**APPENDICES**

**Appendix A: LEARNING ACTIVITY PACKAGE MANUAL**

**LEARNING ACTIVITY PACKAGE MANUAL FOR SENIOR SECONDARY SCHOOL TWO (SSII) STUDENTS ON ORGANIC CHEMISTRY**

**INSTRUCTIONS:**

This Learning Activity Package Manual (LAPM) is specifically designed to expose you to contents and activities in organic chemistry, for effective learning.

You will be provided with all necessary information to enable you achieve the purpose. You will go through the package step by step at your own pace. You will also be required to complete each learning activity, record your observations and thereafter respond to the questions that follow. You are free to request for assistance from your teacher on areas you might experience some difficulties during the lesson.

The performance objectives of each topic are stated at the beginning of each lesson to enable you have a focus of what you are required to achieve by the end of the lesson. You are expected to keep good record of your work.

**WEEK 1: Lessons One**

**TOPIC:** Organic Chemistry

**Sub-topic:** Structure and valency of carbon

**Duration:** 4 periods (40 minutes per period)

**Pre-Test:**

Answer the following questions;

1. List 4 different forms in which carbon can exist?

2. What is the valency of carbon?

3. Give 4 reasons why carbon can combine with many substances?

4. Draw the tetrahedral structure of carbon?

**Performance Objectives**

By the end of the lesson, you should be able to;

1. List the different forms carbon can exist;

2. Determine the valency of carbon;

3. Explain why carbon can combine with many substances;

4. Draw the tetrahedral structure of carbon.

**Concept**

**Carbon**

Carbon is the name for the element with atomic number 6 and is represented by the symbol C. Carbon has 6 protons, 6 neutrons and 6 electrons. It is a non-metal that belong to group 4 in the periodic table. It occurs naturally as diamond and graphite in a pure form. Carbon also occurs in an impure form as coal; it occurs in the combined state as petroleum, wood and natural gases. Other sources that contain carbon are mineral deposits of metallic trioxocarbonates(iv) eg. Calcium trioxocarbonate(iv), limestone, and Magnesium trioxocarbonate(iv), dolomite; Carbon(iv)oxide in air and water; Charcoal which is of various forms or types eg. Wood charcoal, animal charcoal, sugar charcoal, etc; Coke, which is obtained by heating coal in the absence of air to a very high temperature otherwise known as the destructive distillation of coal; and finally soot or carbon black (lamp black).

Structure and valency of carbon:

The carbon atom has four unpaired valence electrons in its outermost (L) shell. This enables the carbon atom to form four single covalent bonds by sharing electrons with neighbouring atoms, which may be carbon atoms or atoms of other elements, so that the outermost shell of its atom is completely filled. The four covalent bonds of carbon are directed symmetrically in space at an angle of 109.5o to one another, i.e. they are arranged in a tetrahedral form, so that they point towards the corners of a regular tetrahedron when the carbon atom is placed in its centre.

109.5o

 C

Reasons why carbon can form numerous stable organic compounds:

1. Catenation: this is the ability of atoms of the same element to form long chains or rings. Carbon is unique in its ability to form very long chains, branched chains or ring compounds.

2. Multiple bonds: carbon is the only element in group (iv) which forms stable double and triple bonds to itself and to oxygen, sulphur and nitrogen.

3. When carbon has filled shell, it has no lone pair of electrons and cannot act as donor, because strong bonds are formed and this results in lack of reactivity of many carbon compounds.

4. The ease with which carbon combines with hydrogen, nitrogen and the halogens.

5. The ability of carbon atoms to form single, double or triple bonds and the strong carbon-carbon bonds formed.

**Learning Activity 1.1**

**Construction of 3 dimensional model/structure of Carbon Atom**

**Materials:** Coloured (Styrofoam) balls, poster board/cardboard paper, compass, glue, plasticine, pair of scissors and string.

**Method/Procedure**

1. Get 12 styrofoam balls of different colours (6 of one colour for the protons and 6 of another colour for the neutrons) and 6 small plasticine balls for the electrons.

2. Glue the six protons and six neutrons into a ball, alternating between protons and neutrons as you glue.

3. Cut a small ring and a large ring out of cardboard paper. Use string to tie these rings in concentric circles around [the nucleus](http://socratic.org/physics/subatomic-physics/the-nucleus).

4. Glue/place two electrons to the inner circle and four to the outer circle.

5. Attach string to the outer circle for hanging.

**Learning Activity questions**

Answer the followings questions;

a. Why did you glue the protons and neutrons together?

b. Why did you not glue the electrons together with the proton and neutron?

c. What charge has the proton, neutron and electron?

d. What does the small and large cut cardboard paper rings represent?

**Self-Test / Evaluation**

Answer the following questions;

1. Give 4 reasons why carbon can combine with many substances?

2. Draw the tetrahedral structure of carbon?

3. List 4 different forms in which carbon can exist?

4. What is the valency of carbon?

**Mastery / Post-test;**

Answer the following questions;

1. What is carbon?

2. Draw the electronic structure of carbon?

3. What are the forms in which carbon can exist in the pure state?

**Enrichment Opportunities**

Study pages 512 – 513 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 136 – 137 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**WEEK 2: Lesson Two**

**TOPIC:** Organic Chemistry

**Sub-topic:** Hydrocarbons, Isomerism, Homologous series, Functional groups and Nomenclature

**Duration:** 6 periods (40 minutes per period)

**Pre-test:**

Answer the following questions;

1. What are hydrocarbons?

2. Define the term isomerism and give 3 examples?

3. What is homologous series?

4. Define functional groups and give 4 examples?

5. What are the procedures for naming an organic compound?

**Performance objectives**

By the end of the lesson, you should be able to;

1. Explain the meaning of hydrocarbons;

2. Give the definition of isomerism and some examples;

3. Explain the meaning of homologous series;

4. Define the term functional groups and give some examples;

5. Outline the procedures for naming organic compounds.

**Concept**

**Hydrocarbons**

Hydrocarbons are organic compounds composed only of two elements, carbon and hydrogen, just as their name imply. They are among the simplest organic compounds. They have the general molecular formula of CxHy, where x and y are whole numbers. The hydrocarbons are among the simplest organic compounds. Some examples are; Methane CH4, Propane C3H8, Pentane C5H12, Benzene C6H6, etc.

The hydrocarbons are classified into two main groups; Aliphatic and Aromatic hydrocarbons.

*The Aliphatic hydrocarbons*

These are organic compounds composed of carbon-carbon chains. They could be straight chain, branched chain or in the form of a ring.

They are sub-divided into two, based on the structure; Acyclic and Cyclic aliphatic hydrocarbons.

In the Acyclic aliphatic hydrocarbons, the carbon atoms are joined together to form long straight or branched chains.

In the Cyclic aliphatic hydrocarbons, the carbon chains join together at the ends to form a ring.

*The Aromatic Hydrocarbons*

Aromatic hydrocarbons are special class of cyclic compounds based on benzene, C6H6, a 6-carbon ring compound. All other aromatic compounds are derivatives of benzene, e.g phenylamine (aniline) and phenol. Some derivatives may also contain straight carbon chains as side chains.

**Learning Activity 2.1**

**Making 3D Models of Hydrocarbons**

Materials Needed/Apparatus:

Black coloured plasticine, White coloured plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Roll pieces of plasticine into balls, the balls represents atoms.

2. The black plasticine balls will represent carbon atoms while the white plasticine balls will represent hydrogen atoms.

3. The match stick or toothpick will serve as bond.

4. Push single stick into the carbon atom at 4 different positions making sure that the bonds are tetrahedrally oriented.

5. Push hydrogen atom (white ball) into each of the bonds (stick).

6. Using the above method, make models of the following hydrocarbons

i. Methane (CH4), ii. Propane (C3H8). iii. Pentane (C5H12).

*Isomerism*

Isomerism is the existence of two or more compounds that have the same molecular formula (the same number and types of atoms) but possessing different molecular structure (structural formula) and different properties. There are structural isomers, geometric isomers, optical isomers and stereoisomers.

