**ORGANIC CHEMISTRY**

* Organic chemistry is the branch of chemistry that studies carbon compounds present in living things, once living things or synthetic/man-made.
* Carbon is tetravalent.
* It is able to form stable covalent bonds with itself and many non-metals like hydrogen, nitrogen, oxygen and halogens to form a variety of compounds.
* This is because:
1. Carbon uses all the four valence electrons to form four, strong covalent bond.
2. Carbon can covalently bond to form a single, double or triple covalent bond with itself.
3. Carbon atoms can covalently bond to form a very long chain or ring.
* When carbon covalently bond with Hydrogen, it forms a group of organic compounds called **Hydrocarbons**

**HYDROCARBONS**

* Hydrocarbons are a group of organic compounds made up of hydrogen and carbon atoms only.
* Depending on the type of bond that exist between the individual carbon atoms, hydrocarbon are classified as:

 (i) Alk**a**nes

 (ii) Alk**e**nes

 (iii) Alk**y**nes

 **(i) Alkanes**

**(a)Nomenclature/Naming**

* These are hydrocarbons with a general formula **CnH2n+2** where **n** is the number of Carbon atoms in a molecule.
* The carbon atoms are linked by single bond to each other and to hydrogen atoms.

They include:

|  |  |  |  |
| --- | --- | --- | --- |
| n | Molecularformula | Structural formula | Name |
| 1 | CH4 |  | Meth**ane** |
| 2 | C2H6 |  | Eth**ane** |
| 3 | C3H8 |  | Prop**ane** |
| 4 | C4H10 |  | But**ane** |
| 5 | C5H12 |  | Pent**ane** |

**Note**

1. The **general formula**/**molecular formular** of a compound shows the number of each atoms of elements making the compound
* Decane has a molecular formula **C10H22**; this means there are 10 carbon atoms and 22 hydrogen atoms in a molecule of decane.
1. The **structural formula** shows the arrangement/bonding of atoms of each element making the compound e.g
2. Since carbon is **tetravalent**, each atom of carbon in the alkane **MUST** always be bonded using **four** covalent bonds.
3. Since Hydrogen is **monovalent**, each atom of hydrogen in the alkane **MUST** always be bonded using **one** covalent bond/one shared pair of electrons.
4. One member of the alkane differs from the next/previous by a CH2 group.
5. A homologous series:
6. Differ by a CH2  group from the next /previous consecutively
7. Have similar chemical properties
8. Have similar chemical formula that can be represented by a general formula e.g alkanes have the general formulaCnH2n+2.
9. The physical properties (e.g.melting/boiling points)show steady gradual change)
10. The 1st four alkanes have the prefix **meth\_,eth\_,prop\_** and **but\_** to represent 1,2,3 and 4 carbons in the compound..
11. If one hydrogen atom in an alkane is removed, an alkyl group is formed.e.g

|  |  |  |  |
| --- | --- | --- | --- |
| Alkane name | molecular structureCnH2n+**2** | **Alkyl name** | **Molecula structure****CnH2n+1** |
| methane | CH4 | **methyl** | **CH3** |
| ethane | CH3CH3 | **ethyl** | **CH3 CH2** |
| propane | CH3 CH2 CH3 | **propyl** | **CH3 CH2 CH2** |
| butane | CH3 CH2 CH2 CH3 | **butyl** | **CH3 CH2 CH2 CH2** |

**Isomers of alkanes**

* Isomers are compounds with the same molecular **formula** but different structural **formula**.
* Isomerism is the existence of compounds having the same molecular formula but different structural formula.
* The 1st three alkanes do not form isomers. Isomers are named by using the IUPAC (**I**nternational **U**nion of **P**ure and **A**pplied **C**hemistry) system ofnaming**.**
* The IUPAC system of nomenclatureuses the following basic rules/guidelines:

**Practice on IUPAC nomenclature of alkanes**

**(a)Draw the structure of:**

 **(i)2-methylpentane**

Molecular formula

 **CH3**

 **CH3 CH CH2 CH3 //CH3 CH (**CH3 **) CH2CH3**

 **(ii)2,2-dimethylpentane**

 Molecular formular

 **CH3**

 **CH3 C CH2 CH3 //CH3 C (**CH3 **)2 CH2CH3**

**CH3**

**(iii) 2,2,3-trimethylbutane**

 Molecular formular

 **CH3**

 **CH3 C CH CH3 //CH3 C (**CH3 **)3 CH2CH3**

**CH3** **CH3**

 **(iv) 1,1,1,2,2,2-hexabromoethane**

Molecular formula

 **CBr3 CBr3**

 **(v) 1,1,1-tetrachloro-2,2-dimethylbutane**

 **CH3**

 **CCl 3 C CH3 //C Cl 3 C (**CH3 **)2 CH3**

**CH3**

 **Occurrence and extraction**

* **Crude oil**, natural **gas** and **biogas** are the main sources of alkanes:
1. Crude oil is a mixture of many flammable hydrocarbons/substances.
2. Using fractional distillation, each hydrocarbon fraction can be separated from the other. The hydrocarbon with lower /smaller number of carbon atoms in the chain have lower boiling point and thus collected first.

**Uses of different crude oil fractions**

|  |  |  |
| --- | --- | --- |
| Carbon atoms in a molecule | Common name of fraction | Uses of fraction |
| 1-4 | Gas | L.P.G gas for domestic use |
| 5-12 | Petrol | Fuel for petrol engines |
| 9-16 | Kerosene/Paraffin | Jet fuel and domestic lighting/cooking |
| 15-18 | Light diesel | Heavy diesel engine fuel |
| 18-25 | Diesel oil | Light diesel engine fuel |
| 20-70 | Lubricating oil | Lubricating oil to reduce friction. |
| Over 70 | Bitumen/Asphalt | Tarmacking roads |

**School laboratory preparation of alkanes**

* In a school laboratory, alkanes may be prepared from the reaction of a sodium alkanoate with solid sodium hydroxide/soda lime.

Chemical equation:

Sodium alkanoate + soda lime alkane + Sodium carbonate

CnH2n+1COONa(s) + NaO**H**(s) C n H2n+2 + Na2CO3(s)

The “H” in NaO**H** is transferred/moves to the CnH2n+1in CnH2n+1COONa(s) to form C n H2n+**2**.

**Examples**

1. **Meth**ane is prepared from the heating of a mixture of sodium **ethan**oate and soda lime and collecting over water

Sodium **ethan**oate + soda lime **meth**ane + Sodium carbonate

CH3COONa(s) + NaO**H**(s) CH4 + Na2CO3(s)

The “H” in NaO**H** is transferred/moves to the CH3in CH**3**COONa(s) to form CH**4**.

 2. **Eth**ane is prepared from the heating of a mixture of sodium **prop**anoate and soda lime and collecting over water

Sodium **prop**anoate + soda lime **eth**ane + Sodium carbonate

CH3 CH2COONa(s) + NaO**H**(s) CH3 CH3 + Na2CO3(s)

The “H” in NaO**H** is transferred/moves to the CH3 CH2in CH3 CH2COONa (s) to form CH3 CH**3**

Laboratory set up for the preparation of alkanes



**Properties of alkanes**

**I. Physical properties**

* Alkanes are colourless gases, solids and liquids that are not poisonous.
* They are slightly soluble in water.
* The solubility decrease as the carbon chain/the molar mass increase
* The melting and boiling point increase as the carbon chain increase.
* This is because of the increase in van-der-waals /intermolecular forces as the carbon chain increase.
* The 1st four straight chain alkanes (methane, ethane, propane and butane) are therefore gases, the next six (pentane, hexane, heptane, octane, nonane, and decane) are liquids while the rest from unidecane (11 carbon atoms) are solids.
* The density of straight chain alkanes increase with increasing carbon chain as the intermolecular forces increases.

**Summary of physical properties of alkanes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Alkane | General formula | Melting point(K) | Boiling point(K) | Density gcm-3 | State at room(298K) temperature and pressure atmosphere (101300Pa)  |
| Methane | CH4 | 90 | 112 | 0.424 | gas |
| Ethane | CH3CH3 | 91 | 184 | 0.546 | gas |
| Propane | CH3CH2CH3 | 105 | 231 | 0.501 | gas |
| Butane | CH3(CH2)2CH3 | 138 | 275 | 0.579 | gas |
| Pentane | CH3(CH2)3CH3 | 143 | 309 | 0.626 | liquid |
| Hexane | CH3(CH2)4CH3 | 178 | 342 | 0.657 | liquid |
| Heptane | CH3(CH2)5CH3 | 182 | 372 | 0.684 | liquid |
| Octane | CH3(CH2)6CH3 | 216 | 399 | 0.703 | liquid |
| Nonane | CH3(CH2)7CH3 | 219 | 424 | 0.708 | liquid |
| Octane | CH3(CH2)8CH3 | 243 | 447 | 0.730 | liquid |

**II. Chemical properties**

1. **Burning/ combustion.**
* Alkanes burn with a **blue**/non-luminous flame in **excess** air to form carbon (IV) oxide and water.

 Alkane + Air carbon (**IV**) oxide + water (excess air/oxygen)

* Alkanes burn with a **blue**/**no-sooty**/ flame in **limited** air to form carbon (II) oxide and water.

 Alkane + Air carbon(**II**) oxide + water (limited air)

Examples

1. (a) Methane when ignited burns with a blue non sooty flame in excess air to form carbon(IV) oxide and water.

**CH4(g) + 2O2(g) CO2(g) + 2H2O(l/g)**

 (b) Methane when ignited burns with a blue non sooty flame in limited air to form carbon(II) oxide and water.

**2CH4(g) + 3O2(g) 2CO(g) + 4H2O(l/g)**

1. (a) Ethane when ignited burns with a **blue** **non** **sooty** flame in **excess** air to form carbon(IV) oxide and water.

**2C2H6(g) + 7O2(g) 4CO2(g) + 6H2O(l/g)**

 (b) Ethane when ignited burns with a **blue** **non** **sooty** flame in **limited** air to form carbon (II) oxide and water.

**2C2H6(g) + 5O2(g) 4CO(g) + 6H2O(l/g)**

1. (a) Propane when ignited burns with a **blue** **non** **sooty** flame in **excess** air to form carbon (IV) oxide and water.

**C3H8(g) + 5O2(g) 3CO2(g) + 4H2O(l/g)**

 (b) Ethane when ignited burns with a **blue** **non** **sooty** flame in **limited** air to form carbon (II) oxide and water.

