9

DepED
DEPARTMENT OF EDUCATION

Science

Learning Activity Sheets

Quarter 1: Week 5

ORGANIC REACTION MECHANISMS

CONSUMER CHEMISTRY-STE 9

Name: Paul Gerald D. Pare Date: 11/5/20

Section: 9 - Adenine Q1W5

ORGANIC REACTION MECHANISMS

Background Information

Organic reactions involve the chemical reactions among organic compounds. The reaction of given organic compounds may involve one of three fundamental classes of reactions. In some cases, a reaction proceeds spontaneously on mere contact with reactants, but more frequently catalysts are required to bring it about.

Learning Competency

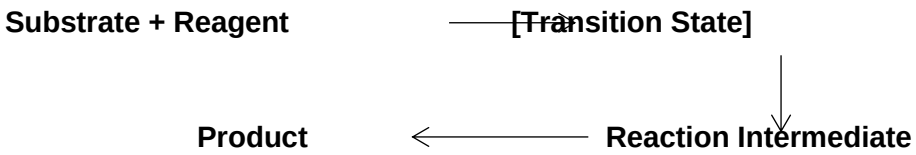
Describe the chemical reactions involving organic compounds

- Addition
- Elimination
- Polymerization

A. Reaction Mechanism

Every reaction involves the breaking of existing bonds in the reactants and the formation of new bonds in the products. The sequence of bond-breaking and bond-forming processes may occur in several types or they may occur in one synchronous step. The series of steps which describe the transformation of the reactants into products are called the **reaction mechanisms.**

An overall picture of a reaction mechanism may be illustrated as follows:



where:

Substrate – the organic compound that undergoes a particular kind of reaction

Reagent – the substance which acts upon the substrate to bring about a reaction

Transition state – the state of bond-breaking and bond-forming processes

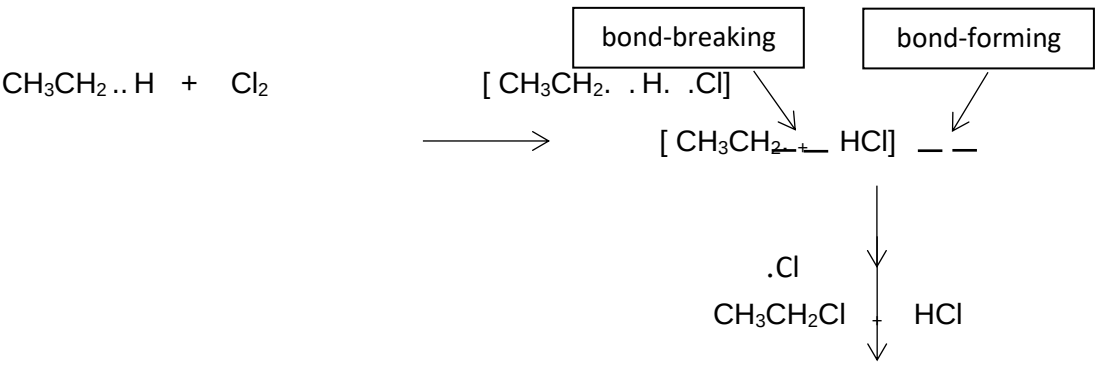
Reaction Intermediate – the unstable but reactive specie produced from the transition state after a bond is broken

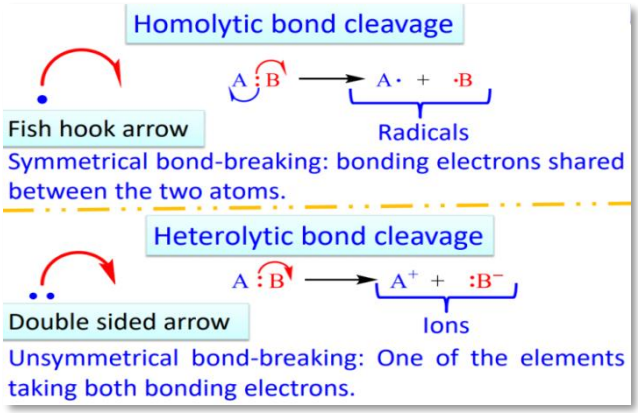
Example:

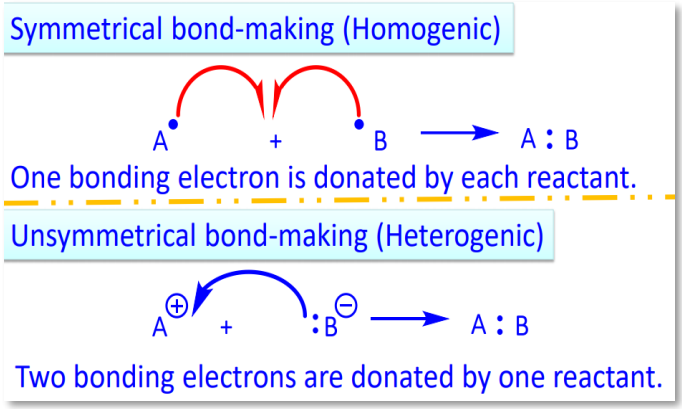
A general reaction mechanism for the chlorination of ethane,

$$CH_3CH_3 + Cl_2 \xrightarrow{uv} CH_3CH_2Cl + HCl$$

is shown below:







Free Radical Reactions

- Reactions that involve symmetrical bond- breaking ***(hemolytic)*** and bond-making ***(homogenic)***
- Atoms or group of atoms with odd number of electrons
- Free radicals cannot all be paired
- Species are highly reactive

Polar Reactions

- Reactions that involve unsymmetrical bond- breaking ***(heterolytic)*** and bond-making ***(heterogenic)***
- The most common reaction among organic compounds
- Occur between negatively charged ***(anions)*** and positively charged ***(cations)*** ions

B. REACTION INTERMEDIATES AND ITS STABILITY

There are three known reactions intermediates which are formed when single covalent bonds are cleaved or broken. The fragments resulting from bond cleavage processes are highly reactive and ordinarily react very rapidly with other molecules in their environment. Under these circumstances, reaction intermediates are more transitory species in the progress of a reaction from reactants to products.

1. Alkyl Free Radical

An alkyl free radical is a species that contains an unpaired electron. It is formed when a covalent bond between two atoms breaks in such a manner that each of the initially bonded atoms retains one of the electrons in the bond. Such kind of bond breaking is called **homolytic cleavage (symmetrical)**

$CH_3 .. X \longrightarrow CH_3 . + . X$

Alkyl free radicals are classified as primary, secondary or tertiary according to the number of carbon atoms attached to the carbon bearing the unpaired electron.

1^0 $CH_3\dot{C}H_2$ ethyl radical

2^0 $CH_3\dot{C}HCH_3$ isopropyl radical

3^0 $CH_3\dot{C}(CH_3)_3$ tert-butyl radical

Free radicals are stabilized by groups that donate electrons to the trivalent carbon radical. Alkyl groups are better at releasing electrons than are hydrogen substituents. The more the alkyl groups that are attached to the carbon radical, the more stable the radical. Thus, the order of free radical stability and ease of formation are:

Tertiary > Secondary > Primary

2. Carbocation or carbonium ion

A ***carbocation or carbonium ion*** is a species that contains a positively charged carbon. It is formed when a covalent bond breaks in such a manner that the pair of electrons leave with the departing atom. This kind of bond breaking is called **heterolytic cleavage (unsymmetrical)**

$CH_3 : X \longrightarrow CH_3^+ + : X^-$

Carbocations are classified as primary, secondary or tertiary according to the number of carbons that are attached to the positively charged carbon.

1^0 $CH_3CH_2^+$ ethyl carbocation

2^0 $CH_3CH^+CH_3$ isopropyl carbocation

3^0 $CH_3C^+(CH_3)_2$ tert-butyl carbocation

Carbocations, like free radicals, are stabilized by substituents, such as alkyl groups, that release electrons to the positively charged carbon. Thus, the order of carbocation stability and ease of formation parallel that of free radicals:

Tertiary > Secondary > Primary

3. Carbanion

A carbanion is a species that contains negatively charged carbon. It is formed when a hydrogen atom in an organic compound is removed as a proton by a strong Lewis base, leaving a pair of electrons to the carbon atom.

$$CH_3 : H + :B \longrightarrow :CH_3^- + B : H$$

Carbanions do not follow the same order of stability as that of the carbocations and free radicals due to the unshared pair of electrons on them. The stability of carbanions depend on the strength of the base,:B and the structural features that contribute to the stability of the ion.

