins. Fats have the highest concentration of calories.On the average, that's nine calories per gram of pure fat. Proteins and carbohydrates each have four calories per gram of pure protein or pure carbohydrate on the average. So understanding the role of calories in your diet can help you balance your calories in with your calories out, and help you achieve weight management goals.

On the sample Nutrition Facts label, the serving size of this food is 1 cup and there are 2 servings in this container. There are 260 calories per serving of this food. If you eat the entire container of this product, you will eat 2 servings. That means you double the calories (260 x 2= 520 calories) If you eat 2 servings, you will have eaten over 500 calories.

Sample Nutritional Label

Retrieved: http://www.health.gov/dietaryguidelines/dga2005/healthieryou/html/chapter5.html

Q3. Carbohydrates and lipids are composed of the same chemical elements, but in diffeent proportions. Both are used primarily as energy sources for cell metabolism. Which type of molecule has the higher calorie content per gram? Explain the reasons for your answers.

Wait! You still need to explore another activity to enhance your knowledge on the identification of protein present in foods.

Activity 2

A. Test for Proteins

Objectives:

- Perform standard chemical test for proteins.
- Relate indicator reactions to the presence of organic nutrients.

Materials:

- 0.5 M sodium hydroxide solution
- 0.5 M copper (II) sulfate solution
- droppers
- test tubes
- test tube racks
- food samples (egg white, cooked fish, cooked meat, cooked legumes, taho)

Procedure:

<u>Biuret Test</u>

1. Place a pinch of food sample to be tested into a test tube.
2. Add 5 drops of NaOH and 5 drops of $CuSO_4$ solution to the test tube.
3. Gently shake the test tube.
4. Observe the content of each test tubes (using white paper as background). If the food contains protein, it will turn pink or blue- violet. Record the amount (0, +, ++, +++, ++++) of proteins for each food substance in table C.

Positive Test: Biuret is clear or light blue in the absence of protein and pink or blue-violet in the presence of protein.

Amount of Protein in Food	0 None	+ Trace	++ Little protein	+++ Moderate protein	++++ Much protein
Color	Light Blue	Light pink	Pink	Blue-violet	Dark blue-violet

CAUTION: Biuret reagent can burn your skin. Wash off spills & splash immediately with plenty of water.Inform the teacher when this occur.

Data/Results

Table C

Food Samples	Biuret Test
egg white	
cooked fish	
cooked meat	
cooked legumes	
taho	

Q4. Describe what you observed in each test tube.

Q5. Which foods may be used for building body parts?

B. The Denaturation of Proteins

Adapted from Sourcebook on Practical Work for Teacher Trainers, High School Chemistry volume 2, UP-NISMED

Objectives:

- Identify the agents for the denaturation of proteins.
- Relate the denaturation of proteins to home or ordinary activities.
- Explain what happens to proteins upon denaturation.

Materials:

- dilute egg white solution
- 0.1 M copper (II) sulfate solution
- conc. HCl
- ethanol
- test tubes
- dropper
- alcohol burner

Procedure:

1. Set up four test tubes (labeled A, B, C, and D) in a test tube rack. Place about 2 cm^3 of the egg white solution in each test tube. Add a few drops of each of the following reagent solutions to separate egg white samples in test tubes A, B, and C.
   A. 0.1 M Copper(II) sulfate solution
   B. conc. HCl
   C. ethanol

Take Note: Preparation of egg white sample: Mix together one portion of egg white with five portions of water in a small beaker. Add a very small amount of sodium chloride.

Observe what happens in each test tube.

Q6. Describe what you observed in each test tube.

Q7. Copper sulfate is used as a fungicide in the garden. Explain the relation of this application to what you have just observed.

Q8. A 70% solution of ethanol in water is used as a disinfectant. Explain the basis for this application.