**2C3H8(g) + 7O2(g) 6CO(g) + 8H2O(l/g)**

**ii) Substitution**

* Substitution reaction is one in which a hydrogen atom is replaced by a halogen in presence of ultraviolet light (**catalyst**).
* Alkanes react with halogens in presence of ultraviolet light to form halogenoalkanes.
* During substitution:
1. The halogen molecule is split into free atom/radicals.
2. One free halogen radical/atoms knock /remove one hydrogen from the alkane leaving an alkyl radical.
3. The alkyl radical combine with the other free halogen atom/radical to form halogenoalkane.
4. The chlorine atoms substitute repeatedly in the alkane. Each substitution removes a hydrogen atom from the alkane and form hydrogen halide.
5. Substitution stops when all the hydrogen in alkanes are replaced with halogens.

**Examples of substitution reactions**

Methane has no effect on bromine or chlorine in diffused light/dark. In sunlight, a mixture of chlorine and methane explode to form colourless mixture of chloromethane and hydrogen chloride gas. The pale green colour of chlorine gas fades.

Chemical equation

1. **CH4(g) + Cl2(g) CH3Cl (g) + HCl (g)**
2. Chloromethane + chlorine dichloromethane + Hydrogen chloride

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

1. dichloromethane + chlorine trichloromethane + Hydrogen chloride

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

1. trichloromethane + chlorine tetrachloromethane + Hydrogen chloride

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

**Uses of alkanes**

1. Most alkanes are used as fuel e.g. Methane is used as biogas in homes. Butane is used as the Laboratory gas.

2. On cracking, alkanes are a major source of Hydrogen for the manufacture of ammonia/Haber process.

3. In manufacture of Carbon black which is a component in printers ink.

4.In manufacture of useful industrial chemicals like methanol, methanol, and chloromethane.

**(ii) Alkenes**

**(a)Nomenclature/Naming**

* These are hydrocarbons with a general formula **CnH2n** and have at least a **( C C)** double bond as the functional group .
* The carbon atoms are linked by at least one **double** bond to each other and single bonds to hydrogen atoms.

They include:

|  |  |  |  |
| --- | --- | --- | --- |
| n | Molecularformula | Condensed structural formula | Name |
| 2 | C2H6 |  CH2 CH2  | Eth**ene** |
| 3 | C3H8 |  CH2 CH CH3 | Prop**ene** |
| 4 | C4H10 |  CH2 CH CH2CH3 | But**ene** |
| 5 | C5H12 |  CH2 CH (CH2)2CH3 | Pent**ene** |
| 6 | C6H14 |  CH2 CH (CH2)3CH3 | Hex**ene** |
| 7 | C7H16 |  CH2 CH (CH2)4CH3 | Hept**ene** |
| 8 | C8H18 |  CH2 CH (CH2)5CH3 | Oct**ene** |
| 9 | C9H20 |  CH2 CH (CH2)6CH3 | Non**ene** |
| 10 | C10H22 |  CH2 CH (CH2)7CH3 | dec**ene** |

**Note**

* One member of the alkene, like alkanes, differs from the next/previous by a CH2 group. They also form a homologous series.

 e.g

Propene differs from ethene by one carbon and two Hydrogen atoms from ethene.

A homologous series of alkenes like that of alkanes:

 (i) Differ by a CH2 group from the next /previous consecutively

 (ii) Have similar chemical properties

 (iii) Have similar chemical formula represented by the general formula CnH2n

(iv) The physical properties also show steady gradual change

* The = C= C = double bond in alkene is the functional group. A functional group is the **reacting site** of a compound.
* The = C= C = double bond in alkene can easily be broken to accommodate more two more monovalent atoms.
* The = C= C = double bond in alkenes make it thus **unsaturated.**
* Most of the reactions of alkenes take place at the = C **=** C =bond.

**(b)Isomers of alkenes**

* Isomers are alkenes lie alkanes have the same molecular general formula but different molecular structural formula.
* Ethene and propene do not form isomers. Isomers of alkenes are also named by using the IUPAC (International Union of Pure and Applied Chemistry) system of naming.

 The IUPAC system of nomenclature of naming alkenes uses the following basic rules/guidelines:

* **Alkene exhibit two types of isomerism:**
1. branching isomerism
* Chain/branch isomers are compounds having the same general formula but different structural formula e.g

Butene and 2-methyl propene both have the same general formualr but different branching chain.

1. positional isomerism
* Position isomers can be formed when the=C = C= double bond is shifted between carbon atoms e.g.

But-2-ene means the double =C = C= is between Carbon “2”and “3”

But-1-ene means the double =C = C= is between Carbon “1”and “2”

Both But-1-ene and But-2-ene are position isomers of Butene

**Practice on IUPAC nomenclature of alkenes**

Name the following isomers of alkene

H2C CHCH2 CH2 CH3 pent -1- ene

H2C C(CH3)CH2 CH2 CH3 2-methylpent -1- ene

H2C C(CH3)C(CH3)2 CH2 CH3 2,3,3-trimethylpent -1- ene

H2C C(CH3)C(CH3)2 C(CH3)2 CH3 2,3,3,4,4-pentamethylpent -1- ene

H3C C(CH3)C(CH3) C(CH3)2 CH3 2,3,4,4-tetramethylpent -2- ene

 H2C CBrCBr CBr CH3 2,3,4-tribromopent -1,3- diene

H2C CHCH CH2 But -1,3- diene

 H2C C(CH3)C(CH3) CH2 2,3-dimethylbut -1,3- diene

**Occurrence and extraction**

* At indusrial level,alkenes are obtained from the cracking of alk**a**nes.
* Cracking is the process of breaking long chain alkanes to smaller/shorter alk**a**nes, an alk**e**ne and hydrogen gas at high temperatures.
* Cracking is a major source of useful hydrogen gas

**Examples**

1. When irradiated with high energy radiation,Propane undergo cracking to form methane gas, ethene and hydrogen gas.

Chemical equation

**CH3CH2CH3 (g) CH4(g) + CH2=CH2(g) + H2(g)**

1. Octane undergo cracking to form hydrogen gas, butene and butane gases

Chemical equation

**CH3(CH2) 6 CH3 (g) CH3CH2CH2CH3(g) + CH3 CH2CH=CH2(g) + H2(g**

**School laboratory preparation of alk**e**nes**

* In a school laboratory, alk**e**nes may be prepared from dehydration of alkanols using:

(i) concentrated sulphuric(VI)acid(H2SO4).

(ii) aluminium(III)oxide(Al2O3) i.e

Alkanol Conc. H2SO4 Alkene + Water

 Alkanol Al2O3 Alkene + Water

1.(a) At about 180oC,concentrated sulphuric(VI)acid dehydrates/removes water from ethanol to form eth**e**ne. The gas produced contains traces of carbon (IV) oxide and sulphur (IV) oxide gas as impurities.

It is thus passed through concentrated sodium/potassium hydroxide solution to remove the impurities.

Chemical equation

**CH3CH2OH (l) conc H2SO4/180oC CH2=CH2(g) + H2O(l)**

(b) On heating strongly aluminium(III)oxide(Al2O3),it dehydrates/removes water from ethanol to form eth**e**ne.

Chemical equation

**CH3CH2OH (l) (Al2O3/strong heat CH2=CH2(g) + H2O(l)**

Laboratory set up for the preparation of alk**e**nes/**ethene**

**Caution**

1. Ethanol is highly inflammable
2. Conc H2SO4 is highly corrosive on skin contact.
3. Common school thermometer has maximum calibration of 110oC and thus cannot be used. It breaks/cracks.

**(i)Using conentrated sulphuric(VI)acid**



* Some broken porcelain or sand should be put in the flask when heating to:
1. prevent bumping which may break the flask.
2. ensure uniform and smooth boiling of the mixture
* The temperatures should be maintained at above160oC.

At lower temperatures another compound -**ether** is predominantly formed instead of ethene gas**.**

**(ii)Using aluminium(III)oxide**



**(e)Properties of alk**e**nes**

 **I. Physical properties**

* Like alk**a**nes, alk**e**nes are colourles gases, solids and liquids that are not poisonous.
* They are slightly soluble in water.
* The solubility in water decrease as the carbon chain and as the molar mass increase but very soluble in organic solvents like tetrachloromethane and methylbenzene.
* The melting and boiling point increase as the carbon chain increase.
* This is because of the increase in van-der-waals /intermolecular forces as the carbon chain increase.
* The density of straight chain alk**e**nes, like alkanes, increase with increasing carbon chain as the intermolecular forces increases.

**Summary of physical properties of the 1st five alkenes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Alk**e**ne | General formula | Melting point(oC) | Boiling point(K) | State at room temperature  |
| Eth**e**ne | CH2CH2 | -169 | -104 | gas |
| Prop**e**ne | CH3 CHCH2 | -145 | -47 | gas |
| But**e**ne | CH3CH2 CHCH2 | -141 | -26 | gas |
| Pent-1-**e**ne | CH3(CH2 CHCH2 | -138 | 30 | liquid |
| Hex-1-**e**ne | CH3(CH2) CHCH2 | -98 | 64 | liquid |

**II. Chemical properties**

1. **Burning/combustion**

Alkenes burn with a yellow, luminous/sooty flame in excess air to form carbon (IV) oxide and water.

Alk**e**ne + Air carbon (**IV**) oxide + water

Alkenes burn with a yellow/ luminous sooty/ flame in limited air to form carbon (II) oxide and water.

Alk**e**ne + Air carbon (**II**) oxide + water

**Examples of burning alkenes**

1. Ethane

**C2H4(g) + 3O2(g) 2CO2(g) + 2H2O(l)**

 excess

**C2H4(g) + 3O2(g) 2CO2(g) + 2H2O(l)**

 **limited**

b. propene

 **2C3H6(g) + 9O2(g) 6CO2(g) + 6H2O(l/g)**

 excess

**C3H6(g) + 3O2(g) 3CO(g) + 3H2O(l/g)**

 limited

1. **Addition reactions**
* An addition reaction is one which an unsaturated compound reacts to form a saturated compound. Addition reactions of alkenes are named from the reagent used to convert the double =C=C= to single C-C bond.
1. **Hydrogenation**
* Hydrogenation is an addition reaction in which **hydrogen** in presence of **Palladium/Nickel** catalyst at high temperatures react with alk**e**nes to form alk**a**nes.