C. ISOMERS

Isomers are different compounds that have the same molecular formulas. The isomers are distinct chemical individual; therefore, they have different chemical and physical properties.

1. **Structural isomers** are isomers that differ in the order in which their atoms are connected. Structural isomers may be further classified into three types:
   a. **Chain isomers** are isomers of molecules whose carbon atoms are connected in straight chains or branched chains.

   Example:

   C_5H_{12} $CH_3CH_2CH_2CH_2CH_3$ pentane

   $CH_3CH(CH_3)CH_2CH_3$ 2-methylbutane

b. Positional isomers are isomers of molecules having the same functional group. The functional group is attached at nonequivalent positions in the carbon structure.

Example:

C_3H_8O $CH_3CH_2CH_2OH$ 1-propanol

CH_3CHCH_3 2-propanol
|
OH

c. Functional isomers are isomers of molecules having different functional groups.

Example:

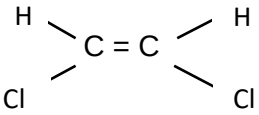
C_3H_6O CH_3CH_2CHO propanal

CH_3COCH_3 acetone

2. Stereoisomers are isomers that have the same structure but differ in the arrangement of their atoms in space.

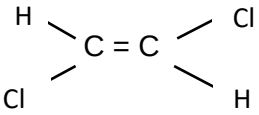
Example:

$C_2H_2Cl_2$



cis-1,2-dichloroethene

$C_2H_2Cl_2$



trans-1,2-dichloroethene

Activity 1- Getting to Know Stage

Direction: Identify the terms describe on each statement below. Write your answer on the space provided. Refer to the pool of terms below.

Carbocation 1. It is a species that contains a positively charged carbon.

Reaction Mechanisms 2. These are the series of steps which describe the transformation of the reactants into products.

Transition States 3. This is the state of bond-breaking and bond-forming processes.

Stereoisomers 4. These are isomers that have the same structure but differ in the arrangement of their atoms in space.

Structural/Constitutional Isomers 5. These are isomers that differ in the order in which their atoms are connected.

Free Radicals 6. It is a species that contains an unpaired electron.

Symmetrical Bond Breaking 7. Other term for homolytic bond cleavage

Unsymmetrical Bond Breaking 8. Other term for heterolytic bond cleavage

Secondary carbon 9. Classification of carbon with two carbons attached to it.

Tertiary carbon 10. Classification of carbon with three carbons attached to it.

Symmetrical	**Transition state**
Tertiary	**Stereoisomers**
Reaction mechanisms	**Free radicals**
Structural isomers	**Unsymmetrical**
Carbocations	**Secondary**

Activity 2: Truth or Lie

Directions: Write **TRUTH** if the statement is correct. If the statement is incorrect, underline the word/s that make the statement wrong and write the correct word that will replace to make it correct. Write your answer on the space provided.

_Truth_____1. Tertiary carbocations and free radicals are more stable and more reactive than the primary one.

_Unsymmetrical__2. Symmetrical bond-breaking and bond-making involve positively and negatively charged ions.

_Homolytic_____3. Heterolytic bond cleavage and homogenic bond-making form free radicals.

_Truth_____4. Carbonians are negatively charged carbons.

_Free radical____5. Polar reactions contain atoms or group of atoms with odd number of electrons.

_Same _____6. Isomers are different compounds with same molecular formula and same physical and chemical properties.

_Truth_____7. Homolytic bond cleavage involves electrons shared between two atoms.

_Heterogenic____ 8. Homogenic bond-making involves two bonding electrons shared by one reactant.

_Polar_____9. Free radical reactions involve formation of ions.

Free Radicals _10. Carbanions have the same stability rules with carbocations.

Activity 3: You Fill Me Up!

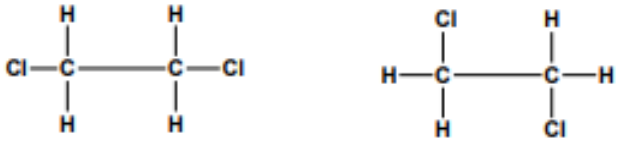
Direction: Fill in the missing spaces on the table below with the correct term, reactant or product.