2. Get test tube D and apply heat. Observe any change.

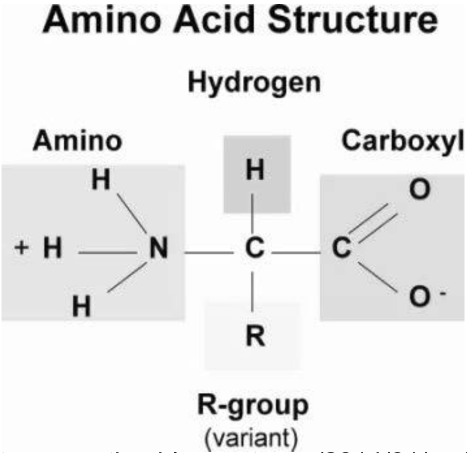
Q9. Describe what happens.

Q10. Give other examples of ordinary activities at home that involve the denaturation of proteins.

Proteins


Proteins are made up of the elements carbon, hydrogen, oxygen, nitrogen and sulfur. Let's continue the story of Aaron Jay on his journey this time to the world of proteins. From the result of his activity, he was able to know that egg white, fish, meat, and cheese are foods rich in proteins. He learned from their discussion that proteins are found in all living cells.They are the second most common molecules found in the human body (after water) and make up about 10% to 20% of the mass of a cell. So whenever Aaron Jay eats protein-rich foods, his digestive system breaks the long protein chains into simpler substances called **amino acids.** He learned from his Chemistry class that amino acids are the building blocks of proteins. Of the 20 amino acids found in human protein, only 11 can be synthesized by the body and 9 have to be supplied by the foods we eat. These 9 amino acids are also called **essential amino acids**. Adults only need to obtain eight of them: valine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine and tryptophan. The ninth amino acid - histidine - is only essential for infants. Your body doesn't store amino acids, so it needs a regular daily supply of these essential building blocks. Nonessential is a slightly misleading label because these amino acids actually fill essential roles, but since they're synthesized by your body, they're not an essential part of your diet. Of the 11 nonessential amino acids, eight are called conditional amino acids. When you're sick or under significant stress, your body may not be able to produce enough of these amino acids to meet your needs. The list of conditional amino acids includes arginine, glutamine, tyrosine, cysteine, glycine, proline, serine, and ornithine. The remaining three - alanine, asparagine, and aspartate - are nonessential.

Aaron Jay also learned that whenever he eats protein foods, he is supplied with amino acids for the rebuilding of his body system.



http://entrytest-preparation.blogspot.com/2014/01/amino-acids.html

Figure 12. Structure of amino acid

Figure 12 shows the structure of amino acids. Amino acids are organic molecules that contain two functional groups: a basic NH_2 amino group and an acidic- COOH carboxylic acid group.

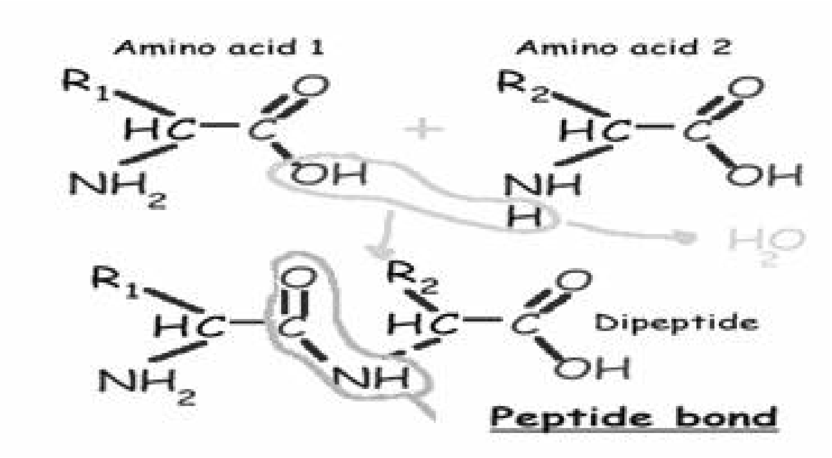


Figure 13. Peptide Bond

When two amino acids react with each other in an acid-base reaction, a peptide is formed. The basic amino group of one amino acid reacts with the acidic carboxylic group of another amino acid, forming the peptide, and a molecule of water is lost. This reaction shown above is classified as a condensation reaction because the two amino acid molecules join together and water is formed. The bond formed is called a peptide bond, and the product is a dipeptide because it is made up of two amino acid units. Longer chains are called polypeptides and chains of 50 or more amino acids are called proteins.