**Examples**

1. When Hydrogen gas is passed through liquid vegetable and animal **oil** at about 180oC in presence of Nickel catalyst, solid **fat** is formed.
* Hydrogenation is thus used to **harden** oils to solid fat especially margarine.

Chemical equation

H2C=CH2 + H2  Ni/Pa H3C - CH3

 H H H H

 C = C + H – H - Ni/Pa H - C – C - H

 H H H H

1. Prop**e**ne undergo hydrogenation to form Propane
2. Both But-1-**e**ne and But-2-**e**ne undergo hydrogenation to form Butane

 **(ii) Halogenation.**

* Halogenation is an addition reaction in which a halogen (Fluorine, chlorine, bromine, iodine) reacts with an alk**e**ne to form an alkane.
* The double bond in the alk**e**nes breaks and forms a single bond.
* The colour of the halogen **fades** as the number of moles of the halogens remaining unreacted reduces.

**Examples**

1 Ethene reacts with bromine to form 1,2-dibromoethane.

Chemical equation

H2C=CH2 + Br2  H2 Br C - CH2 Br

 Ethene + Bromine 1,2-dibromoethane

2. Propene reacts with chlorine to form 1,2-dichloropropane.

Chemical equation

H3C CH=CH2 + Cl2  H3C CHCl - CH2Cl

Propene + Chlorine 1,2-dichloropropane

3. Both But-1-**e**ne and But-2-**e**ne undergo halogenation with iodine to form 1,2-diiodobutane and 2,3-diiodobutane

4. But-1,3-di**e**ne should undergo halogenation to form Butane. The reaction uses **two** moles of iodine molecules/**four** iodine atoms to break the two double bonds.

 **(iii) Reaction with hydrogen halides.**

**Hydrogen halides** react with alk**e**ne to form a halogenoalkane. The double bond in the alk**e**ne breaks and forms a single bond.

* The main compound is one which the **hydrogen** atom bond at the carbon with **more** **hydrogen** .

Examples

1. Ethene reacts with hydrogen bromide to form bromoethane.

Chemical equation

H2C=CH2 + HBr H3 C - CH2 Br

 **(iv) Reaction with bromine/chlorine water.**

Chlorine and bromine water is formed when the halogen is dissolved in distilled water.

* Chlorine water has the formular HOCl (hypochlorous/chloric (I)acid) .
* Bromine water has the formular HOBr (hydrobromic(I)acid).

During the addition reaction, the halogen move to one carbon and the OH to the other carbon in the alkene at the =C=C= double bond to form a **halo-alkanol.**

Bromine water + Alkene bromoalkan**o**l

Chlorine water + Alkene bromoalkan**o**l

**Examples**

1 Ethene reacts with bromine water to form bromoethan**ol**.

Chemical equation

H2C=CH2 + HOBr H2 Br C - CH2 OH

2. Propene reacts with chlorine water to form chloropropan-2-ol / 2-chloropropan-1-ol.

Chemical equation

H3C CH=CH2 + HOCl H3C CHCl - CH2OH

Propene Chlorine water 2-chloropropanol

**(v) Oxidation.**

* Alkenes are oxidized to alkanols.
* When an alk**e**ne is bubbled into orange acidified potassium dichromate (VI) solution, the colour of the oxidizing agent changes to green.
* When an alk**e**ne is bubbled into purple acidified potassium/ manganate(VII) solution, the oxidizing agent is decolorized.

**Examples**

1. Ethene is oxidized to ethan-1,2-di**ol** by acidified potassium manganate (VII) solution/ acidified potassium dichromate(VI) solution.
* The purple acidified potassium manganate (VII) solution is decolorized.
* The orange acidified potassium dichromate (VI) solution turns to green.

Chemical equation

 **OH OH**

 **H2C=CH2 [O] CH2 - CH2**

 ethan-1,2-di**ol**

 **(v) Hydrolysis.**

* Hydrolysis is the reaction of a compound with water/addition of H-OH to a compound.
* Alkenes undergo hydrolysis to form alkanols .
* This takes place in two steps:
1. Alkenes react with concentrated sulphuric(VI)acid at room temperature and pressure to form **alkylhydrogen sulphate**.
2. On adding **water** to alkylhydrogen sulphate, then warming, an alkanol is formed.

**Examples**

(i)Ethene reacts with cold concentrated sulphuric(VI)acid to form ethyl hydrogen sulphate(VII)

Chemical equation

 **H2C=CH2 + H2SO4  CH3 - CH2OSO3H**

 H H H O-SO3H

 C = C  **+** H2SO4  H - C – C - H

 H H H H

 Ethene  ethylhydrogen sulphate

(ii) Ethylhydrogen sulphate(VI) is hydrolysed by water to ethanol

Chemical equation

 **CH3 - CH2OSO3H + H2O CH3 - CH2OH + H2SO4**

 H OSO3H H OH

 H - C - C - H  **+** H2O H- C – C - H + H2SO4

 H H H H

ethylhydrogen sulphate Ethanol

2. Propene reacts with cold concentrated sulphuric(VI)acid to form propyl hydrogen sulphate(VII)

Chemical equation

CH3H2C=CH2  **+** H2SO4  CH3CH2 - CH2OSO3H

 H H H H H O-SO3H

 C = C - C - H **+** H2SO4  H - C - C – C - H

 H H H H H H

 Propene  propylhydrogen sulphate

(ii) Propylhydrogen sulphate(VI) is hydrolysed by water to propanol

Chemical equation

CH3 - CH2OSO3H  **+** H2O CH3 - CH2OH + H2SO4

 H H OSO3H H H OH

H - C - C - C - H  **+** H2O H - C - C – C - H + H2SO4

 H H H H H H

propylhydrogen sulphate propanol

**(vi) Polymerization or self addition**

* Addition polymerization is the process where a small unsaturated monomer (alkene ) molecule join together to form a large saturated molecule.
* **Only alkenes undergo addition polymerization.**
* During addition polymerization
1. The double bond in alkenes break
2. Free radicals are formed
3. The free radicals collide with each other and join to form a larger molecule. The more collisions the larger the molecule.

**Examples of addition polymerization**

1.Formation of Polyethene

* Polyethene is polymer formed when ethene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.
* During polymerization:
1. many molecules are brought nearer to each other by the high pressure(which reduces the volume occupied by reacting paticles
2. the double bond joining the ethane molecule break to free readicals
3. the free radicals collide with each other and join to form a larger molecule

Since the molecule is a **repetition** of one monomer, then the polymer is:

 H H

 C – C

 n

 H H

* Where **n** is the number of monomers in the polymer.
* The number of monomers in the polymer can be determined from the molar mass of the polymer and monomer from the relationship:
* Number of monomers/repeating units in monomer = Molar mass polymer

 Molar mass monomer

**Examples**

**Polythene has a molar mass of 4760.Calculate the number of ethene molecules in the polymer(C=12.0, H=1.0 )**

Number of monomers/repeating units in polyomer = Molar mass polymer

 Molar mass monomer

 Substituting 4760 = 170 ethene molecules

 28

* The **commercial** name of polyethene is **polythene**.
* It is an elastic, tough, transparent and durable plastic.
* Polythene is used:
1. in making plastic bag
2. bowls and plastic bags
3. packaging materials

2.Formation of Polychlorethene

Polychloroethene is an addition polymer formed when chloroethene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.

During polymerization:

 H H H H

 n C = C C – C

H **Cl** H Cl n

 **Chlorethene** **Polychlorothene**

**Test for the presence of – C = C – double bond.**

**(i)Burning/combustion**

* All unsaturated hydrocarbons with a **C = C** bond burn with a yellow sooty flame.

 **(ii)Oxidation by acidified KMnO4/K2Cr2O7**

Bromine water, Chlorine water and Oxidizing agentsacidified KMnO4/K2Cr2O7change to **unique** colour in presence of **C = C**

Experiment

* Scoop a sample of the substance provided into a clean test tube. Add 10cm3 of distilled water. Shake. Take a portion of the solution mixture. Add three drops of acidified KMnO4/K2Cr2O7 .

|  |  |
| --- | --- |
|  Observation |  Inference |
| Acidified KMnO4 decolorizedOrange colour of acidified K2Cr2O7turns greenBromine water is decolorizedChlorine water is decolorized | **– C = C –****– C = C –** bond |

**Some uses of Alkenes**

1. In the manufacture of plastic

2. Hydrolysis of eth**e**ne is used in industrial manufacture of ethanol.

3. In ripening of fruits.

4. In the manufacture of detergents.

**(iii) Alkynes**

**(a)Nomenclature/Naming**

* These are hydrocarbons with a general formula **CnH2n**-**2** and **C C** triple bond as the functional group.

They include:

|  |  |  |  |
| --- | --- | --- | --- |
| n | Molecularformula | Structural formula | Name |
| 2 | C2H2 |  CH CH | Eth**y**ne |
| 3 | C3H4 |  CH C CH3 | Prop**y**ne |
| 4 | C4H6 |  CH C CH2CH3 | But**y**ne |
| 5 | C5H8 |  CH C (CH2)2CH3 | Pent**y**ne |
| 6 | C6H10 |  CH C (CH2)3CH3 | Hex**y**ne |

**Note**

* One member of the alk**y**ne ,like alk**e**nes and alk**a**nes, differ from the next/previous by a CH2  group(molar mass of 14 **a**tomic **m**ass **u**nits).They thus form a homologous series.
* A homologous series of alkenes like that of alkanes:
1. differ by a CH2  group from the next /previous consecutively
2. have similar chemical properties
3. have similar chemical formula with general formula CnH2n-2
4. the physical properties also show steady gradual change
* The - C C - triple bond in alk**y**ne is the functional group. The functional group is the **reacting site** of the alk**y**nes.
* The  triple bond in alk**y**nes make it thus **unsaturated** like alkenes**.**

**Isomers of alkynes**

Isomers of alkynes have the same molecular general formula but different molecular structural **formula**.