Bond Cleavage/Bond Making Type	Reactants	Products	Free Radical/ Polar Reactions
Homolytic Bond Cleavage	**A : B**	→ **A · + · B**	**Free Radical Reactions**
Heterolytic Bond Cleavage	**A : B**	→ **$A^+ + B^-$**	**Polar Reactions**
Homogenic Bond Making	**A · + · B**	→ **A : B**	**Free Radical Reactions**
Heterogenic Bond Making	**$A^+ + B^-$**	→ **A : B**	**Polar Reactions**

Activity 4: Are we Isomers?

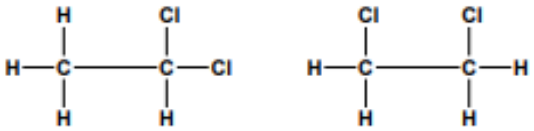
Directions: Encircle the letter of the pairs of structural isomers.

A.

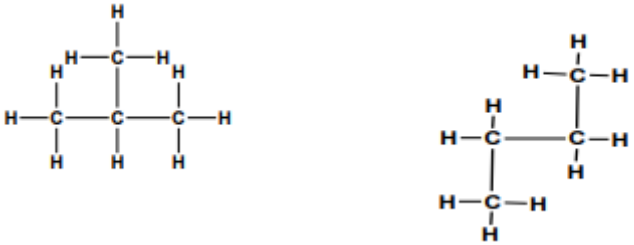


B.

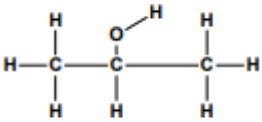
C.

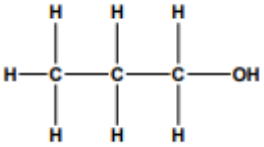


D.



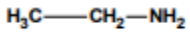
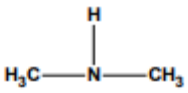
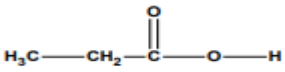
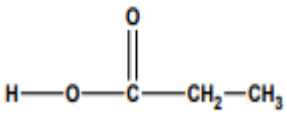
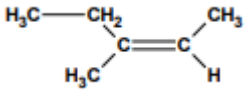
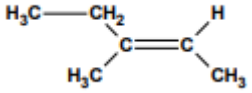
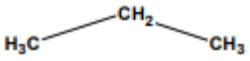
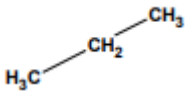
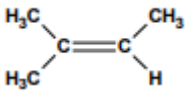
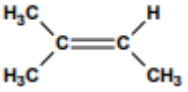
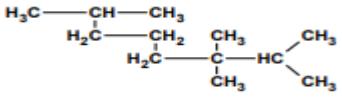
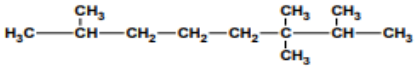
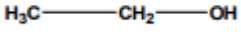
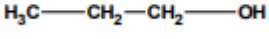
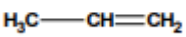
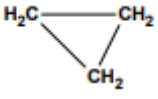
E.

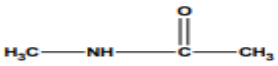
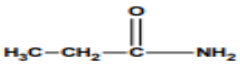




Activity 5: Are you Isomers?

Examine each of the following pairs of chemical structures and decide if they are identical, isomers or different compounds.

	Chemical Structure 1	Chemical Structure 2	Identical / Isomers / Different Compounds
1			**Identical**
2			**Isomers**
3			**Identical**
4			**Isomers**
5			**Identical**
6			**Isomers**
7			**Isomers**
8			**Different Compounds**
9			**Isomers**

10			**Different Compounds**

Reflection:

1. What are the two (2) activities that you have enjoyed most? Why?

_____

_____

_____

2. What are the activities that you will not forget?

_____

_____

_____

References:

https://www.researchgate.net/publication/335396038_ADVANCED_ORGANIC_CHEMISTRY_-I_MPC_102T_UNIT-I_Basic_Aspects_of_Organic_Chemistry_Types_of_Reaction_Mechanisms_and_Methods_of_Determining_Them

https://profiles.uonbi.ac.ke/sderese/files/h-sch_102__types_of_organic_reactions_and_mechanisms.pdf