Example; Butane (C4H10) and 2-methylpropane (C4H10) are isomers; the structures are as shown below:

H

H

H

H

H

H

H

H

H

H

H

 C – C – C – C C – C – C

H

H

C

H

H

H

H

H

H

H

H

H

H

H

 Butane (C­4H10) 2-methylpropane (C4H10)

**Learning Activity 2.2**

**Making 3D models of the Isomers of Butane (C4H10)**

Using the same materials you used in learning activity 2.1, construct 3 dimensional structures of the 2 Isomers of Butane; N-Butane and 2-methylpropane.

*Homologous series*

A homologous series is a family of organic compounds which follows a regular structural pattern, in which each successive member differs in its molecular formula by – CH2 – group.

It is also a series of compounds in which each member differs from the next by a specific number and kind of atoms. They show similar chemical properties and have physical properties that change regularly as the molar mass increases.

With the homologous series, the numerous organic compounds can be grouped into a comparatively small number of families of compounds. Each member of the series is known as a homologue. For instance, the alkanes are the simplest homologous series with a general molecular formula of CnH2n+2 where n is a whole number equal to or greater than 1. Other examples of homologous series will include; Alkenes (CnH2n), Alkynes (CnH2n-2), Alkanols (CnH2n+1OH), Carboxylic or Organic acids (CnH2n+1COOH), etc.

Characteristics of homologous series are;

i. All members conform to a general molecular formula as shown in the examples above.

ii. Each homologue differs from the next in molecular formula by – CH2 – and in its relative molecular mass by an increase in 14.

iii. All members show similar chemical properties.

iv. They posses similar method of preparation.

v. The physical properties of members such as boiling point change gradually as the number of carbon atoms increases.

The homologous series is very useful in organic chemistry because, it helps in the study of numerous organic compounds under limited number of families thereby saving us the energy and time with which we would have been studying the compounds singly. This is because knowing the homologous series, the properties of a compound could be predicted.

**Learning Activity 2.3**

**Making 3D Structures of examples of homologous series**

Materials Needed/Apparatus:

Different colours of plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Roll pieces of plasticine into balls, the balls represents atoms.

2. The black balls for carbon atoms, white balls for hydrogen atoms, brown ball for oxygen atom.

3. The match stick or toothpick for bonds.

4. Using the atoms (plasticine balls) and bonds (match sticks or tooth picks), construct a model of the following members of homologous series;

i. Alkene (Eg. Ethene, H2C = CH2) ii. Alkanol (Eg. Ethanol, H3C – CH2OH)

iii. Carboxylic acid (Eg. Ethanoic acid, H3C – COOH) note that in the structure, 1 oxygen is double bonded to the carbon while the other oxygen is single bonded to carbon and hydrogen.

*Functional group*

A functional group is an atom, a radical or bond common to a homologous series and which determines the main chemical properties of the series. If there are two or more functional groups in one molecule of a compound, the properties of one are often modified or influenced by the presence of the other.

Examples of functional groups will include; Hydroxyl group – OH, Amino group – NH2, Carboxyl group – COOH, Amides – CONH2, Double bonded carbon atoms C = C, etc.

The functional groups determine the basic chemistry of a compound, i.e. it is the functional group that determines the chemical behaviour or characteristics of an organic compound. The functional group is based on the principle that, the chemical properties of a homologous series will change when a functional group is attached to a homologue and that the chemical properties of such homologue will be reflecting the chemical properties of the functional group attached. For instance, if a halogen is attached to an alkane homologous series, the series will change to haloalkane homologous series and the chemical properties of the haloalkane homologous series will be different from those of the alkane homologous series.

*IUPAC Nomenclature of Hydrocarbons (IUPAC – International Union of pure and applied chemistry)*

The IUPAC has put forward a system of naming the organic compounds which relates the name of the compound to its molecular structure. In this system of nomenclature, every name consists of; a root, suffix, and as many prefixes as necessary.

1. The root name is generally an aliphatic hydrocarbon. The systematic name of a compound is formed from the root hydrocarbon by adding a suffix and prefixes to denote the substitution of the hydrogen atoms by an alkyl, functional groups or multiple bonds.

2. The suffix(es) is/are added to the root to indicate the presence of the principal substituent which is usually also the principal functional group in the molecule. Compounds that have the same functional groups such as those belonging to the same homologous series, would carry a common suffix at the end of their names. Examples are; Alkanes end with – ane eg. Methane (CH4), Ethane (C2H6) etc.; Alkenes end with – ene eg. Ethene (C2H4), Propene (C3H6) etc.; Alkanols end with – ol, eg. Methanol (CH3OH), Ethanol (C2H5OH) etc.

Note that a suffix is a sound or syllable(s) added at the end of a word to make another word.

3. The prefix(es) are syllable(s) added in front of the root name of an organic compound.

Cyclic compounds can be indicated by adding the prefix cyclo – to the names of the corresponding aliphatic compounds eg. Cyclopentane, Cyclohexane, Cyclobutane etc.

4. Prefixes also used to indicate the presence of substituted alkyl or functional groups other than the principal group, as well as the positions of the substituents in the carbon chain. When more than one of the same substituent group is present, the multiplying prefixes such as di – for 2, tri – for 3, tetra – for 4 etc. are used. If more than one prefix is needed, they are placed in alphabetical order.

5. The positions of the substituent groups and the multiple bonds in the carbon chain of a compound are indicated by the number of the carbon atom or atoms to which they are attached. In numbering the carbon atoms, number all the carbon atoms in the longest chain starting from the end which is closest to the branch chain or other modifications of the simple alkane structure.

*Rules of Naming Organic Compounds*

i. Take the longest continuous carbon chain as the root hydrocarbon and name it according to the number of carbon atoms it contains, adding the appropriate suffix to indicate the principal substituent group.

ii. Number the carbon atoms in the root hydrocarbon from the end which will give the lowest number to the suffix and then the prefix(es).

iii. Indicate the other substituents by prefixes preceded by numbers to show their positions on the carbon chain.

Examples of IUPAC names of Organic Compounds

i. CH3 - CH2- CH(CH3)-CH = CH2 ii. CH3-CH2-C(CH3)=CH-CH3

3-Methylpent-1-ene 3-Methylpent-2-ene

iii. Cl-CH2-CH2-CH2-OH iv. H-C(Cl,Cl)-CH(Cl,Cl)

 3-Chloropropan-1-ol 1,1,2,2 Tetrachloroethane

**Learning Activity 2.4**

**Making 3D Models of Organic Compounds**

Materials Needed/Apparatus:

Different colours of plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Using the different atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following organic compounds;

i. 3-methylpent-1-ene ii. 3-methylpent-2-ene iii. 3-chloropropan-1-ol

iv. 1,1,2,2 Tetrachloroethane

**Self-Test / Evaluation**

Answer the following questions;

1. What is homologous series?

2. What are the procedures for naming an organic compound?

3. Define functional groups and give 4 examples?

4. Define the term isomerism and give 3 examples?

5. What are hydrocarbons?

**Mastery / Post-test;**

Answer the following questions;

i. Draw the structure of Cyclohexane ii. Draw the structure of Ethanoic acid

**Enrichment Opportunities**

Study pages 514 – 523 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study page 137 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**WEEK 3: Lesson Three**

**TOPIC:** Hydrocarbons

**Sub-topic:** Saturated and Unsaturated hydrocarbons, Aliphatic hydrocarbons (Alkanes; properties, preparation and uses)

**Duration:** 6 periods (40 minutes per period)

**Pre-test:**

Answer the following questions;

1. When is a hydrocarbon compound said to be saturated?

2. Give 3 examples each of saturated and unsaturated hydrocarbons?

3. What is the general formula of the Alkanes?

4. Outline 3 properties of the Alkane homologous series?

5. Explain two methods of preparing the Alkanes?

6. List 5 uses of the Alkanes?

**Performance objectives**

By the end of the lesson, you should be able to;

1. define saturated and unsaturated hydrocarbons;

2. give examples of hydrocarbons which are saturated and those which are unsaturated;

3. give the general formula of the Alkanes;

4. list all the properties of the Alkane homologous series;

5. explain the methods of preparing the Alknaes in the laboratory; and

6. identify the uses of the Alkanes.

**Concept**

*Saturated and Unsaturated Hydrocarbons*

A saturated hydrocarbon is a compound in which the carbon atoms are joined together by single covalent bonds. They are hydrocarbons that contain only single carbon-carbon bonds. They are called the Alkanes (Eg. Methane (CH4), Ethane (C2H6), Propane (C3H8) etc).