Naming of branching isomers

* Identify the longest continuous/straight carbon chain which contains the **C C**  **triple** bond to get/determine the **parent** alkene.
* Number the longest chain from the end of the chain which contains the  **triple** bond so as triple bond get lowest number possible.
* Indicate the positions by splitting “**alk**-position-**yne**” e.g. but-2-**y**ne, pent-1,3-di**y**ne.
* The position **indicated** must be for the carbon atom at the **lower** position in the  **triple bond.** i.e
* But-2-**y**ne means triple at Carbon “2”and “3”
* Pent-1,3-di**y**ne means two triple bonds; one between carbon “1” and “2”and between carbon “3” and “4”
* Determine the position, number and type of branches.
* Name them as methyl, ethyl, propyl e.tc. according to the number of alkyl carbon chains attached to the alk**y**ne.
* Name them fluoro-,chloro-,bromo-,iodo- if they are halogens
1. H3C CH(CH3)C(CH3)2 CCH 3,3,4-trimethylpent -1- yne
2. HC C C(CH3)2 C(CH3)2 CH3  3,3,4,4-tetramethylpent -1- yne
3. H3C C(CH3) 2C C CH3  4,4-dimethylpent -2- yne
4. HC CC(CH3) 2 C CH3  3,3,-dimethylpent -1,4- diyne
5. BrC CC C CH3  1-bromopent -1,3- diyne

Naming of positional isomers

**Preparation of Alkynes.**

* Ethyne is prepared from the reaction of water on calcium carbide.
* The reaction is highly exothermic and thus a layer of sand should be put above the calcium carbide to absorb excess heat to prevent the reaction flask from breaking.
* Copper(II)sulphate(VI) is used to catalyze the reaction



Chemical equation

**CaC2(s) + 2 H2O(l) Ca(OH) 2 (aq) + C2H2 (g)**

**Properties of alkynes**

**I. Physical properties**

* Like alk**a**nes and alk**e**nes,alkynes are colourles gases, solids and liquids that are not poisonous.
* They are slightly soluble in water. The solubility in water decrease as the carbon chain and as the molar mass increase but very soluble in organic solvents like tetrachloromethane and methylbenzene.
* The melting and boiling point increase as the carbon chain increase.
* This is because of the increase in van-der-waals /intermolecular forces as the carbon chain increase.
* The density of straight chain alk**y**nes increase with increasing carbon chain as the intermolecular forces increases.

**Summary of physical properties of the 1st five alkenes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Alk**y**ne | General formula | Melting point(oC) | Boiling point(oC) | State at room(298K) temperature and pressure atmosphere (101300Pa)  |
| Eth**y**ne | CH CH | -82 | -84 | gas |
| Prop**y**ne | CH3 C CH | -103 | -23 | gas |
| But**y**ne | CH3CH2 CCH | -122 |  8 | gas |
| Pent-1-**y**ne | CH3(CH2) 2 CCH | -119 | 39 | liquid |
| Hex-1-**y**ne | CH3(CH2) 3C CH | -132 | 71 | liquid |

**II. Chemical properties**

1. **Burning/combustion**
* Alk**y**nes burn with a **yellow**/ luminous very **sooty flame** in **excess** air to form carbon (IV) oxide and water.

 Alk**y**ne + Air carbon (**IV**) oxide + water

* Alk**e**nes burn with a **yellow**/ luminous very **sooty** flame in **limited** air to form carbon (II) oxide/carbon and water.

 Alk**y**ne + Air carbon (**II**) oxide /carbon + water

* Burning of alkynes with a yellow/ luminous sooty/ flame is a confirmatory test for the presence of the triple bond because they have very high C:H ratio.

**Examples of burning alkynes**

1.(a) Eth**y**ne when ignited burns with a **yellow** **sooty** flame in **excess** air to form carbon (IV) oxide and water.

 **2C2H2(g) + 5O2(g) 4CO2(g) + 2H2O(l/g)**

 (b) Eth**y**ne when ignited burns with a **yellow** **sooty** flame in **limited** air to form a mixture of unburnt carbon and carbon (II) oxide and water.

 **C2H2(g) + O2(g) 2CO2(g) + C + 2H2O(l/g)**

1. **Addition reactions**
* An addition reaction is one which an unsaturated compound reacts to form a saturated compound.
* Addition reactions of alk**y**nes are also named from the reagent used to convert the triple to single C- C bond.
1. **Hydrogenation**
* Hydrogenation is an addition reaction in which hydrogen in presence of Palladium/Nickel catalyst at 150oC temperatures react with alkynes to form alkenes then alkanes.

Examples

1.During hydrogenation, **two** hydrogen atom in the hydrogen molecule attach itself to one carbon and the other **two** hydrogen to the second carbon breaking the **triple** bond to **double** then **single**.

Chemical equation

 **HC = CH + H2  -Ni/Pa H2C = CH2**

 **H2C = CH2 + H2  -Ni/Pa H3C - CH3**

**(ii) Halogenation.**

* Halogenation is an addition reaction in which a halogen (Fluorine, chlorine, bromine, iodine) reacts with an alk**y**ne to form an alkene then alkane.
* The triple bond in the alk**y**nes breaks and forms a double then single bond.
* The colour of the halogen **fades** as the number of moles of the halogens remaining unreacted decreases.
* Two bromine atoms bond at the 1st carbon in the triple bond while the other two goes to the 2nd carbon.

**Examples**

1Ethyne reacts with brown bromine vapour to form 1,1,2,2-tetrabromoethane.

Chemical equation

 BrBr

HC = CH + 2Br2  HC - CH

 Br Br

**(iii) Reaction with hydrogen halides.**

* **Hydrogen halides** react with alk**y**ne to form a haloalk**e**ne then haloalk**a**ne. The triple bond in the alk**y**ne breaks and forms a double then single bond.
* The main compound is one which the hydrogen atom bond at the carbon with **more** **hydrogen** .

Examples

1. Ethyne reacts with hydrogen bromide to form bromoethane.

Chemical equation

H C = C H + 2HBr H3 C - CH Br2

2 Prop**y**ne reacts with hydrogen iodide to form 2,2-diiodopropane (as the main product )

Chemical equation

H3C C = CH + 2HI H3C CHI2 - CH3

**ALKANOLS (Alcohols)**

**(A) INTRODUCTION.**

* Alkanols belong to a homologous series of organic compounds with a general formula **CnH2n +1 OH** and thus **-OH** as the functional group .
* The 1st ten alkanols include

|  |  |  |
| --- | --- | --- |
| n | General formular | IUPAC name |
| 1 | CH3OH |  Methan**ol** |
| 2 | CH3 CH2OHC2H5 OH | Ethan**ol** |
| 3 | CH3 (CH2)2OHC3H7 OH | Propan**ol** |
| 4 | CH3 (CH2)3OHC4H9 OH | Butan**ol** |
| 5 | CH3(CH2)4OHC5H11 OH | Pentan**ol** |
| 6 | CH3(CH2)5OHC6H13 OH | Hexan**ol** |
| 7 | CH3(CH2)6OHC7H15 OH | Heptan**ol** |
| 8 | CH3(CH2)7OHC8H17 OH | Octan**ol** |
| 9 | CH3(CH2)8OHC9H19 OH | Nonan**ol** |
| 10 | CH3(CH2)9OHC10H21 OH | Decan**ol** |

 **Isomers Of Alkanols.**

* Alkanols exhibit both structural and position isomerism. The isomers are named by using the following basic guidelines:
1. Like alkanes , identify the **longest** carbon chain to be the parent name.
2. Identify the position of the **-OH** functional group to give it the **smallest /lowest** position.
3. Identify the type and position of the sidebranches.

**Practice examples of isomers of alkanols**

1. **Isomers of propanol C3H7OH**

 CH3CH2CH2OH - Propan-1-ol

 OH

 CH3CHCH3 - Propan-2-ol

* Propan-2-ol and Propan-1-ol are position isomers because only the position of the –OH functional group changes.
1. **Isomers of Butanol C4H9OH**

 CH3 CH2 CH3 CH2 OH Butan-1-ol

 CH3 CH2 CH CH3

 OH Butan-2-ol

 CH3

 CH3 C CH3

 OH 2-methylpropan-2-ol

* Butan-2-ol and Butan-1-ol are position isomers because only the position of the -OH functional group changes.
* 2-methylpropan-2-ol is both a structural and position isomers because both the position of the functional group and the arrangement of the atoms in the molecule changes.
1. **Isomers of Pentanol C5H11OH**

CH3 CH2 CH2CH2CH2 OH Pentan-1-ol (Position isomer)

CH3 CH2 CH CH3

 OH Pentan-2-ol (Position isomer)

CH3 CH2 CH CH2 CH3

 OH Pentan-3-ol (Position isomer)

 CH3

CH3 CH2 CH2 C CH3

 OH 2-methylbutan-2-ol (Position /structural isomer)

 CH3

CH3 CH2 CH2 C CHOH

 CH3 2,2-dimethylbutan-1-ol (Position /structural isomer)

 CH3

CH3 CH2 CH C CH3

 CH3 OH 2,3-dimethylbutan-1-ol (Position /structural isomer)

**Draw the structure of the following compounds**

1. **1,2-dichloropropan-2-ol**

1. **1,2-dichloropropan-1-ol**
2. **Ethan1,2-diol**

1. **Propan1,2,3-triol**

**LABORATORY PREPARATION OF ALKANOLS.**

* Fermentation is the reaction where sugar is converted to alcohol/alkanol using biological catalyst/enzymes in **yeast.**
* It involves **three** processes:
1. Conversion of starch to maltose using the enzyme **diastase.**

 **(C6H10O5)n (s) + H2O(l)** diastase enzyme **C12H22O11(aq)**

 (Starch) (Maltose)

1. Hydrolysis of Maltose to glucose using the enzyme **maltase.**

**C12H22O11(aq)+ H2O(l)** maltase enzyme **2 C6H12O6(aq)**

 (Maltose) (glucose)

1. Conversion of glucose to ethanol and carbon (IV) oxide gas using the enzyme **zymase.**

**C6H12O6(aq**) zymase enzyme **2 C2H5OH(aq) + 2CO2(g)**

(glucose) (Ethanol)

* At concentration greater than 15% by volume, the ethanol produced kills the yeast enzyme stopping the reaction.
* To increases the concentration, fractional distillation is done to produce spirits (e.g. Brandy=40% ethanol).
* Methanol is much more poisonous /toxic than ethanol.
* Taken large quantity in small quantity it causes instant blindness and liver, killing the consumer victim within hours.

**Role of yeast**

Yeast is a single cell fungus which contains the enzyme maltase and zymase that catalyse the fermentation process.