After the discussion on essential & non essential amino acids, Aaron Jay's teacher discussed the primary, secondary, tertiary, and quarternary structures of proteins.

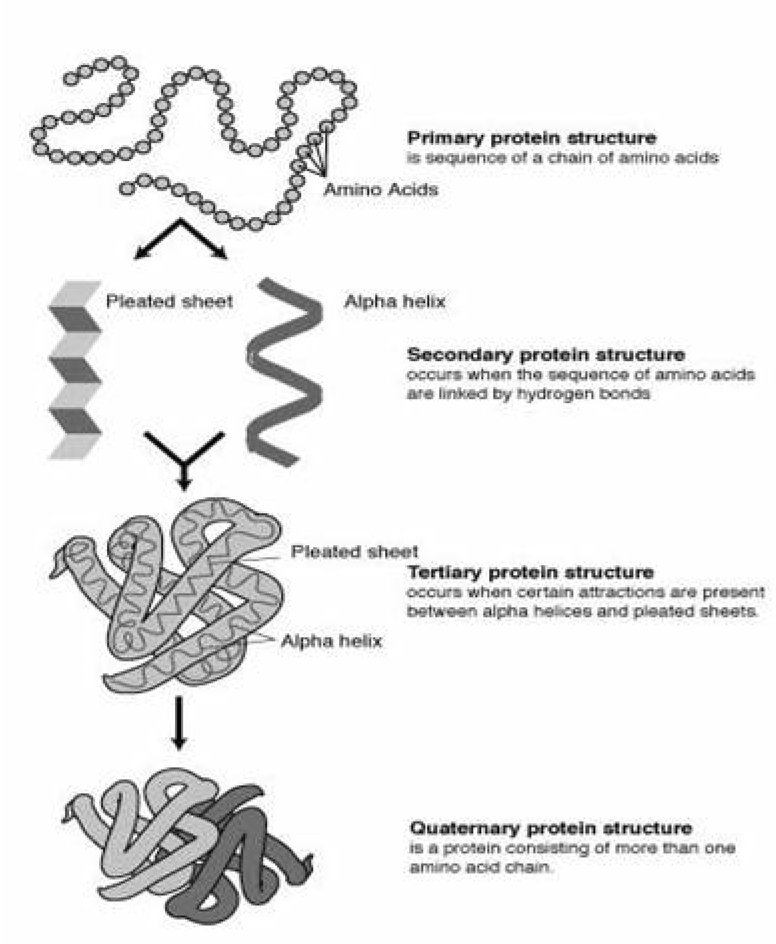


Figure 14. Primary, Secondary ,Tertiary, and Quaternary Proteins

Proteins are characterized by their primary, secondary, tertiary and quaternary structures.The kind of amino acids, which make up the chain, the sequence in which the amino acids are arranged and the length of the chain distinguishes the primary structure of proteins. The secondary structures of proteins refer to the coiling of the protein chain into a α–helix structure, formation of b sheets, or twisting into random structures. These structures are the results of interactions between R groups, H-bonding or formation of –S-S- bonds between chains. Protein molecules are so long that they automatically coil, fold or twist. The resulting shape is unique for each polypeptide in a particular medium, at a particular pH. The tertiary structure describes the shape of the coiled chain when it is folded or hydrated in its natural state. (Adapted: Practical Work for Teacher Trainers, High School Chemistry volume 2, UP-NISMED)

The quaternary protein structure involves the clustering of several individual peptides into a final specific shape. A variety of bonding interactions including hydrogen bonding, salt bridges and disulfide bonds hold the various chains into a particular geometry.