An unsaturated hydrocarbon is a compound which contains carbon atoms joined together by double or triple covalent bonds. Unsaturated hydrocarbons contain double or triple carbon-carbon bonds. They are the Alkenes (Eg. Ethene (C2H4), Propene (C3H6), etc.) and the Alkynes (Eg. Ethyne (C2H2), Propyne (C3H4), etc.).

*Aliphatic Hydrocarbons – The Alkane homologous series*

The alkanes are aliphatic hydrocarbons whose molecules have very similar structures to each other. They form a homologous series of saturated hydrocarbons whose general molecular formula can be represented as CnH2n+2, where n is an integer greater than or equal to +1.

The alkanes are hydrocarbons in which the constituent carbon atoms are tetrahedrally bonded by single covalent bonds to the hydrogen atoms and other carbon atoms.

Below are molecular formula, structural formula and names of some members of the alkane homologous series, including the isomers. They are arranged in increasing molecular weight.

|  |  |  |
| --- | --- | --- |
| Molecular Formula | Structural Formula and Isomers | Name  |
| CH4 |  HHH C H  | Methane |
| C2H6 |  HHHH C – C – HH  | Ethane  |
| C3H8 |  HHHHH C – C – C – HHH  | Propane  |
| C4H10 |  HHHHHH C – C – C – C – HHHH HHHHH C – C – C – HCHH HH  | Butane2-methylpropane |

*Properties of Alkanes*

Combustion; the alkanes burn in oxygen (air) to give out heat, carbon(iv)oxide and steam.

 CxHy + 2O2(g) yH2O + xCO2

Eg. CH4(g) + 2O2(g) 2H2O(g) + CO2(g)

Other reactions of alkanes;

Alkanes are generally unreactive because their molecules are non-polar and contain single covalent bonds. But the only reaction they undergo is the substitution reaction, in which another atom substitutes a hydrogen atom from the alkane compound. Eg. In the reaction between methane and chlorine, an atom of chlorine is substituted for a hydrogen atom in the methane molecule as shown below;

 CH4(g) + Cl2(g) CH3Cl(l) + HCl(g)

 Chloromethane

 CH3Cl(l) + Cl2(g) CH2Cl2(l) + HCl(g)

 Dichloromethane

 CH2Cl2(l) + Cl2(g) CHCl3(l) + HCl(g)

 Trichloromethane

 CHCl3(l) + Cl2(g) CCl4(l) + HCl(g)

 Tetrachloromethane

*Methods of Preparation*

The alkanes can be prepared in the following methods;

1. All the alkanes can be obtained by the fractional distillation of crude oil. Although the main source of methane is natural gas.

2. They can also be prepared in the laboratory by de-carboxylation (removal of CO2) of the appropriate carboxylic acid.

3. They can also be prepared by heating an appropriate sodium salt with soda-lime.

*Uses of Alkanes*

i. The alkanes are used mainly as fuels. For instance, CH4 is the main component of natural gas while butane is the main component of camping gas and lighter fuel. Octane is an important component of petrol.

ii. They are also used to produce very useful unsaturated hydrocarbons such as ethane (C2H4) through the process of cracking.

iii. Methane is used for making hydrogen, carbon black, carbon(iv)sulphide, alkynes, hydrocyanic acid, trichloromethane (chloroform, an anaesthetic used in surgical operations), dichloromethane (CH2Cl2 used for dissolving paints) and tetrachloromethane (an important organic solvent used for removing grease stains.

**Learning Activity 3.1**

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkane compounds;

i. Propane ii. Butane iii. 2-methylpropane

2. Draw the structural formula of the following alkane compounds;

i. Pentane (C5H12) ii. 2-methylbutane (C5H12­) iii. 2,2-dimethylpropane (C5H12)

**Self-Test / Evaluation**

Answer the following questions;

1. List 5 uses of the Alkanes?

2. What is the general formula of the Alkanes?

3. Explain two methods of preparing the Alkanes?

4. Outline 3 properties of the Alkane homologous series?

5. Give 3 examples of saturated and unsaturated hydrocarbons?

6. When is a hydrocarbon compound said to be saturated?

**Mastery / Post-test;**

Answer the following questions;

1. What is substitution reaction in alkanes?

2. Give 3 differences between saturated and unsaturated hydrocarbons?

3. Give 3 examples each of acyclic and cyclic aliphatic hydrocarbons?

**Enrichment Opportunities**

Study pages 524 – 527 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study page 137 – 140 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**WEEK 4: Lessons Four and Five**

**TOPIC:** Hydrocarbons

**Sub-topic:** Alkenes and Alkynes (properties, preparations and uses)

**Duration:** 6 periods (40 minutes per period)

**Pre-test:**

Answer the following questions;

1. What are the general molecular formula of the alkenes and alkynes?

2. Why are alkenes and alkynes said to be unsaturated?

3. List the methods of preparing the alkenes and the alkynes?

4. Draw the structures of 4 examples of alkene homologous series?

5. Draw all the isomers of hexyne?

**Performance objectives**

By the end of the lessons, you should be able to;

1. write the general molecular formula of the alkenes and alkynes;

2. explain unsaturation in the alkenes and alkynes;

3. explain the methods of preparing alkenes and alkynes;

4. identify the structures of alkene homologous series; and

5. explain isomerism in hexyne.

**Concept**

Lesson Four:

*The Alkene homologous series*

The alkenes are homologous series of hydrocarbons with a general molecular formula of CnH2n, where n is a positive integer equal to or greater than 2. They contain 2 hydrogen atoms less than the alkanes. The alkenes are unsaturated hydrocarbons which contain a carbon-carbon double bond as well as single bonds. The alkenes are given names similar to the alkanes depending on the number of carbon atoms in the molecule. The -ane of the corresponding alkane is replaced by -ene.

Below are molecular formula, structural formula and names of some members of the alkene homologous series, including the isomers. They are arranged in increasing molecular weight.

|  |  |  |
| --- | --- | --- |
| Molecular Formula | Structural Formula and Isomers | Name  |
| C2H4 |  HHHH C – C –  | Ethene  |
| C3H6 |  HHHHH C – C – C – H  | Prop-1-ene  |
| C4H10 |  HHHHHH C – C – C – C – HH HHHHHH C – C – C – C – HH HHH C – C – C – HCHH HH  | But-1-eneBut-2-ene2-methylprop-1-ene |

*Properties of Alkenes*

Combustion:

The alkenes burn to give carbon(iv)oxide and water, with a smoky and luminous flame because of the high proportion of carbon.

Eg. C2H4­(g) + 3O2(g) 2CO2(g) + 2H2O(l)

Other reactions of alkenes;

The alkenes are generally more reactive than the alkanes because of the double bond in their structure which make them unsaturated compounds.

Addition Reactions of Ethene (C2H4) and Propene (C3H6) with Bromine.

Due to their unsaturated nature, the alkenes react by addition, which means specie is simply added on as shown in the following examples;

1. Addition Reactions of Ethene and Propene with Bromine;

a. C2H4(g) + Br2(g) C – C –

Br

Br

H

H

H

H

Ethene 1,2-dibromoethane

H

H

H

H

H

b. C3H6(g) + Br2(g) – C – C – C –

Br

Br

H

 Propene 1,2-dibromopropane

Polymerisation:

The alkenes undergo polymerisation especially ethane and its derivatives to form important compounds such as polyethene, polychloethene, etc.

Polymerisation is a process whereby many simple molecules known as monomers are linked to form a much larger molecule known as a polymer.

*Methods of Preparation:*

1. The main commercial source of the alkenes is from the thermal or catalytic cracking of larger alkane molecules. In the process, mixtures of alkenes are obtained which are separated by fractional distillation. Eg. C12H26 C8H18 + C4H8

 C8H18 C5H12 + C3H6

2. Another method used in the preparation of alkenes involves dehydration of the appropriate alcohol. Eg. Ethene can be prepared by heating ethanol with conc. tetraoxosulphate (vi) acid (H2SO4).