**PHYSICAL AND CHEMICAL PROPERTIES OF ALKANOLS**

1. **Effects on litmus paper**

|  |  |
| --- | --- |
| **Substance/alkanol** | **Effect on litmus paper** |
| Prepared sample | Blue litmus paper remain blueRed litmus paper remain red |
| Absolute ethanol | Blue litmus paper remain blueRed litmus paper remain red |
| Methylated spirit | Blue litmus paper remain blueRed litmus paper remain red |

Explanation

Alkanols are neutral compounds/solution that have characteristic sweet smell and taste.

They have no effect on both blue and red litmus papers.

1. **Solubility in water.**

Observation

**No layers** formed between the two liquids.

Explanation

* Ethanol is **miscible** in water.
* Both ethanol and water are polar compounds.
* The solubility of alkanols decrease with increase in the alkyl chain/molecular mass.

The alkyl group is insoluble in water while –OH functional group is soluble in water.

As the molecular chain becomes **longer**, the effect of the **alkyl** group **increases** as the effect of the functional group **decreases (**polarity decreases**)**.

1. **Melting/boiling point.**
* Pure ethanol has a boiling point of 78oC at sea level/one atmosphere pressure.

Explanation

The melting and boiling point of alkanols increase with increase in molecular chain/mass .

This is because the intermolecular/van-der-waals forces of attraction between the molecules increase.

More heat energy is thus required to weaken the longer chain during melting and break during boiling.

1. **Density**
* Density of alkanols increase with increase in the intermolecular/van-der-waals forces of attraction between the molecules, making it very close to each other.

This reduces the volume occupied by the molecule and thus increases the mass per unit volume (density).

**Summary table showing the trend in physical properties of alkanols**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Alkanol | Melting point(oC) | Boiling point(oC) | Densitygcm-3 | Solubility in water |
| Methanol | -98 | 65 | 0.791 | soluble |
| Ethanol | -117 | 78 | 0.789 | soluble |
| Propanol | -103 | 97 | 0.803 | soluble |
| Butanol | -89 | 117 | 0.810 | Slightly soluble |
| Pentanol | -78 | 138 | 0.814 | Slightly soluble |
| Hexanol | -52 | 157 | 0.815 | Slightly soluble |
| Heptanol | -34 | 176 | 0.822 | Slightly soluble |
| Octanol | -15 | 195 | 0.824 | Slightly soluble |
| Nonanol | -7 | 212 | 0.827 | Slightly soluble |
| Decanol | 6 | 228 | 0.827 | Slightly soluble |

 **Chemical properties**

1. **Burning**
* Pure ethanol and methylated spirit easily catch fire / highly flammable.
* They burn with an almost colourless non-sooty/ **blue** flame to form **carbon (IV) oxide** (in excess air/oxygen)or **carbon(II) oxide** (limited air) and **water**.
* Ethanol is thus a **saturated** compound like alkanes.

Chemica equation

C2 H5OH(l) + 3O2 (g) 3H2O(l) + 2CO2 (g) ( excess air)

C2 H5OH(l) + 2O2 (g) 3H2O(l) + 2CO (g) ( limited air)

 2CH3OH(l) + 3O2 (g) 4H2O(l) + 2CO2 (g) ( excess air)

Due to its flammability, ethanol is used;

1. as a fuel in spirit lamps
2. as gasohol when blended with gasoline
3. **Reaction with metals/Formation of alkoxides**

Experiment

* Cut a very small piece of sodium. Put it in a beaker containing about 20cm3 of the prepared sample in a beaker.
* Test the products with litmus papers. Repeat with absolute ethanol and methylated spirit.

Sample observations

|  |  |
| --- | --- |
| Substance/alkanol | Effect of adding sodium |
|   Ethanol  | 1. effervescence/fizzing/bubbles
2. colourless gas produced that extinguish burning splint with explosion/ “Pop” sound
3. colourless solution formed
4. blue litmus papers remain blue
5. red litmus papers turn blue
 |

Explanations

* Metals reacts slowly with alkanols to form basic solution called **alkoxides** and producing hydrogengas.
* If the alkanol has some water the metals react faster with the water to form **alkalis** i.e.

Sodium + Alkanol Sodium **alk**oxides + Hydrogen gas

Potassium + Alkanol Potassium **alk**oxides + Hydrogen gas

NB/ The alkoxide salt hydrolyses in water to generate –OH which makes the solution alkaline

**Examples**

1. Sodium metal reacts with ethanol to form sodium **eth**oxide

**2CH3CH2OH(l) + 2Na(s) 2CH3CH2ONa (aq) + H2 (s)**

1. Potassium metal reacts with ethanol to form Potassium **eth**oxide

**2CH3CH2OH(l) + 2K(s) 2CH3CH2OK (aq) + H2 (s)**

1. **Formation of Esters/Esterification**

|  |  |
| --- | --- |
| **Substance/alkanol** | **Effect on adding equal amount of ethanoic acid in presence of conc. Sulphuric (VI)acid** |
| Absolute ethanol | Sweet fruity smell |
| Methanol | Sweet fruity smell |

Explanation

* Alkanols react with alkanoic acids to form a group of homologous series of sweet smelling compounds called esters and water.
* This reaction is catalyzed by concentrated sulphuric(VI)acid in the laboratory.

Alkanol + Alkanoic acid Conc. H2SO4 Ester + water

* Esters derive their names from the alkanol first then alkanoic acids. The alkanol “becomes” an **alkyl** group and the alkanoic acid “becomes” **alkanoate** hence **alkylalkanoate**. e.g.

 Ethanol + Ethanoic acid Ethylethanoate + Water

 Ethanol + Propanoic acid Ethylpropanoate + Water

* During the formation of the ester, the “O” joining the alkanol and alkanoic acid comes from the alkanol.

 R1 -CO**OH** + R2 –O**H** **R1 -COO –R2** + **H2O**

e.g.

Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate and water.

 C2H5OH (l) + CH3COOH(l) Conc. H2SO4 CH3COO C2H5(**aq**)+H2O(l)

1. **Oxidation**

|  |  |  |  |
| --- | --- | --- | --- |
| Substance/alkanol | Adding acidified KMnO4/K2Cr2O7 | pH of resulting solution/mixture | Nature of resulting solution/mixture |
| Pure ethanol | (i) Purple colour of KMnO4 decolorized(ii) Orange colour of K2Cr2O7 turns green. | pH= 4/5/6pH = 4/5/6 | Weakly acidicWeakly acidic |

**Explanation**

* Both acidified KMnO4 and K2Cr2O7 are oxidizing agents (add oxygen to other compounds. They oxidize alkanols to a group of homologous series called alkanals then further oxidize them to alkanoic acids.
* The oxidizing agents are themselves reduced hence changing their colour:

 (i) Purple KMnO4 is reduced to colourless Mn2+

 (ii)Orange K2Cr2O7is reduced to green Cr3+

The pH of alkanoic acids show they have few H+ because they are weak acids i.e

Alkanol + [O] alkanoic acid

 **NB** The [O] comes from the oxidizing agents acidified KMnO4 or K2Cr2O7

Examples

1. When ethanol is warmed with three drops of acidified KMnO4 there is decolorization of KMnO4

CH3CH2OH + [O] CH3COOH

1. When methanol is warmed with three drops of acidified K2Cr2O7 ,the orange colour of acidified K2Cr2O7 changes to green.

 CH3OH + [O] HCOOH

5. **Hydrolysis /Hydration and Dehydration**

**I. Hydrolysis/Hydration** is the reaction of a compound/substance with water.

Alkenes react with water vapour/steam at high temperatures and high pressures in presence of phosphoric acid catalyst to form alkanols.i.e.

 Alkenes + Water H3PO4 catalyst Alkanol

 60 atm/300oC

**Examples**

1. H2C =CH2 (g) + **H2O**(l) 60 atm/300oC/ H3PO4 CH3 C**H2O**H(l)
2. CH3 CH2 C=CH2 (g) + **H2O**(l) 60 atm/300oC/ H3PO4  CH3 CH2 CH2 C**H2O**H(l)

**II. Dehydration** is the process which concentrated sulphuric(VI)acid (**dehydrating agent**) removes water from a compound/substances.

Concentrated sulphuric(VI)acid dehydrates alkanols to the corresponding alkenes at about 180oC.

Examples

1. At 180oC and in presence of Concentrated sulphuric(VI)acid, ethanol undergoes dehydration to form ethene.

 CH3 C**H2O**H(l)180oC/ H2SO4  H2C =CH2 (g) + **H2O**(l)

2. Propanol undergoes dehydration to form propene.

 CH3 CH2 C**H2O**H(l) 180oC/ H2SO4  CH3CH =CH2 (g) + **H2O**(l)

 **Similarities of alkanols with Hydrocarbons**

 **I.** Similarity with alkanes

* Both alkanols and alkanes burn with a **blue non-sooty flame** to form carbon (IV) oxide(in excess air/oxygen)/carbon(II)oxide(in limited air) and water. This shows they are saturated with high C:H ratio. e.g.

**II.** Similarity with alkenes/alkynes

Both alkanols (R-OH) and alkenes/alkynes

1. Decolorize acidified KMnO4
2. Turns Orange acidified K2Cr2O7 to green.
* Alkan**o**ls (R-**OH**) are oxidized to alkan**oic** acids(R-**OOH**).
* Alkenes are oxidized to alkanols with double –OH functional groups.

**III.** Differences with alkenes/alkynes

* Alkanols do not decolorize bromine and chlorine water.
* Alkenes decolorizes bromine and chlorine water to form halogenoalkanols

**IV.** Differences in melting and boiling point with Hydrocarbons

* Alkanos have higher melting point than the corresponding hydrocarbon (alkane/alkene/alkyne)
* This is because most alkanols exist as **dimer.** A dimer is a molecule made up of two other molecules joined usually by van-der-waals forces/hydrogen bond or dative bonding.
* Two alkanol molecules form a dimer joined by hydrogen bonding.

**Example**

* In Ethanol the oxygen atom attracts the shared electrons in the covalent bond more to itself than Hydrogen.
* This creates a partial negative charge (δ-) on oxygen and partial positive charge (δ+) on hydrogen.
* Two ethanol molecules attract each other at the partial charges through Hydrogen bonding forming a **dimme**r.

 H H H

Hydrogen bonds

Covalent bonds

 H C C O H H

 H H H O C C H

 H H

* Dimerization of alkanols means more energy is needed to break the Hydrogen bonds before breaking the intermolecular forces joining the molecules of all organic compounds during boiling/melting.

**USES OF SOME ALKANOLS**

(a) Methanol is used as industrial alcohol and making methylated spirit

(b) Ethanol is used:

 1. as alcohol in alcoholic drinks e.g Beer, wines and spirits.