Proteins perform varied functions in the body. How they perform their functions depend on their composition and structures. The particular form and shape each protein molecule takes determines or dictates its function within the organism. Aaron Jay remembered the result of their activity on denaturation of protein. When denaturing agents change the secondary and tertiary structures of proteins, the protein functions are impaired.

The protein molecules in egg white fold and aggregates, which dissolve in water. The long string of molecules unfolds once it is denatured by such agents as heat, salt, baking soda, rubbing alcohol, etc.

From the results of the activity 2, Aaron Jay learned that denaturation finds many applications at home. An example is the extraction of oil from coconut milk emulsion (gata). Proteins act as the emulsifying agent. When the coconut milk emulsion is heated, oil separates from water and is then recovered. The tasty solid residue remaining (latek) after water evaporates is denatured protein. Also, the preservation of food by pickling and salting also involves denaturation of proteins. Vinegar and salts are agents for denaturation. Decay microorganisms are killed when their cell proteins are denatured. (Adapted: Practical Work for Teacher Trainers, High School Chemistry volume 2, UP-NISMED)

Aaron Jay also learned that protein malnutrition, also known as Kwashiorkor, affects children in underdeveloped countries.Although protein malnutrition can be classified as a type of malnutrition; protein malnutrition usually goes hand in hand with calorie malnutrition and referred to as Protein-Energy Malnutrition (PEM).

Another type of protein is the **enzymes.** It is known as biological catalysts. In Grade 8 biology, you have learned the amazing action of catalysts particularly during digestion process.These molecules speed up biochemical reactions without themselves being used up in the process. They are also highly specific. That is, they act only on certain molecules called substrates (reactants), while leaving the rest of the system unaffected. The role of an enzyme can be compared to a lock and a key. The lock will not open unless you use the right key. In the same manner an enzyme works for a specific substrate like the enzyme **lactase.** Its role is to breakdown the sugar lactose into glucose and galactose. You must appreciate the role of enzymes in the body. Without them, chemical reactions in the body may be too slow to occur at normal condition and may affect the normal functioning of the different systems of the body.

After the discussion on proteins, Aaron Jay was amazed at how diverse this group is and the myriad of functions they possess that are very important to all living things.

NUCLEIC ACIDS

Mother and daughters
Photo credit: Edwin Manalang

Aaron Jay wonders why siblings resemble each other, or how a mother and her daughters look alike. He will discover the answer as he explores the next lesson. Nucleic acids are molecules that code for hereditary traits by controlling the production of protein. Like proteins, nucleic acids are long chain of polymers consisting of simpler units or monomers. There are two kinds of nucleic acids: DNA, or deoxyribonucleic acid; and RNA, or ribonucleic acid. DNA found mainly in the cell nuclei contains the genetic information that codes for the sequences of amino acids in proteins. RNA is found in many places in the cell and carries out the synthesis of proteins.

The monomers of nucleic acids are nucleotides. They are made up of three parts: a five carbon sugar (pentose), a phosphate group, and a ring-shaped base containing nitrogen.

In this model, the sphere represents a phosphate group, the pentagon represents a five–carbon sugar (pentose) and the rectangle represents a nitrogen-containing base.

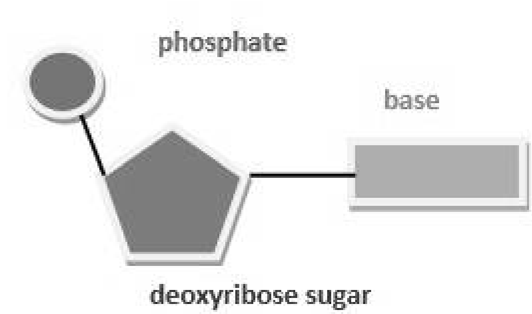


Figure 15. Show a model of a nucleotide.