 C2H5OH(l) C2H4(g) + H2O(l)

*Uses of Alkenes:*

1. The cracking of petroleum produces large quantities of ethane for industrial uses such as polyethene products.

2. Propene is used to produce plastics such as Perspex.

3. Buta-1,3-diene is used in synthetic rubber manufacture.

**Learning Activity 4.1**

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkene compounds;

i. Ethene ii. But-1-ene iii. 2-methylprop-1-ene

2. Draw the structural formula of the following alkene compounds;

i. Hex-2-ene (C6H12) ii. Hept-3-ene (C7H14­) iii. 3,3-dimethylhept-1-ene (C9H18)

Lesson Five:

*The Alkyne homologous series*

The alkynes are groups of hydrocarbons which belong to the same homologous series. They have a general molecular formula of CnH2n-2, where n is a positive integer equal to or greater than 2. Each alkyne molecule contains four (4) hydrogen atoms less than the corresponding alkane and two (2) hydrogen atoms less than the corresponding alkene. The alkynes are unsaturated hydrocarbons which contain a carbon-carbon triple bond as well as single bonds in each molecule. They show a higher degree of unsaturation than the alkenes and are therefore more reactive than the alkenes and the alkanes. The alkynes are given names similar to the alkanes depending on the number of carbon atoms in the molecule. The -ane of the corresponding alkane is replaced by -yne.

Below are molecular formula, structural formula and names of some members of the alkyne homologous series, including the isomers. They are arranged in increasing molecular weight.

|  |  |  |
| --- | --- | --- |
| Molecular Formula | Structural Formula and Isomers | Name  |
| C2H2 |  HH C – C –  | Ethyne  |
| C3H4 |  HHH C – C – C – H | Prop-1-yne  |
| C4H6 |  HHHH C – C – C – C – HH HHHH C – C – C – C – HH | But-1-yneBut-2-yne |

*Properties of Alkynes*

Combustion:

1. The alkynes (ethyne) burns in air to give a very smoky and luminous flame to form carbon(iv)oxide and water.

 Eg. 2C2H2­(g) + 5O2(g) 4CO2(g) + 2H2O(l)

2. If ethyne is used in a special burner with an extra oxygen supply, it burns brilliantly giving the very hot oxy-acetylene (oxy-ethyne) flame which is capable of cutting through metals.

3. When a sample of ethyne is tested with a lighted taper, it burns with a yellow, sooty flame owing to its high carbon content and carbon is deposited.

 2C2H2­(g) + O2(g) 4C(s) + 2H2O(g)

Other reactions of alkynes:

Addition Reactions;

Alkynes are highly unsaturated, containing carbon-carbon triple bond in its structure. They undergo addition reactions combining with a maximum of four (4) univalent atoms or radicals per molecule to form addition products. The addition reactions take place in two stages;

a. The first stage yields a product with a carbon-carbon double bond ie. Alkenes.

b. The second stage converts this into a fully saturated compound with only carbon-carbon single bonds ie. Alkanes.

Examples

1. Addition reaction of Alkyne (Ethyne) with Hydrogen

 C2H2 + H2 C2H4 + H2 C2H6

 Ethyne Ethene Ethane

2. Addition reactions of Alkyne (Ethyne) with Halogens (Bromine, Br2)

 C2H2 + Br2 C2H2Br2 + Br2 C2H2Br4

 Ethyne 1,2-dibromoethene 1,1,2,2-tetrabromoethane

Chlorine reacts explosively with ethyne producing carbon and hydrogen chloride gas

C2H2(g) + Cl2(g) 2C(s) + 2HCl(g)

Ethyne reacts with Chlorine and Bromine in the presence of a catalyst (metallic halide) to yield halogenated compounds at room temperature.

Polymerisation

Alkynes also polymerises especially, ethyne which polymerises to form the aromatic hydrocarbon, benzene (C6H6) when it is passed through a hot tube containing a complex organo-nickel catalyst.

 3C2H2(g) C6H6(g)

Methods of Preparation:

1. alkynes can be prepared in the laboratory by the action of alcoholic potassium hydroxide on dibromoalkanes.

Eg. CH2BrCH2Br KOH/C2H5OH C2H2 + 2HBr

 1,2-dibromoethane Ethyne

2. However, ethyne can be prepared in the laboratory conveniently by the action of cold water on calcium carbide.

ie. CaC2(s) + 2H2O(l) – C – C –

H

H

 Calcium carbide Ethyne

Uses of Alkynes:

1. Ethyne is used as the starting material for the production of Polyvinychloride (PVC), 1,1,2,2-tetrachloroethane (a solvent for grease and oils), artificial or synthetic fibres and ethanoic acid.

2. Ethyne is used in the oxyacetylene torch and in lamps.

**Learning Activity 4.2**

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkyne compounds;

i. Ethyne ii. Prop-1-yne iii. But1-yne iv. But-2-yne

2. Draw the structural formula of the following alkyne compounds;

i. Pent-2-yne (C5H8). ii. Hex-3-yne (C6H10­). iii.3,5-dimethylhept-1-ene (C9H16).

**Self-Test / Evaluation**

Answer the following questions;

1. What are the general molecular formula of the alkenes and alkynes?

2. Why are alkenes and alkynes said to be unsaturated?

3. List the methods of preparing the alkenes and the alkynes?

4. Draw the structures of 4 examples of alkene homologous series?

5. Draw all the isomers of hexyne?

**Mastery / Post-test;**

Answer the following questions;

1. What are aromatic hydrocarbons?

2. Draw the resonating structures of benzene?

3. In a tabular format, distinguish between the alkanes, alkenes and alkynes?

**Enrichment Opportunities**

Study pages 528 – 535 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study page 149 – 154 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Appendix C: COOPERATIVE LEARNING INSTRUCTIONAL MANUAL FOR SENIOR SECONDARY TWO (SSII) STUDENTS ON ORGANIC CHEMISTRY**

**Instructions**

This workbook is specifically designed to drill you on topics in Organic Chemistry. You are required to carry out all activities in this workbook in your respective groups. Each group should have a leader and a recorder.

The teacher will teach the contents to the whole class after which you will study the frames and activities at your respective groups.

You are free to ask the teacher questions on areas you do not understand, especially when no member of your group can answer that. The performance objectives of each topic are stated at the beginning of the lesson.

Every member of each group should participate actively in the lesson. No single individual should monopolise the discussion and activity sessions. Each member of the group should have an activity assigned to him/her to do. Ensure that the recorder keeps good record of your activities. When you complete each lesson, you will be assessed on individual basis.

**WEEK ONE: LESSON 1**

**TOPIC:** Organic Chemistry

**Sub-topic:** Structure and valency of carbon

**Duration:** 4 periods (40 minutes per period)

**Performance Objectives**

By the end of the lesson, you should be able to;

1. List the different forms carbon can exist;

2. Determine the valency of carbon;

3. Explain why carbon can combine with many substances;

4. Draw the tetrahedral structure of carbon.

**PRESENTATION 1.1: BY THE TEACHER**

**Carbon**

Carbon is the name for the element with atomic number 6 and is represented by the symbol C. Carbon has 6 protons, 6 neutrons and 6 electrons. It is a non-metal that belong to group 4 in the periodic table. It occurs naturally as diamond and graphite in a pure form. Carbon also occurs in an impure form as coal; it occurs in the combined state as petroleum, wood and natural gases. Other sources that contain carbon are mineral deposits of metallic trioxocarbonates(iv) eg. Calcium trioxocarbonate(iv), limestone, and Magnesium trioxocarbonate(iv), dolomite; Carbon(iv)oxide in air and water; Charcoal which is of various forms or types eg. Wood charcoal, animal charcoal, sugar charcoal, etc; Coke, which is obtained by heating coal in the absence of air to a very high temperature otherwise known as the destructive distillation of coal; and finally soot or carbon black (lamp black).

Structure and valency of carbon:

The carbon atom has four unpaired valence electrons in its outermost (L) shell. This enables the carbon atom to form four single covalent bonds by sharing electrons with neighbouring atoms, which may be carbon atoms or atoms of other elements, so that the outermost shell of its atom is completely filled. The four covalent bonds of carbon are directed symmetrically in space at an angle of 109.5o to one another, i.e. they are arranged in a tetrahedral form, so that they point towards the corners of a regular tetrahedron when the carbon atom is placed in its centre.

109.5o

 C

Reasons why carbon can form numerous stable organic compounds:

1. Catenation: this is the ability of atoms of the same element to form long chains or rings. Carbon is unique in its ability to form very long chains, branched chains or ring compounds.