 2. as antiseptic to wash woulds

3. in manufacture of vanishes, ink, glue and paint because it is volatile and thus easily evaporate

 4. as a fuel when blended with petrol to make gasohol.

**ALKANOIC ACIDS (Carboxylic acids)**

* Alkanoic acids belong to a homologous series of organic compounds with a general formula **CnH2n +1 COOH** and thus -**COOH** as the functional group.
1. The general name of an alkanoic acids is derived from the alkane name then ending with “**–oic**” acid as the table above shows.
2. The members have R-**COOH** as the functional group.
3. They have the same general formula represented by R-COOH where R is an alkyl group.
4. Each member differs by –CH2- group from the next/previous.
5. They show a similar and gradual change in their physical properties e.g. boiling and melting point.
6. They show similar and gradual change in their chemical properties.
7. Since they are acids they show similar properties with mineral acids.

**(B) ISOMERS OF ALKANOIC ACIDS.**

Alkanoic acids exhibit both structural and position isomerism. The isomers are named by using the following basic guidelines

(i)Like alkanes, identify the longest carbon chain to be the parent name.

(ii)Identify the position of the - functional group to give it the smallest/lowest position.

 (iii)Identify the type and position of the side group branches.

**Practice examples on isomers of alkanoic acids**

1. Isomers of butanoic acid C3H7COOH

CH3 CH2 CH2 COOH

 Butan-1-oic acid

 CH3

H2C C COOH 2-methylpropan-1-oic acid

2-methylpropan-1-oic acid and Butan-1-oic acid are structural isomers because the position of the functional group does not change but the arrangement of the atoms in the molecule does.

1. Isomers of pentanoic acid C4H9COOH

CH3CH2CH2CH2 COOH pentan-1-oic acid

 CH3

 CH3CH2CH COOH 2-methylbutan-1-oic acid

 CH3

H3C C COOH 2,2-dimethylpropan-1-oic acid

 CH3

Name The Following

a. HOOC- COOH

b. HOOC- CH2COOH

c. HOOC CH2 CH2 COOH

**Laboratory Preparation of Alkanoic Acids.**

**In a school laboratory**, alkanoic acids can be prepared by adding an oxidizing agent (H+/KMnO4 or H+/K2Cr2O7) to the corresponding alkanol then warming.

R- CH2 – **OH** + [O] H+/KMnO4 R- C –**OOH** + H2O(l)

 (alkanol) (alkanoic acid)

Examples

1. Ethan**o**l on warming in acidified KMnO4 is oxidized to ethan**a**l then ethan**oic** acid .

**CH3- CH2 – OH + [O] H+/KMnO4 CH3- C –OOH + H2O(l)**

 (ethanol) (ethanoic acid)

1. Propan**o**l on warming in acidified KMnO4 is oxidized to propan**a**l then propan**oic** acid

**CH3- CH2- CH2 – OH + [O] H+/KMnO4 CH3- CH2- C**–**OOH + H2O(l)**

 (propanol) (propanoic acid)

 (Ethanol) (Ethanoic acid)

**PHYSICAL AND CHEMICAL PROPERTIES OF ALKANOIC ACIDS.**

1. **Physical properties of alkanoic acids**

The table below shows some physical properties of alkanoic acids

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Alkanol | Melting point(oC) | Boiling point(oC) | Density(gcm-3) | Solubility in water |
| Methanoic acid | 18.4 | 101 | 1.22 | soluble |
| Ethanoic acid | 16.6 | 118 | 1.05 | soluble |
| Propanoic acid | -2.8 | 141 | 0.992 | soluble |
| Butanoic acid | -8.0 | 164 | 0.964 | soluble |
| Pentanoic acid | -9.0 | 187 | 0.939 | Slightly soluble |
| Hexanoic acid | -11 | 205 | 0.927 | Slightly soluble |

**From the table note the following:**

1. Melting and boiling point decrease as the carbon chain increases due to increase in intermolecular forces of attraction between the molecules requiring more energy to separate the molecules.
2. The density decreases as the carbon chain increases as the intermolecular forces of attraction increases between the molecules making the molecule very close reducing their volume in unit mass.
3. Solubility decreases as the carbon chain increases as the soluble –COOH end is shielded by increasing insoluble alkyl/hydrocarbon chain.
4. Like alkanols ,alkanoic acids exist as dimmers due to the hydrogen bonds within the molecule. i.e..



1. **Chemical properties of alkanoic acids**
* The following experiments show the main chemical properties of ethanoic (alkanoic) acid.
1. **Effect on litmus papers**

|  |  |  |
| --- | --- | --- |
| Solution/acid | Observations/effect on litmus papers | Inference |
| Ethanoic acid | Blue litmus paper turn redRed litmus paper remain red | H3O+/H+(aq)ion |
| Citric acid | Blue litmus paper turn redRed litmus paper remain red | H3O+/H+(aq)ion |

Explanation

All acidic solutions contains H+/H3O+(aq) ions. The H+ /H3O+ (aq) ions is responsible for turning blue litmus paper/solution to red

1. **pH**

|  |  |  |
| --- | --- | --- |
| Solution/acid | pH | Inference |
| Ethanoic acid | 4/5/6 | Weakly acidic |
| Citric acid | 4/5/6 | Weakly acidic |

* Alkanoic acids are weak acids that partially/partly dissociate to release few H+ ions in solution. The pH of their solution is thus 4/5/6 showing they form weakly acidic solutions when dissolved in water.
* All alkanoic acid dissociate to releases the **“H”** at the functional group in -COO**H** to form the **alkanoate ion;** –COO**-**
1. **Reaction with metals**

|  |  |  |
| --- | --- | --- |
| **Solution/acid** | **Observations** | **Inference** |
| Ethanoic acid | 1. effervescence, fizzing, bubbles
2. colourless gas produced that burn with “pop” sound/explosion
 | H3O+/H+(aq)ion |

**Explanation**

* Metals higher in the reactivity series displace the hydrogen in all acids to evolve/produce hydrogen gas and form a salt.
* Alkanoic acids react with metals with metals to form alkanoates salt and hydrogen gas.
* Only the “H”in the functional group -COO**H** is displaced and not in the alkyl hydrocarbon chain.

**Examples**

1. For a monovalent metal with monobasic acid

 **2R – COOH + 2M 2R- COOM + 2H2(g)**

1. For a divalent metal with monobasic acid

 **2R – COOH + M (R- COO) 2M + H2(g)**

Examples

1. Sodium reacts with ethanoic acid to form sodium ethanoate and produce hydrogen gas.

 **CH3COOH (aq) + Na(s) CH3COONa (aq) + H2(g)**

 (Ethanoic acid) (Sodium ethanoate)

1. Calcium reacts with ethanoic acid to form calcium ethanoate and produce hydrogen gas.

 **2CH3COOH (aq) + Ca(s) (CH3COO) 2Ca (aq) + H2(g)**

 (Ethanoic acid) (Calcium ethanoate)

1. **Reaction with hydrogen carbonates and carbonates**

|  |  |  |
| --- | --- | --- |
| **Solution/acid** | **Observations** | **Inference** |
| Ethanoic acid | (i) effervescence, fizzing, bubbles(ii) colourless gas produced that forms a white precipitate with lime water | H3O+/H+(aq)ion |
| Succinic acid | (i) effervescence, fizzing, bubbles(ii) colourless gas produced that forms a white precipitate with lime water | H3O+/H+(aq)ion |

* All acids react with hydrogen carbonate/carbonate to form salt, water and bubbles of carbon (IV) oxide and water.
* Alkanoic acids react with hydrogen carbonate/carbonate to form alkanoates, water and bubbles of carbon (IV) oxide and water.

**Examples**

1. Sodium hydrogen carbonate reacts with ethanoic acid to form sodium ethanoate , water and carbon(IV)oxide gas.

**CH3COOH (aq) + NaHCO3 (s) CH3COONa (aq) + H2O(l) + CO2 (g)**

 (Ethanoic acid) (Sodium ethanoate)

1. **Esterification**
* Alkanols react with alkanoic acid to form the sweet smelling homologous series of esters and water.
* The reaction is catalysed by concentrated sulphuric(VI)acid in the laboratory but naturally by sunlight /heat.
* Each ester has a characteristic smell derived from the many possible combinations of alkanols and alkanoic acids.

Examples

1. Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate and water.

 C2H5OH (l) + CH3COOH(l) Conc. H2SO4 CH3COO C2H5(**aq**)+H2O(l)

2. Ethanol reacts with propanoic acid to form the ester ethylpropanoate and water.

 C2H5OH (l)+ CH3 CH2COOH(l) Conc. H2SO4 CH3CH2COO C2H5(**aq**)+H2O(l)

**DETERGENTS**

* Detergents are cleaning agents that improve the cleaning power /properties of water.
* A detergent therefore should be able to:
* dissolve substances which water cannot dissolve e.g grease ,oil, fat which are then washed away after cleaning.
* There are two types of detergents:

 (a) Soapy detergents

 (b) Soapless detergents

1. **SOAPY DETERGENTS**
* Soapy detergents usually called soap is long chain salt of organic alkanoic acids.
* Common soap is sodium octadecanoate .It is derived from reacting concentrated sodium hydroxide solution with octadecanoic acid(18 carbon alkanoic acid) i.e.

**NaOH(aq) + CH3 (CH2) 16 COOH(aq) CH3 (CH2) 16 COO – Na+ (aq) +H2 O(l)**

* Commonly, soap can be represented as;

 R-COO – **Na**+where;

R is a long chain alkyl group and -COO – **Na**+ is the alkanoate ion.

* In a school laboratory and at industrial and domestic level, soap is made by reacting concentrated sodium hydroxide solution with esters from **fat** and **oil**.
* The process of making soap is called **saponification.** During saponification, the ester is **hydrolyzed** by the alkali to form sodium salt and **glycerol/** is produced.