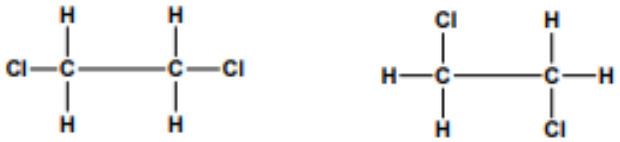
ANSWER KEY

Activity 1 1. Carbocation 2. Reaction Mechanisms 3. Transition state 4. Stereoisomers 5. Structural isomers 6. Alkyl Free radicals/ Free radicals 7. Symmetrical bond-breaking 8. Unsymmetrical bond-breaking 9. Secondary carbon 10. Tertiary carbon	Activity 2 1. Truth 2. (Symmetrical) Unsymmetrical 3. (Heterolytic) Homolytic 4. Truth 5. (Polar) Free radical 6. (same) Different 7. Truth 8. (Homogenic) Heterogenic 9. (Free Radical) Polar 10. (Carbanions) Free radical	

Bond Cleavage/Bond Making Type	Reactants	Products	Free Radical/ Polar Reactions
Homolytic Bond Cleavage	**A : B**	**A · + · B**	**Free Radical Reactions**
Heterolytic Bond Cleavage	**A : B**	**A^+ + : B^-**	**Polar Reactions**
Homogenic Bond Making	**A · + · B**	**A : B**	**Free Radical Reactions**
Heterogenic Bond Making	**A^+ + : B^-**	**A : B**	**Polar Reactions**

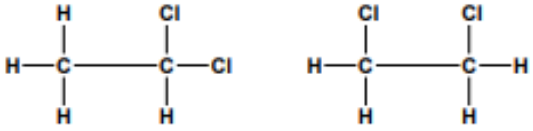
Encircle the letter of the pairs of structural isomers.

A.

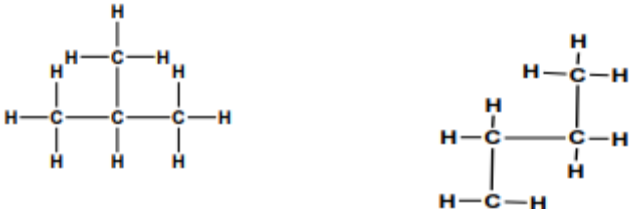


B.

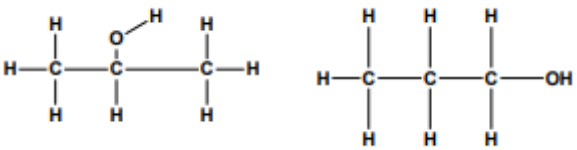
C.



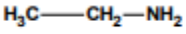
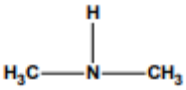
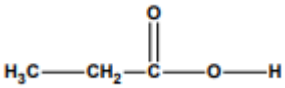
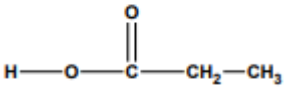
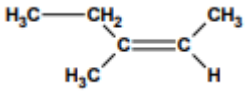
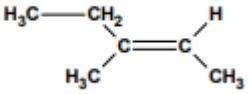
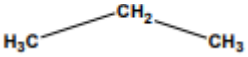
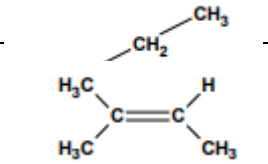
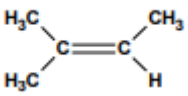
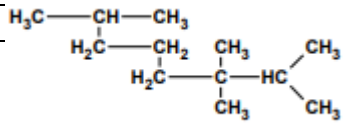
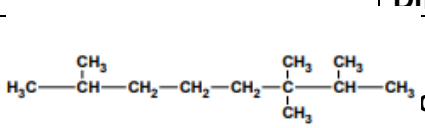
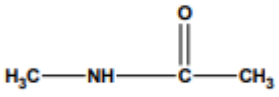
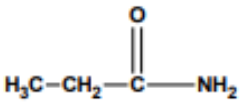
D.



E.



Examine each of the following pairs of chemical structures and decide if they are identical, isomers or different compounds.

	Chemical Structure 1	Chemical Structure 2	Identical / Isomers / Different Compounds
1			Identical
2			Isomers
3			Identical
4			Isomers
5			Identical
6			Isomers
7			Isomers
8			Different compounds
9			Isomers
10			Different compounds