2. Multiple bonds: carbon is the only element in group (iv) which forms stable double and triple bonds to itself and to oxygen, sulphur and nitrogen.

3. When carbon has filled shell, it has no lone pair of electrons and cannot act as donor, because strong bonds are formed and this results in lack of reactivity of many carbon compounds.

4. The ease with which carbon combines with hydrogen, nitrogen and the halogens.

5. The ability of carbon atoms to form single, double or triple bonds and the strong carbon-carbon bonds formed.

**TEAM STUDY/ACTIVITY**

Study pages 512 – 513 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 136 – 137 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 1.1: Construction of 3 dimensional model/structure of Carbon Atom**

**Materials:** Coloured (Styrofoam) balls, poster board/cardboard paper, compass, glue, plasticine, pair of scissors and string.

**Method/Procedure**

1. Get 12 styrofoam balls of different colours (6 of one colour for the protons and 6 of another colour for the neutrons) and 6 small plasticine balls for the electrons.

2. Glue the six protons and six neutrons into a ball, alternating between protons and neutrons as you glue.

3. Cut a small ring and a large ring out of cardboard paper. Use string to tie these rings in concentric circles around [the nucleus](http://socratic.org/physics/subatomic-physics/the-nucleus).

4. Glue/place two electrons to the inner circle and four to the outer circle.

5. Attach string to the outer circle for hanging.

**Group activity questions**

a. Why did you glue the protons and neutrons together?

b. Why did you not glue the electrons together with the proton and neutron?

c. What charge has the proton, neutron and electron?

d. What does the small and large cut cardboard paper rings represent?

**Individual Evaluation**

Answer the following questions;

1. Give 4 reasons why carbon can combine with many substances?

2. Draw the tetrahedral structure of carbon?

3. List 4 different forms in which carbon can exist?

4. What is the valency of carbon?

**WEEK TWO: Lesson 2**

**TOPIC:** Organic Chemistry

**Sub-topic:** Hydrocarbons, Isomerism, Homologous series, Functional groups and Nomenclature

**Duration:** 6 periods (40 minutes per period)

**Performance objectives**

By the end of the lesson, you should be able to;

1. Explain the meaning of hydrocarbons;

2. Give the definition of isomerism and some examples;

3. Explain the meaning of homologous series;

4. Define the term functional groups and give some examples;

5. Outline the procedures for naming organic compounds.

**PRESENTATION 2.1: BY THE TEACHER**

**Hydrocarbons**

Hydrocarbons are organic compounds composed only of two elements, carbon and hydrogen, just as their name imply. They are among the simplest organic compounds. They have the general molecular formula of CxHy, where x and y are whole numbers. The hydrocarbons are among the simplest organic compounds. Some examples are; Methane CH4, Propane C3H8, Pentane C5H12, Benzene C6H6, etc.

The hydrocarbons are classified into two main groups; Aliphatic and Aromatic hydrocarbons.

*The Aliphatic hydrocarbons*

These are organic compounds composed of carbon-carbon chains. They could be straight chain, branched chain or in the form of a ring.

They are sub-divided into two, based on the structure; Acyclic and Cyclic aliphatic hydrocarbons.

In the Acyclic aliphatic hydrocarbons, the carbon atoms are joined together to form long straight or branched chains.

In the Cyclic aliphatic hydrocarbons, the carbon chains join together at the ends to form a ring.

*The Aromatic Hydrocarbons*

Aromatic hydrocarbons are special class of cyclic compounds based on benzene, C6H6, a 6-carbon ring compound. All other aromatic compounds are derivatives of benzene, e.g phenylamine (aniline) and phenol. Some derivatives may also contain straight carbon chains as side chains.

**TEAM STUDY/ACTIVITY**

Study pages 502, 523 – 524 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 136 – 137 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 2.1: Making 3D Models of Hydrocarbons**

Materials Needed/Apparatus:

Black coloured plasticine, White coloured plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Roll pieces of plasticine into balls, the balls represents atoms.

2. The black plasticine balls will represent carbon atoms while the white plasticine balls will represent hydrogen atoms.

3. The match stick or toothpick will serve as bond.

4. Push single stick into the carbon atom at 4 different positions making sure that the bonds are tetrahedrally oriented.

5. Push hydrogen atom (white ball) into each of the bonds (stick).

6. Using the above method, make models of the following hydrocarbons

i. Methane (CH4), ii. Propane (C3H8). iii. Pentane (C5H12).

**PRESENTATION 2.2: BY THE TEACHER**

*Isomerism*

Isomerism is the existence of two or more compounds that have the same molecular formula (the same number and types of atoms) but possessing different molecular structure (structural formula) and different properties. There are structural isomers, geometric isomers, optical isomers and stereoisomers.

Example; Butane (C4H10) and 2-methylpropane (C4H10) are isomers; the structures are as shown below:

H

H

H

H

H

H

H

H

H

H

H

 C – C – C – C C – C – C

H

H

C

H

H

H

H

H

H

H

H

H

H

H

 Butane (C­4H10) 2-methylpropane (C4H10)

**TEAM STUDY/ACTIVITY**

Study pages 519 – 521 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 137 – 138 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 2.2: Making 3D models of the Isomers of Butane (C4H10)**

Using the same materials you used in learning activity 2.1, construct 3 dimensional structures of the 2 Isomers of Butane; N-Butane and 2-methylpropane.

**PRESENTATION 2.3: BY THE TEACHER**

*Homologous series*

A homologous series is a family of organic compounds which follows a regular structural pattern, in which each successive member differs in its molecular formula by – CH2 – group.

It is also a series of compounds in which each member differs from the next by a specific number and kind of atoms. They show similar chemical properties and have physical properties that change regularly as the molar mass increases.

With the homologous series, the numerous organic compounds can be grouped into a comparatively small number of families of compounds. Each member of the series is known as a homologue. For instance, the alkanes are the simplest homologous series with a general molecular formula of CnH2n+2 where n is a whole number equal to or greater than 1. Other examples of homologous series will include; Alkenes (CnH2n), Alkynes (CnH2n-2), Alkanols (CnH2n+1OH), Carboxylic or Organic acids (CnH2n+1COOH), etc.

Characteristics of homologous series are;

i. All members conform to a general molecular formula as shown in the examples above.

ii. Each homologue differs from the next in molecular formula by – CH2 – and in its relative molecular mass by an increase in 14.

iii. All members show similar chemical properties.

iv. They posses similar method of preparation.

v. The physical properties of members such as boiling point change gradually as the number of carbon atoms increases.

The homologous series is very useful in organic chemistry because, it helps in the study of numerous organic compounds under limited number of families thereby saving us the energy and time with which we would have been studying the compounds singly. This is because knowing the homologous series, the properties of a compound could be predicted.

**TEAM STUDY/ACTIVITY**

Study pages 514 – 515 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 137 – 138 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 2.3: Making 3D Structures of examples of homologous series**

Materials Needed/Apparatus:

Different colours of plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Roll pieces of plasticine into balls, the balls represents atoms.

2. The black balls for carbon atoms, white balls for hydrogen atoms, brown ball for oxygen atom.

3. The match stick or toothpick for bonds.

4. Using the atoms (plasticine balls) and bonds (match sticks or tooth picks), construct a model of the following members of homologous series;

i. Alkene (Eg. Ethene, H2C = CH2) ii. Alkanol (Eg. Ethanol, H3C – CH2OH)

iii. Carboxylic acid (Eg. Ethanoic acid, H3C – COOH) note that in the structure, 1 oxygen is double bonded to the carbon while the other oxygen is single bonded to carbon and hydrogen.

**PRESENTATION 2.4: BY THE TEACHER**

*Functional group*

A functional group is an atom, a radical or bond common to a homologous series and which determines the main chemical properties of the series. If there are two or more functional groups in one molecule of a compound, the properties of one are often modified or influenced by the presence of the other.

Examples of functional groups will include; Hydroxyl group – OH, Amino group – NH2, Carboxyl group – COOH, Amides – CONH2, Double bonded carbon atoms C = C, etc.

The functional groups determine the basic chemistry of a compound, i.e. it is the functional group that determines the chemical behaviour or characteristics of an organic compound. The functional group is based on the principle that, the chemical properties of a homologous series will change when a functional group is attached to a homologue and that the chemical properties of such homologue will be reflecting the chemical properties of the functional group attached. For instance, if a halogen is attached to an alkane homologous series, the series will change to haloalkane homologous series and the chemical properties of the haloalkane homologous series will be different from those of the alkane homologous series.