 C17H35COO**CH2 CH2OH**

 C17H35COO**CH2 + NaOH 3** C17H35COO- **Na**+ **+ CHOH**

 C17H35COO**CH2 CH2OH**

 **Ester Alkali Soap glycerol**

 **propan-1,2,3-triol**

* During this process a little sodium chloride is added to **precipitate** the soap by reducing its solubility. This is called **salting out**.
* Soap is rinsed by distilled water toremove impurities like glycerol and unused alkali

**The cleaning action of soap**

* It is made of a **non-polar** alkyl /hydrocarbon tail and a **polar** -COO-Na+ head.
* The non-polar tail is **hydrophobic** (water hating) and thus does not dissolve in water .It dissolves in non-polar solvent like grease, oil and fat.
* The polar -COO-Na+ head is **hydrophilic** (water loving) and thus dissolve in water. When washing with soapy detergent, the non-polar tail of the soapy detergent surround/dissolve in the dirt on the garment /grease/oil while the polar head dissolve in water.
* Through **mechanical agitation**/stirring/sqeezing/rubbing/beating/kneading, some grease is dislodged/lifted of the surface of the garment. It is immediately surrounded by more soap molecules, float and spread in the water as tiny droplets that scatter light in form of emulsion making the water cloudy and shinny.
* It is removed from the garment by rinsing with fresh water.

**Advantages and disadvantages of using soapy detergents**

* Soapy detergents are biodegradable. They are acted upon by bacteria and rot. They thus do not cause environmental pollution.
* Soapy detergents have the diadvatage in that:
1. They are made from fat and oils which are better eaten as food than make soap.
2. Forms an insoluble precipitate with hard water called **scum.** Scum is insoluble calcium octadecanoate and Magnesium octadecanoate formed when soap reacts with Ca2+ and Mg2+ present in hard water.

This causes wastage of soap.

NB/ Potassium soaps are soft and better than Sodium soap. Potassium is more expensive than sodium and thus its soap is also more expensive.

**SOAPLESS DETERGENTS**

* Soapless detergents are derived from reacting:
1. Concentrated sulphuric (VI) acid with a long chain alkanol to form alkyl hydrogen sulphate.

 R –O**H**  + **H**2SO4 R –O-SO3H + **H2**O

1. The alkyl hydrogen sulphate is then neutralized with sodium/potassium hydroxide to form sodium/potassium alkyl hydrogen sulphate

 Sodium/potassium alkyl hydrogen sulphate is the soapless detergent.

 **R –O-SO3H + NaOH R –O-SO3- Na+ + H2O**

**Advantages and disadvantages of using soapless detergents**

* Soapless detergents are non-biodegradable unlike soapy detergents.
* They persist in water during sewage treatment by causing foaming in rivers ,lakes and streams leading to marine /aquatic death.
* Soapless detergents have the advantage in that they:
1. do not form scum with hard water.
2. are cheap to manufacture/buying
3. are made from petroleum products but soapis made from fats/oil for human consumption.

**Sample revision questions**

1. Study the scheme below

KOH

Fat/oil

Residue X

Filtrate Y

Filtration

Sodium Chloride

Boiling

**(a)Identify the process**

 Saponification

**(b)Fats and oils are esters. Write the formula of the a common structure of ester**

C17H35COO**CH2**

 C17H35COO**CH**

 C17H35COO**CH2**

 **(c)Give one use of fitrate Y**

 Making paint

**(d)What is the function of sodium chloride**

To reduce the solubility of the soap hence helping in precipitating it out

**(e)Explain how residue X helps in washing.**

Has a non-polar hydrophobic tail that dissolves in dirt/grease /oil/fat

 Has a polar /ionic hydrophilic head that dissolves in water.

From mechanical agitation, the dirt is plucked out of the garment and surrounded by the tail end preventing it from being deposited back on the garment.

**(h)State one:**

 **(i) Advantage of continued use of residue X on the environment**

Is biodegradable and thus do not pollute the environment

 **(ii) Disadvantage of using residue X**

Uses fat/oil during preparation/manufacture which are better used for human consumption.

1. **Residue X was added dropwise to some water.The number of drops used before lather forms are as in the table below.**

|  |  |
| --- | --- |
|  | **Water sample** |
| **A** | **B** | **C** |
| **Drops of residue X** | **15** | **2** | **15** |
| **Drops of residue X in boiled water** | **2** | **2** | **15** |

**(i)State and explain which sample of water is:**

 **I. Soft**

Sample B .Very little soap is used and no effect on amount of soap even on boiling/heating.

 **II. Permanent hard**

Sample C. A lot of soap is used and no effect on amount of soap even on boiling/heating. Boiling does not remove permanent hardness of water.

 **III. Temporary hard**

Sample A . A lot of soap is used before boiling. Very little soap is used on boiling/heating. Boiling remove temporary hardness of water.

**(ii)Write the equation for the reaction at water sample C.**

Chemical equation

2C17H35COO- **K**+ (aq)**+** CaSO4(aq)  **(**C17H35COO- **)**Ca2+ (s) + **K**2SO4(aq)

 (insoluble Calcium octadecanote/scum)

Ionic equation

2C17H35COO- **K**+ (aq)**+** Ca2+(aq)  **(**C17H35COO- **)**Ca2+ (s) + **2K**+(aq)

 (insoluble Calcium octadecanote/scum)

**(iii)Explain how water becomes hard**

Natural or rain water flowing /passing through rocks containing calcium (chalk, gypsum, limestone) and magnesium compounds (dolomite)dissolve them to form soluble Ca2+  and Mg2+ ions that causes water hardness.

**(iv)State two useful benefits of hard water**

-Used in bone and teeth formation

 -Coral polyps use hard water to form coral reefs

 -Snails use hard water to make their shells

**2.Study the scheme below and use it to answer the questions that follow.**

Conc. H2SO4

Substance B

6M sodium hydroxide

Brown solid A

Ice cold water

Olive oil

**(a)Identify :**

 **(i)brown solid A**

Alkyl hydrogen sulphate(VI)

 **(ii)substance B**

Sodium alkyl hydrogen sulphate(VI)

**(b)Write a general formula of:**

 **(i)Substance A.**

R-O-S O3 **H**

**(ii)Substance B**

 R-O-S O3**- Na+**

**(c)State one**

**(i) advantage of continued use of substance B**

 **-**Does not form scum with hard water

 -Is cheap to make

 -Does not use food for human as a raw material.

**(ii)disadvantage of continued use of substance B.**

Is non-biodegradable therefore do not pollute the environment

**(d)Explain the action of B during washing.**

Has a non-polar hydrocarbon long tail that dissolves in dirt/grease/oil/fat.

 Has a polar/ionic hydrophilic head that dissolves in water

Through mechanical agitation the dirt is plucked /removed from the garment and surrounded by the tail end preventing it from being deposited back on the garment.

**(e) Ethene was substituted for olive oil in the above process. Write the equation and name of the new products A and B.**

Product A

Ethene + Sulphuric(VI)acid -> Ethyl hydrogen sulphate(VI)

 H2C=CH2 + H2SO4 –> H3C – CH2 –O-SO3H

Product B

Ethyl hydrogen sulphate(VI) + sodium hydroxide -> sodium Ethyl + Water

 hydrogen sulphate

H3C – CH2 –O-SO3H + **Na**OH -> H3C – CH2 –O-SO3-**Na+**+ H2O

**3.Below is part of a detergent**

 **H3C – (CH2 )16 – O - SO3 - K +**

**(a)Write the formular of the polar and non-polar end**

 Polar end

H3C – (CH2 )16 –

 Non-polar end

– O - SO3 - K +

**(b)Is the molecule a soapy or saopless detergent?**

Soapless detergent

**(c)State one advantage of using the above detergent**

-does not form scum with hard water

 -is cheap to manufacture

4.The structure of a detergent is

 H H H H H H H H H H H H H

 H- C- C- C-C- C- C- C- C- C- C -C- C- -C- COO-Na+

 H H H H H H H H H H H H H

a) Write the molecular formula of the detergent. (1mk)

**CH3(CH2)12COO-Na+**

b) What type of detergent is represented by the formula? (1mk)

**Soapy detergent**

c) When this type of detergent is used to wash linen in hard water, spots (marks) are left on the linen. Write the formula of the substance responsible for the spots (**CH3(CH2)12COO-**)2**Ca2+** / **CH3(CH2)12COO-**)2**Mg2+**

**POLYMERS AND FIBRES**

* Polymers and fibres are giant molecules of organic compounds.
* Polymers and fibres are formed when **small** molecules called monomers join together to form **large** molecules called polymers at high temperatures and pressures. This process is called polymerization.
* Polymers and fibres are either:

 (a) **Natural** polymers and fibres

 (b) **Synthetic** polymers and fibres

* Synthetic polymers and fibres are man-made. They include:

 -polyethene

 -polychloroethene

 -polyphenylethene(polystyrene)

 -Terylene(Dacron)

 -Nylon-6,6

 -Perspex(artificial glass)

* Synthetic polymers and fibres have the following characteristic advantages over natural polymers

1. They are light and portable

2. They are easy to manufacture.

3. They can easily be molded into shape of choice.

4. They are resistant to corrosion, water, air , acids, bases and salts.

5. They are comparatively cheap, affordable, colourful and aesthetic

* Synthetic polymers and fibres however have the following disadvantages over natural polymers
1. They are non-biodegradable and hence cause environmental pollution during disposal
2. They give out highly poisonous gases when burnt like chlorine/carbon(II)oxide
3. Some on burning produce Carbon(IV)oxide. Carbon(IV)oxide is a green house gas that cause global warming.
4. Compared to some metals, they are poor conductors of heat,electricity and have lower tensile strength.
* To reduce environmental pollution from synthetic polymers and fibres, the followitn methods of disposal should be used:

1. Recycling: Once produced all synthetic polymers and fibres should be recycled to a new product. This prevents accumulation of the synthetic polymers and fibres in the environment.

2. Production of biodegradable synthetic polymers and fibres that **rot** away.

* There are two types of polymerization:

 (a) addition polymerization

 (b) condensation polymerization

**(a)addition polymerization**

Addition polymerization is the process where a small unsaturated monomer (alkene ) molecule join together to form a large saturated molecule without formation of any other products.

**Examples of addition polymerization**

1. Formation of Polyethene

Polyethene is an addition polymer formed when ethene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.

1. Formation of Polychlorethene

Polychloroethene is an addition polymer formed when chloroethene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.

1. Formation of Polyphenylethene

Polyphenylethene is an addition polymer formed when phenylethene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.

During polymerization:

(i)many molecules are brought nearer to each other by the high pressure(which reduces the volume occupied by reacting particles)

 H H H H H H H H

C = C + C = C + C = C + C = C + **…**

H **C6H5** H **C6H5** H **C6H5** H **C6H5**

phenylethene + phenylethene + phenylethene + phenylethene + **…**

Since the molecule is a repetition of one monomer, then the polymer is:

 H H

 ( C – C )**n**

 H **C6H5**

1. Formation of Polypropene

Polypropene is an addition polymer formed when propene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.