The double-helix consists of two linear strands of polymerized nucleotides that bound about each other. The two strands are held together by **hydrogen bonds** that form between pairs of nucleotides. Adenine (A) forms hydrogen bonds with a thymine (T) of the other strand. Cytosine (C) forms hydrogen bonds with a guanine (G) of the other strand.

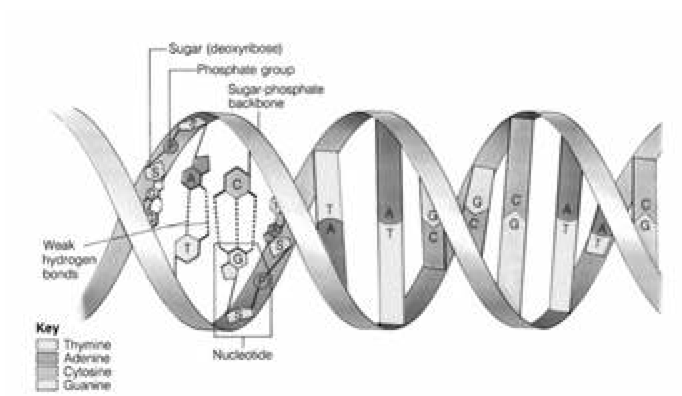


Figure 16. A model of a double helix for DNA

Below is a summary of the differences between the two kinds of nucleic acids: (http://www.diffen.com/difference/DNA_vs_RNA)

	DNA	**RNA**
	Deoxyribonucleic Acid	**Ribonucleic Acid**
Description	It contains the genetic instruction used in the development and functioning of all living organisms.	It is responsible for the template in the synthesis of proteins which in turn control the operation & function of the cell
Function	Long-term storage and transmission of genetic information	Transfer the genetic information for the creation of proteins from the nucleus to the ribosomes
Sugar and Bases	Deoxyribose sugar Phosphate backbone; Four Bases: adenine, guanine, cytosine, and thymine	Ribose sugar Phosphate backbone; Four Bases: adenine, guanine, cytosine, and uracil
Pairing of Bases	A-T (Adenine-Thymine) G-C (Guanine-Cytosine)	A-U (Adenine-Uracil) G-C (Guanine-Cytosine)

The process by which an identical copy of the original DNA is formed is called **DNA replication.** An analogy of DNA replication is opening a zipper.As you open, each side of the zipper acts as a template for the synthesis of a new, complementary strand. The result is two new DNA molecules, which have the same base pair sequence as the original double helix.

Proteins are the ones responsible for observable traits like curly hair, blue eyes, dark skin, etc. DNA and RNA molecules direct the synthesis of proteins in the cells. However, this is beyond the scope of this module.

V. Summary/Synthesis/Feedback (LeMay Jr, 2000)

Carboydrates

- They are molecules made from aldehydes and ketones containing numerous hydroxyl groups.
- Monosaccharides are composed of a single ring.
- Disaccharides consist of two monosaccharides that are chemically combined.
- Polysaccharides are polymers containing numerous monosaccharide monomers.

Lipids

- They are water insoluble molecules that are composed of carbon, hydrogen and oxygen.
- Fats and oils are triglycerides that are combinations of glycerol and three fatty acids.

Proteins

- Proteins are polymers of amino acids. They are found as structural materials in hair, nails and connective tissues.
- Enzymes are proteins that act as biological catalysts**.**

Nucleic Acids

- Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) are nucleic acids.Both DNA and RNA are polymers that are made up of nucleotides.
- Nucleotides are molecules that are composed of three parts: a five carbon sugar, a nitrogen-containing base, and a phosphate group.

Glossary of Terms

- Biomolecule is any molecule that is produced by a living organism, including large macromolecules such as proteins, polysachharides, lipids and nucleic acids.