*IUPAC Nomenclature of Hydrocarbons (IUPAC – International Union of pure and applied chemistry)*

The IUPAC has put forward a system of naming the organic compounds which relates the name of the compound to its molecular structure. In this system of nomenclature, every name consists of; a root, suffix, and as many prefixes as necessary.

1. The root name is generally an aliphatic hydrocarbon. The systematic name of a compound is formed from the root hydrocarbon by adding a suffix and prefixes to denote the substitution of the hydrogen atoms by an alkyl, functional groups or multiple bonds.

2. The suffix(es) is/are added to the root to indicate the presence of the principal substituent which is usually also the principal functional group in the molecule. Compounds that have the same functional groups such as those belonging to the same homologous series, would carry a common suffix at the end of their names. Examples are; Alkanes end with – ane eg. Methane (CH4), Ethane (C2H6) etc.; Alkenes end with – ene eg. Ethene (C2H4), Propene (C3H6) etc.; Alkanols end with – ol, eg. Methanol (CH3OH), Ethanol (C2H5OH) etc.

Note that a suffix is a sound or syllable(s) added at the end of a word to make another word.

3. The prefix(es) are syllable(s) added in front of the root name of an organic compound.

Cyclic compounds can be indicated by adding the prefix cyclo – to the names of the corresponding aliphatic compounds eg. Cyclopentane, Cyclohexane, Cyclobutane etc.

4. Prefixes also used to indicate the presence of substituted alkyl or functional groups other than the principal group, as well as the positions of the substituents in the carbon chain. When more than one of the same substituent group is present, the multiplying prefixes such as di – for 2, tri – for 3, tetra – for 4 etc. are used. If more than one prefix is needed, they are placed in alphabetical order.

5. The positions of the substituent groups and the multiple bonds in the carbon chain of a compound are indicated by the number of the carbon atom or atoms to which they are attached. In numbering the carbon atoms, number all the carbon atoms in the longest chain starting from the end which is closest to the branch chain or other modifications of the simple alkane structure.

*Rules of Naming Organic Compounds*

i. Take the longest continuous carbon chain as the root hydrocarbon and name it according to the number of carbon atoms it contains, adding the appropriate suffix to indicate the principal substituent group.

ii. Number the carbon atoms in the root hydrocarbon from the end which will give the lowest number to the suffix and then the prefix(es).

iii. Indicate the other substituents by prefixes preceded by numbers to show their positions on the carbon chain.

Examples of IUPAC names of Organic Compounds

i. CH3 - CH2- CH(CH3)-CH = CH2 ii. CH3-CH2-C(CH3)=CH-CH3

3-Methylpent-1-ene 3-Methylpent-2-ene

iii. Cl-CH2-CH2-CH2-OH iv. H-C(Cl,Cl)-CH(Cl,Cl)

 3-Chloropropan-1-ol 1,1,2,2 Tetrachloroethane

**TEAM STUDY/ACTIVITY**

Study pages 515 – 519 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

**Group Activity 2.4: Making 3D Models of Organic Compounds**

Materials Needed/Apparatus:

Different colours of plasticine, match stick or tooth pick.

Method / Procedure / Instructions

1. Using the different atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following organic compounds;

i. 3-methylpent-1-ene ii. 3-methylpent-2-ene iii. 3-chloropropan-1-ol

iv. 1,1,2,2 Tetrachloroethane

**Individual Evaluation**

Answer the following questions;

1. What is homologous series?

2. What are the procedures for naming an organic compound?

3. Define functional groups and give 4 examples?

4. Define the term isomerism and give 3 examples?

5. What are hydrocarbons?

**WEEK THREE: Lesson 3**

**TOPIC:** Hydrocarbons

**Sub-topic:** Saturated and Unsaturated hydrocarbons, Aliphatic hydrocarbons (Alkanes; properties, preparation and uses)

**Duration:** 6 periods (40 minutes per period)

**Performance objectives**

By the end of the lesson, you should be able to;

1. define saturated and unsaturated hydrocarbons;

2. give examples of hydrocarbons which are saturated and those which are unsaturated;

3. give the general formula of the Alkanes;

4. list all the properties of the Alkane homologous series;

5. explain the methods of preparing the Alknaes in the laboratory; and

6. identify the uses of the Alkanes.

**PRESENTATION 3.1: BY THE TEACHER**

*Saturated and Unsaturated Hydrocarbons*

A saturated hydrocarbon is a compound in which the carbon atoms are joined together by single covalent bonds. They are hydrocarbons that contain only single carbon-carbon bonds. They are called the Alkanes (Eg. Methane (CH4), Ethane (C2H6), Propane (C3H8) etc).

An unsaturated hydrocarbon is a compound which contains carbon atoms joined together by double or triple covalent bonds. Unsaturated hydrocarbons contain double or triple carbon-carbon bonds. They are the Alkenes (Eg. Ethene (C2H4), Propene (C3H6), etc.) and the Alkynes (Eg. Ethyne (C2H2), Propyne (C3H4), etc.).

*Aliphatic Hydrocarbons – The Alkane homologous series*

The alkanes are aliphatic hydrocarbons whose molecules have very similar structures to each other. They form a homologous series of saturated hydrocarbons whose general molecular formula can be represented as CnH2n+2, where n is an integer greater than or equal to +1.

The alkanes are hydrocarbons in which the constituent carbon atoms are tetrahedrally bonded by single covalent bonds to the hydrogen atoms and other carbon atoms.

Below are molecular formula, structural formula and names of some members of the alkane homologous series, including the isomers. They are arranged in increasing molecular weight.

|  |  |  |
| --- | --- | --- |
| Molecular Formula | Structural Formula and Isomers | Name  |
| CH4 |  HHH C H  | Methane |
| C2H6 |  HHHH C – C – HH  | Ethane  |
| C3H8 |  HHHHH C – C – C – HHH  | Propane  |
| C4H10 |  HHHHHH C – C – C – C – HHHH HHHHH C – C – C – HCHH HH  | Butane2-methylpropane |

*Properties of Alkanes*

Combustion; the alkanes burn in oxygen (air) to give out heat, carbon(iv)oxide and steam.

 CxHy + 2O2(g) yH2O + xCO2

Eg. CH4(g) + 2O2(g) 2H2O(g) + CO2(g)

Other reactions of alkanes;

Alkanes are generally unreactive because their molecules are non-polar and contain single covalent bonds. But the only reaction they undergo is the substitution reaction, in which another atom substitutes a hydrogen atom from the alkane compound. Eg. In the reaction between methane and chlorine, an atom of chlorine is substituted for a hydrogen atom in the methane molecule as shown below;

 CH4(g) + Cl2(g) CH3Cl(l) + HCl(g)

 Chloromethane

 CH3Cl(l) + Cl2(g) CH2Cl2(l) + HCl(g)

 Dichloromethane

 CH2Cl2(l) + Cl2(g) CHCl3(l) + HCl(g)

 Trichloromethane

 CHCl3(l) + Cl2(g) CCl4(l) + HCl(g)

 Tetrachloromethane

*Methods of Preparation*

The alkanes can be prepared in the following methods;

1. All the alkanes can be obtained by the fractional distillation of crude oil. Although the main source of methane is natural gas.

2. They can also be prepared in the laboratory by de-carboxylation (removal of CO2) of the appropriate carboxylic acid.

3. They can also be prepared by heating an appropriate sodium salt with soda-lime.

*Uses of Alkanes*

i. The alkanes are used mainly as fuels. For instance, CH4 is the main component of natural gas while butane is the main component of camping gas and lighter fuel. Octane is an important component of petrol.

ii. They are also used to produce very useful unsaturated hydrocarbons such as ethane (C2H4) through the process of cracking.

iii. Methane is used for making hydrogen, carbon black, carbon(iv)sulphide, alkynes, hydrocyanic acid, trichloromethane (chloroform, an anaesthetic used in surgical operations), dichloromethane (CH2Cl2 used for dissolving paints) and tetrachloromethane (an important organic solvent used for removing grease stains.