During polymerization:

(i)many molecules are brought nearer to each other by the high pressure(which reduces the volume occupied by reacting particles)

 H H H H H H H H

C = C + C = C + C = C + C = C + **…**

H **CH3** H **CH3** H **CH3** H **CH3**

propene + propene + propene + propene + **…**

 H H

 ( C – C )**n**

 H **CH3**

1. Formation of Polytetrafluorothene

Polytetrafluorothene is an addition polymer formed when tetrafluoroethene molecule/monomer join together to form a large molecule/polymer at high temperatures and pressure.

During polymerization:

(i)many molecules are brought nearer to each other by the high pressure(which reduces the volume occupied by reacting particles)

 F F F F F F F F

C = C + C = C + C = C + C = C + **…**

F F F F F F F F

tetrafluoroethene + tetrafluoroethene+ tetrafluoroethene+ tetrafluoroethene + **…**

 F F

 ( C – C )**n**

 F F

1. Formation of rubber from Latex

Natural rubber is obtained from rubber trees.

 During harvesting an incision is made on the rubber tree to produce a milky white substance called **latex.**

Latex is a mixture of rubber and lots of water.

The latex is then added an acid to coagulate the rubber.

Natural rubber is a polymer of 2-methylbut-1,3-diene ;

1. Formation of synthetic rubber

Synthetic rubber is able to resist action of oil,abrasion and organic solvents which rubber cannot.

 Common synthetic rubber is a polymer of 2-chlorobut-1,3-diene ;

**(b)Condensation polymerization**

Condensation polymerization is the process where two or more small monomers join together to form a larger molecule by elimination/removal of a simple molecule. (usually water).

 Condensation polymers acquire a different name from the monomers because the two monomers are two different compounds

 During condensation polymerization:

(i)the two monomers are brought together by high pressure to reduce distance between them.

(ii)monomers realign themselves at the functional group.

(iii)from each functional group an element is removed so as to form simple molecule (of usually H2O/HCl)

(iv)the two monomers join without the simple molecule of H2O/HCl

**Examples of condensation polymerization**

1.Formation of Nylon-6,6

**Method 1**: Nylon-6,6 can be made from the condensation polymerization of hexan-1,6-dioic acid with hexan-1,6-diamine.Amines are a group of homologous series with a general formula R-NH2 and thus -NH2 as the functionalgroup.

During the formation of Nylon-6,6:

(i)the two monomers are brought together by high pressure to reduce distance between them and realign themselves at the functional groups.

 O O H H

 H- O - C – (CH2 ) 4 – C – O - H + H –N – (CH2) 6 – N – H

(iii)from each functional group an element is removed so as to form a molecule of H2O and the two monomers join at the linkage .

 O O H H

 H- O - C – (CH2 ) 4 – C **–** N – (CH2) 6 – N – H + H 2O

.

 Polymer bond linkage

Nylon-6,6 derive its name from the two monomers each with **six** carbon chain

**Method 2**: Nylon-6,6 can be made from the condensation polymerization of hexan-1,6-dioyl dichloride with hexan-1,6-diamine.

Hexan-1,6-dioyl dichloride belong to a group of homologous series with a general formula R-OCland thus -OCl as the functionalgroup.

The R-OCl is formed when the “OH” in R-O**OH**/alkanoic acid is replaced by Cl/chlorine/Halogen

During the formation of Nylon-6,6:

(i)the two monomers are brought together by high pressure to reduce distance between them and realign themselves at the functional groups.

 O O H H

 Cl - C – (CH2 ) 4 – C – Cl + H –N – (CH2) 6 – N – H

(iii)from each functional group an element is removed so as to form a molecule of HCl and the two monomers join at the linkage .

 O O H H

 Cl - C – (CH2 ) 4 – C **–** N – (CH2) 6 – N – H + HCl

.

 Polymer bond linkage

The two monomers each has **six** carbon chain hence the name “nylon-6,6”

The commercial name of Nylon-6,6 is **Nylon** It is a a tough, elastic and durable plastic. It is used to make **clothes**, **plastic ropes** and **carpets.**

2.Formation of Terylene

**Method 1**: Terylene can be made from the condensation polymerization of ethan-1,2-diol with benzene-1,4-dicarboxylic acid.

Benzene-1,4-dicarboxylic acid a group of homologous series with a general formula R-COOHwhere R is a ring of six carbon atom called Benzene ring .The functionalgroup is -COOH.

During the formation of Terylene:

(i)the two monomers are brought together by high pressure to reduce distance between them and realign themselves at the functional groups.

 O O

 H- O - C – C6H5 – C – O - H + H –O – CH2 CH2 – O – H

(iii)from each functional group an element is removed so as to form a molecule of H2O and the two monomers join at the linkage .

 O O

 H- O - C – C6H5  – C **–** O – (CH2) 6 – N – H + H 2O

.

 Polymer bond linkage of terylene

**Method 2**: Terylene can be made from the condensation polymerization of benzene-1,4-dioyl dichloride with ethan-1,2-diol.

Benzene-1,4-dioyl dichloride belong to a group of homologous series with a general formula R-OCland thus -OCl as the functionalgroup and R as a benzene ring.

The R-OCl is formed when the “OH” in R-O**OH** is replaced by Cl/chlorine/Halogen

During the formation of Terylene

(i)the two monomers are brought together by high pressure to reduce distance between them and realign themselves at the functional groups.

 O O

 Cl - C – C5H5 – C – Cl + H –O – CH2 CH2 – O - H

(iii)from each functional group an element is removed so as to form a molecule of HCl and the two monomers join at the linkage .

 O O

 Cl - C – C5H5  – C **–** O – CH2 CH2 – O – H + HCl

.

**Practice questions Organic chemistry**

1. A student mixed equal volumes of Ethanol and butanoic acid. He added a few drops of concentrated Sulphuric (VI) acid and warmed the mixture

 (i) Name and write the formula of the main products

Name………………………………….

Formula……………………………………..

 (ii) Which homologous series does the product named in (i) above belong?

2. The structure of the monomer phenyl ethene is given below:-

HC = CH2

O

 a) Give the structure of the polymer formed when four of the monomers are added together

 b) Give the name of the polymer formed in **(a)** above

7. The formula below represents active ingredients of two cleansing agents **A** and **B**

 Which one of the cleansing agents would be suitable to be used in water containing magnesium hydrogen carbonate? Explain

13. a) State **two** factors that affect the properties of a polymer

 b) Name the compound with the formula below :

 CH3CH2CH2ONa

 c) Study the scheme below and use it to answer the questions that follow:-

CH3CH2CH3

**P**

**Step**

 **V**

CH3CH = CH2

**Step**

 **W**

CH3CH2CH2OH

CH3CH2COOH

**Step R**

 Gas **F**

CH3CH2COONa

**NaOH**

**Step J**

**K2CO3**

**Step X**

**NaOH**

**Heat**

CH3CH2COOCH3

 **G**

Product **T**

+ Na2CO3

 H H

 C – C

 CH3 H

**n**

**K**

 i) Name the following compounds:-

 I. Product **T** ………………………… II. **K** ………

 ii) State **one** common physical property of substance **G**

 iii) State the type of reaction that occurred in step **J**

 iv) Give **one** use of substance **K**

 v) Write an equation for the combustion of compound **P**

 vi) Explain how compounds CH3CH2COOH and CH3CH2CH2OH can be distinguished chemically

 vii) If a polymer **K** has relative molecular mass of 12,600, calculate the value of **n** (H=1 C =12)

14. Study the scheme given below and answer the questions that follow:-

H2 (g) Ni

High temp

Polymer **Q**

Polymerization

Compound **P**

CH3CH2CH3

CH3CH2CH2ONa+ H2

Na(s)

Propan-l-ol

**Step I**

Propylethanoate

CH3CH2COOH

Solution **T** + CO2 (g)

**Step III**

Na2CO3(aq)

Conc. H2SO4 180oC

**Step II**

 (a) (i) Name compound **P** ……………………………………………………………………

 (ii) Write an equation for the reaction between CH3CH2COOH and Na2CO3

 (b) State **one** use of polymer **Q**

 (c) Name **one** oxidising agent that can be used in **step II** …………………………………..

 (d) A sample of polymer **Q** is found to have a molecular mass of 4200. Determine the number of

 monomers in the polymer (H = 1, C = 12)

 (e) Name the type of reaction in **step I** …………………………………………………………..

 (f) State **one** industrial application of **step III**

 (g)State how burning can be used to distinguish between propane and propyne. Explain your

 answer

 (h) 1000cm3 of ethene (C2H4) burnt in oxygen to produce Carbon (II) Oxide and water vapour.

 Calculate the minimum volume of air needed for the complete combustion of ethene

 (Air contains 20% by volume of oxygen)

15. (a) Study the schematic diagram below and answer the questions that follow:-

CH3CH2COOCH2CH2CH3

CH3CHCH2

CH3CH2CH2ONa + Gas **P**

CH3CH2CH2OH

**X**

**V**

HCl Step 5

 Step 1 **R**

Na

Step2

H+

Step 3

Q + H2O

MnO-4

Step 4

Ni H2

 (i) Identify the following:

Substance **Q** ..............................................................................................................

Substance **R**...............................................................................................................

 Gas **P**..........................................................................................................................

 (ii) Name:

 **Step 1**.................................................................................................

 **Step 4**.................................................................................................

 (iii) Draw the structural formula of the major product of step **5**

 (iv) State the condition and reagent in step **3**

17. a) Give the names of the following compounds:

 i) CH3CH2CH2CH2OH ……………………………………………………………………

 ii) CH3CH2COOH …………………………………………………………………

 iii) CH3C – O- CH2CH3 ……………………………………………………………………

21. Give the IUPAC name for each of the following organic compounds;

 i) CH3 - CH - CH2 - CH3

 OH

 ii)CH3 – CH – CH2 – CH2 - CH3

 C2H5

 iii)CH3COOCH2CH2CH3

26. (a) What is meant by the term, esterification?

 (b) Draw the structural formulae of **two** compounds that may be reacted to form ethylpropanoate

27. (a) Draw the structure of pentanoic acid

 (b) Draw the structure and give the name of the organic compound formed when ethanol

 reacts with pentanoic acid in presence of concentrated sulphuric acid