- Condensation reaction is a process by which two molecules form a bond with the removal of a molecule of water.

- Hydrolysis is a reaction in which water is added to a reactant, breaking the reactant into two product molecules.

- Monomer is a small molecule that joins with other similar molecules to make a polymer; repeating units of a polymer

- Polymer is a large organic molecule consisting of small repeating units called monomers.

VI. Summative Assessment

Direction: Analyze each question carefully then choose the letter of the correct answer.

1. Nutritional chemists have found that burning 1 gram of fat releases twice the amount of heat energy as burning 1 gram of starch. Based on this information, which type of biomolecule would cause a person to gain more weight?
   a. carbohydrate
   b. fat
   c. proteins
   d. nucleic acid

2. Lipids are insoluble in water because lipid molecules are _________?

   a. hydrophilic
   b. neutral
   c. hydrophobic
   d. Zwitter ions

3. Which of the following groups are all classified as polysaccharide?
   a. sucrose, glucose and fructose
   b. maltose, lactose and fructose
   c. glycogen, sucrose and maltose
   d. glycogen, cellulose and starch

4. Amino acids are the building blocks of which group of biomolecules?
   a. proteins b. carbohydrates c. lipids d. nucleic acid

5. Which of the following is the major function of carbohydrates?
   1. structural framework
   2. storage
   3. energy production

   a. 1 only b. 2 only c. 3 only d. 1 & 3 only

6. In which organs are glycogen stored in the body?
   A. liver and spleen
   B. liver and muscle
   C. liver and bile
   D. liver and adipose tissue

7. When digesting a complex carbohydrate, water is added and simple sugar is obtained through which process?
   a. Photosynthesis
   b. Condensation
   c. Hydrolysis
   d. Dehydration

8. What kind of molecule is represented by the structure below?
   $CH_3CH_2CH_2CH_2CH=CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH$

   a. monosaccharide
   b. unsaturated fatty acid
   c. saturated fatty acid
   d. phospholipid

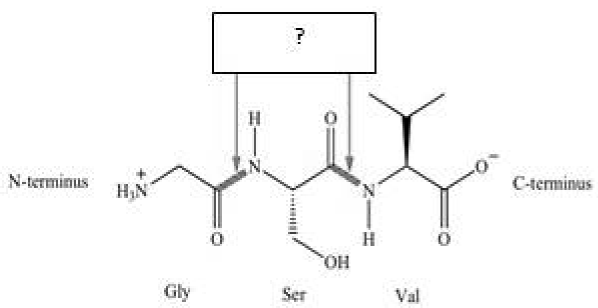
9. Disaccharide is formed by combining two monosaccharides. What do you call the process of combining 2 or more simple sugars?
   a. Hydrolysis
   b. Peptide bonding
   c. Condensation
   d. Saccharide bonding

10. Which of the following elements is NOT present in carbohydrates?
    a. carbon
    b. oxygen
    c. nitrogen
    d. hydrogen

11. Which of the following biomolecules contain only the elements carbon, hydrogen and oxygen?
    a. carbohydrates and lipids
    b. lipids and proteins
    c. proteins and nucleic acids
    d.nucleic acids and carbohydrates

12. Which of the following sugars are the components of lactose?
    a. glucose & galactose
    b. fructose and galactose
    c. glucose & fructose
    d. glucose and glucose

13. What type of chemical bond is illustrated by the arrows below?



    a. sugar-sugar bond
    b. glycerol- fatty acid bond
    c. peptide bond
    d. hydrogen bond

14. Which of the following sugars are the components of maltose?
    a. glucose & galactose
    b. fructose and galactose
    c. glucose & fructose
    d. glucose and glucose

15. The sugar in RNA is _____________, the sugar in DNA is ________.
    a. deoxyribose, ribose
    b. ribose, deoxyribose
    c. ribose, phosphate
    d. ribose, uracil

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