**TEAM STUDY/ACTIVITY**

Study pages 518, 526 – 527 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 137 – 141 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 3.1**

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkane compounds;

i. Propane ii. Butane iii. 2-methylpropane

2. Draw the structural formula of the following alkane compounds;

i. Pentane (C5H12) ii. 2-methylbutane (C5H12­) iii. 2,2-dimethylpropane (C5H12)

**Individual Evaluation**

Answer the following questions;

1. List 5 uses of the Alkanes?

2. What is the general formula of the Alkanes?

3. Explain two methods of preparing the Alkanes?

4. Outline 3 properties of the Alkane homologous series?

5. Give 3 examples of saturated and unsaturated hydrocarbons?

6. When is a hydrocarbon compound said to be saturated?

**WEEK FOUR: Lesson 4**

**TOPIC:** Hydrocarbons

**Sub-topic:** Alkenes and Alkynes (properties, preparations and uses)

**Duration:** 6 periods (40 minutes per period)

**Performance objectives**

By the end of the lessons, you should be able to;

1. write the general molecular formula of the alkenes and alkynes;

2. explain unsaturation in the alkenes and alkynes;

3. explain the methods of preparing alkenes and alkynes;

4. identify the structures of alkene homologous series; and

5. explain isomerism in hexyne.

**PRESENTATION 4.1: BY THE TEACHER**

*The Alkene homologous series*

The alkenes are homologous series of hydrocarbons with a general molecular formula of CnH2n, where n is a positive integer equal to or greater than 2. They contain 2 hydrogen atoms less than the alkanes. The alkenes are unsaturated hydrocarbons which contain a carbon-carbon double bond as well as single bonds. The alkenes are given names similar to the alkanes depending on the number of carbon atoms in the molecule. The -ane of the corresponding alkane is replaced by -ene.

Below are molecular formula, structural formula and names of some members of the alkene homologous series, including the isomers. They are arranged in increasing molecular weight.

|  |  |  |
| --- | --- | --- |
| Molecular Formula | Structural Formula and Isomers | Name  |
| C2H4 |  HHHH C – C –   | Ethene  |
| C3H6 |  HHHHH C – C – C – H  | Prop-1-ene  |
| C4H10 |  HHHHHH C – C – C – C – HH HHHHHH C – C – C – C – HH HHH C – C – C – HCHH HH  | But-1-eneBut-2-ene2-methylprop-1-ene |

*Properties of Alkenes*

Combustion:

The alkenes burn to give carbon(iv)oxide and water, with a smoky and luminous flame because of the high proportion of carbon.

Eg. C2H4­(g) + 3O2(g) 2CO2(g) + 2H2O(l)

Other reactions of alkenes;

The alkenes are generally more reactive than the alkanes because of the double bond in their structure which make them unsaturated compounds.

Addition Reactions of Ethene (C2H4) and Propene (C3H6) with Bromine.

Due to their unsaturated nature, the alkenes react by addition, which means specie is simply added on as shown in the following examples;

1. Addition Reactions of Ethene and Propene with Bromine;

a. C2H4(g) + Br2(g) C – C –

Br

Br

H

H

H

H

Ethene 1,2-dibromoethane

H

H

H

H

H

b. C3H6(g) + Br2(g) – C – C – C –

Br

Br

H

 Propene 1,2-dibromopropane

Polymerisation:

The alkenes undergo polymerisation especially ethane and its derivatives to form important compounds such as polyethene, polychloethene, etc.

Polymerisation is a process whereby many simple molecules known as monomers are linked to form a much larger molecule known as a polymer.

*Methods of Preparation:*

1. The main commercial source of the alkenes is from the thermal or catalytic cracking of larger alkane molecules. In the process, mixtures of alkenes are obtained which are separated by fractional distillation. Eg. C12H26 C8H18 + C4H8

 C8H18 C5H12 + C3H6

2. Another method used in the preparation of alkenes involves dehydration of the appropriate alcohol. Eg. Ethene can be prepared by heating ethanol with conc. tetraoxosulphate (vi) acid (H2SO4).

 C2H5OH(l) C2H4(g) + H2O(l)

*Uses of Alkenes:*

1. The cracking of petroleum produces large quantities of ethane for industrial uses such as polyethene products.

2. Propene is used to produce plastics such as Perspex.

3. Buta-1,3-diene is used in synthetic rubber manufacture.

**TEAM STUDY/ACTIVITY**

Study pages 528 – 531 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 149 – 152 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 4.1**

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkene compounds;

i. Ethene ii. But-1-ene iii. 2-methylprop-1-ene

2. Draw the structural formula of the following alkene compounds;

i. Hex-2-ene (C6H12) ii. Hept-3-ene (C7H14­) iii. 3,3-dimethylhept-1-ene (C9H18)

**PRESENTATION 4.2: BY THE TEACHER**

*The Alkyne homologous series*

The alkynes are groups of hydrocarbons which belong to the same homologous series. They have a general molecular formula of CnH2n-2, where n is a positive integer equal to or greater than 2. Each alkyne molecule contains four (4) hydrogen atoms less than the corresponding alkane and two (2) hydrogen atoms less than the corresponding alkene. The alkynes are unsaturated hydrocarbons which contain a carbon-carbon triple bond as well as single bonds in each molecule. They show a higher degree of unsaturation than the alkenes and are therefore more reactive than the alkenes and the alkanes. The alkynes are given names similar to the alkanes depending on the number of carbon atoms in the molecule. The -ane of the corresponding alkane is replaced by -yne.

Below are molecular formula, structural formula and names of some members of the alkyne homologous series, including the isomers. They are arranged in increasing molecular weight.

|  |  |  |
| --- | --- | --- |
| Molecular Formula | Structural Formula and Isomers | Name  |
| C2H2 |  HH C – C –   | Ethyne  |
| C3H4 |  HHH C – C – C – H  | Prop-1-yne  |
| C4H6 |  HHHH C – C – C – C – HH HHHH C – C – C – C – HH | But-1-yneBut-2-yne |

*Properties of Alkynes*

Combustion:

1. The alkynes (ethyne) burns in air to give a very smoky and luminous flame to form carbon(iv)oxide and water.

 Eg. 2C2H2­(g) + 5O2(g) 4CO2(g) + 2H2O(l)

2. If ethyne is used in a special burner with an extra oxygen supply, it burns brilliantly giving the very hot oxy-acetylene (oxy-ethyne) flame which is capable of cutting through metals.

3. When a sample of ethyne is tested with a lighted taper, it burns with a yellow, sooty flame owing to its high carbon content and carbon is deposited.

 2C2H2­(g) + O2(g) 4C(s) + 2H2O(g)

Other reactions of alkynes:

Addition Reactions;

Alkynes are highly unsaturated, containing carbon-carbon triple bond in its structure. They undergo addition reactions combining with a maximum of four (4) univalent atoms or radicals per molecule to form addition products. The addition reactions take place in two stages;

a. The first stage yields a product with a carbon-carbon double bond ie. Alkenes.

b. The second stage converts this into a fully saturated compound with only carbon-carbon single bonds ie. Alkanes.

Examples

1. Addition reaction of Alkyne (Ethyne) with Hydrogen

 C2H2 + H2 C2H4 + H2 C2H6

 Ethyne Ethene Ethane

2. Addition reactions of Alkyne (Ethyne) with Halogens (Bromine, Br2)

 C2H2 + Br2 C2H2Br2 + Br2 C2H2Br4

 Ethyne 1,2-dibromoethene 1,1,2,2-tetrabromoethane

Chlorine reacts explosively with ethyne producing carbon and hydrogen chloride gas

C2H2(g) + Cl2(g) 2C(s) + 2HCl(g)

Ethyne reacts with Chlorine and Bromine in the presence of a catalyst (metallic halide) to yield halogenated compounds at room temperature.

Polymerisation

Alkynes also polymerises especially, ethyne which polymerises to form the aromatic hydrocarbon, benzene (C6H6) when it is passed through a hot tube containing a complex organo-nickel catalyst.

 3C2H2(g) C6H6(g)

Methods of Preparation:

1. alkynes can be prepared in the laboratory by the action of alcoholic potassium hydroxide on dibromoalkanes.

Eg. CH2BrCH2Br KOH/C2H5OH C2H2 + 2HBr

 1,2-dibromoethane Ethyne

2. However, ethyne can be prepared in the laboratory conveniently by the action of cold water on calcium carbide.

ie. CaC2(s) + 2H2O(l) – C – C –

H

H

 Calcium carbide Ethyne

Uses of Alkynes:

1. Ethyne is used as the starting material for the production of Polyvinychloride (PVC), 1,1,2,2-tetrachloroethane (a solvent for grease and oils), artificial or synthetic fibres and ethanoic acid.

2. Ethyne is used in the oxyacetylene torch and in lamps.

**TEAM STUDY/ACTIVITY**

Study pages 531 – 534 of New School Chemistry for Senior Secondary Schools by Osei Yaw Ababio, 2010 edition.

Also study pages 152 – 154 of Science Teachers Association of Nigeria (STAN) Chemistry for Senior Secondary Schools.

**Group Activity 4.2**

Materials Needed/Apparatus:

Black coloured plasticine balls (Carbon atoms), White coloured plasticine balls (Hydrogen atoms), match stick or tooth pick.

Method / Procedure / Instructions

1. Using the carbon and hydrogen atoms (Plasticine balls) and the sticks, make 3 dimensional models of the following alkyne compounds;

i. Ethyne ii. Prop-1-yne iii. But1-yne iv. But-2-yne

2. Draw the structural formula of the following alkyne compounds;

i. Pent-2-yne (C5H8) ii. Hex-3-yne (C6H10­) iii. 3,5-dimethylhept-1-ene (C9H16)

**Individual Evaluation**

Answer the following questions;

1. What are the general molecular formula of the alkenes and alkynes?

2. Why are alkenes and alkynes said to be unsaturated?

3. List the methods of preparing the alkenes and the alkynes?

4. Draw the structures of 4 examples of alkene homologous series?

5. Draw all the isomers of hexyne?

**Appendix C: Chemistry Achievement Test**

**Chemistry Achievement Test on Organic Chemistry (CATOC)**

**Section A**

Name of school:...................................................................................................................

Name of student:.................................................................................................................

Class:...............................................

Sex: Male Female (Tick ✓)

**Section B**

Instructions

a. Choose and tick ✓ only the correct answer from options a - d

b. Erase completely any answer made in error

c. Do not cheat in any form d. Time allowed is 1.30 hrs

e. Answer all the questions.

Questions

1. The following are general characteristics of carbon except?

a. covalent nature and non-polar. b. low melting and boiling points

c. low reactivity with other elements except oxygen and the halogens

d. hydrogen bond in petrol

2. Exceptional large number of carbon compounds is essentially due to the ability of?

a. carbon to catenate liberally b. various groups to catenate

c. nitrogen, hydrogen, phosphorous and the halogens to catenate with themselves

d. hydrocarbons to dominate other groups

3. What is the name of C(CH3)4?

a. butane b. tetramethyl butane. c. methyl propane. d. 2,2-dimethyl propane

4. What is the name of the homologous series with the general formula shown below?

 O

R – C NH2

a. amine. b. amino acids. c. oxy-amines. d. amides.

5. Which is not among the characteristics of functional groups in organic compounds?

a. determine the chemical properties of the homologous series

b. does not modify the other when they are more than one in a molecule

c. have a general formula which may include the functional group

d. are responsible for the physical properties

6. The IUPAC name of ClCH2-CH2-CH2OH is?

a. 1-chloropropan-3-ol. b. 3-chloropropan-1-ol. c. 1-chloropropanol.

d. 3-chloropropanol.

7. Which of these compounds is not a hydrocarbon?

a. benzene b. ethane c. ethanol d. butyne

8. What is the name given to the compound shown below?

 CH2

 H2C CH2

 H2C CH2

 CH2

a. benzene b. hexane c. cyclohexane d. hydrobenzene

9. When two or more compounds have the same molecular formula but different structures they are known as?

a. allotropes. b. tantamerism. c. mirror isomers. d. structural isomers.

10. Which is not among the uses of Petroleum?

a. fuels only. b. fuels and money. c. fuels and pollutants.

d. fuels and petrochemical raw materials

11. The main natural sources of hydrocarbons are from fossil fuels and these include except?

a. natural gas b. coke c. coal d. petroleum

12. Alkenes and Alkynes reacts the same, except with?

a. ammoniacal AgNO3 solution. b. oxygen. c. bromine water.

d. acidified KMNO4 solution.

13. Functional group for the alkanol is?

a. -OH. b. CnH2n-2 c. COOH d. OH-

14. What is this compound CH3(CH2)2CONH2 called?

a. methyl amine. b. butyl amine. c. butyl amide. d. Urea.

15. Which among the following is an aromatic hydrocarbon?

a. cyclopentane b. toluene c. pentanal d. ethane

16. What is the product formed when methane reacts with chlorine; CH4 + Cl2  ?

a. CH4Cl2 + H2 b. CH3Cl + HCl c. CH2Cl + 2HCl d. CH2Cl2 + H2

17. Which of the following compounds is an alkane?

a. C2H2 b. C3H6 c. C4H6 d. C6H14

18. What type of reaction takes place when ethane reacts with hydrogen bromide?

a. oxidation reaction b. substitution reaction c. addition reaction

d. polymerisation reaction

19. Which of the following molecules is the most unsaturated?

a. ethyne b. methane c. ethene d. propane

20. Write the general formula for the alkynes?

a. CnH2n b. CnH2n+2 c. CnH2n-2 d. CnH2n-n

21. Hydrocarbons are organic compounds that contain....?

a. carbon and oxygen only. b. carbon, hydrogen and oxygen only.

c. carbon and sulphur only. d. carbon and hydrogen only.

22. Which method is often used in separating the hydrocarbons found in petroleum?

a. catalytic cracking b. polymerisation c. fractional distillation

d. hydrogenation

23. Which of the following compounds do not exhibit isomerism?

a. C2H6 b. C4H8 c. C6H14 d. C5H8

24. What is the name of the compound C2H5COOH?

a. ethanoic acid. b. propanoic acid. c. Butanoic acid. d. methanoic acid.

25. what is the general molecular formula of the alkene homologous series?

a. CnHn b. CnH2n+2 c. CnH2n d. CnH2n2-2

**Appendix D: CATOC Marking Guide**

1. d

2. a

3. d

4. d

5. b

6. b

7. c

8. c

9. d

10. c

11. b

12. b

13. a

14. c

15. b

16. b

17. d

18. b

19. a

20. c

21. d

22. c

23. a

24. b

25. c

**Appendix E: TEST BLUE PRINT FOR THE CATOC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Content** | **Knowledge****(Remembering)****45%** | **Comprehension****(Understanding)****30%** | **Application****(Thinking)****25%** | **Total** |
| Structure and Valency of Carbon - 10%  | A**1** | B**1** | C**1** | Ta3 |
| Hydrocarbons (Saturated,Unsaturated, Alkanes, Alkenes and Alkynes) - 45% | D**5** | E**3** | F**3** | Tb11 |
| Isomerism, Homologous series, Functional groups) 25% | G**3** | H**2** | I**1** | Tc6 |
| IUPAC Nomenclature20% | J**2** | K**2** | L**1** | Td5 |
| Total  | Te11 | Tf8 | Tg6 | 25 |

**Calculations:**

**Total number of items = 25**

From the table above, ‘Structure and valency of carbon’ was allotted 10%; ‘Hydrocarbons (saturated, unsaturated, alkanes, alkenes and alkynes)’ had 45%, ‘Isomerism, Homologous series and Functional groups’ had 25%; while IUPAC nomenclature was allotted 20%. Likewise, Knowledge was allotted 40%, Comprehension 35% and Application 25%.

Calculating the totals, Ta to Tg;

Ta = 10/100 × 25 = 3 Tb = 45/100 × 25 = 11

Tc  = 25/100 × 25 = 6 Td = 20/100 × 25 = 5

Te = 45/100 × 25 = 11 Tf = 30/100 × 25 = 8

Tg = 25/100 × 25 = 6

Calculating the number of items/questions for each cell, A to L;

A = 11/25 × 3 = 1 B = 8/25 × 3 = 1 C = 6/25 × 3 = 1

D = 11/25 × 11 = 5 E = 8/25 × 11 = 3 F = 6/25 ×11 = 3

G = 11/25 × 6 = 3 H = 8/25 × 6 = 2 I = 6/25 × 6 = 1

J = 11/25 × 5 = 2 K = 8/25 × 5 = 2 L = 6/25 × 5 = 1