**NATIONAL 4 AND NATIONAL 5 CHEMISTRY**



**Unit 2: Nature’s Chemistry**

**Topic 2**

**HYDROCARBONS**



|  |
| --- |
| **Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Class \_\_\_\_\_** |

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| --- |
| Unit 2: Nature’s Chemistry |
| Topic 2: Hydrocarbons |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| LEVEL N4 N5 | **AFTER COMPLETING THIS TOPIC YOU SHOULD BE ABLE TO:** | NOTES (Page) | **How well I have understood (✓)** | | |
| **☺** | **😐** | **☹** |
| N4 | Name the alkanes (C1 – C8) and write their molecular, full and shortened structural formulae. | 4 - 6 |  |  |  |
| N4 | Write a general formula to work out the number of hydrogen atoms in an alkane from the number of carbon atoms. | 7 |  |  |  |
| N4 | State the physical and chemical properties of the alkanes (C1 – C8). | 7 - 8 |  |  |  |
| N4 | Write the word and formula equation for the combustion of the alkanes (C1 – C8). | 8 |  |  |  |
| N4 | Give examples of the uses of the alkanes. | 9 |  |  |  |
| N4 | Name the alkenes (C2 – C8) and write their molecular, full and shortened structural formulae. | 9 - 11 |  |  |  |
| N4 | Write a general formula to work out the number of hydrogen atoms in an alkene from the number of carbon atoms. | 12 |  |  |  |
| N4 | Distinguish an alkane from an alkene by the –ene ending and the presence of the C=C bond in an alkene, and the – ane ending and only C-C in an alkane. | 12 - 14 |  |  |  |
| N4 | State the physical and chemical properties of the alkanes (C2 – C8). | 12 |  |  |  |
| N4 | Write the word and formula equation for the combustion of the alkanes (C2 – C8). | 13 |  |  |  |
| N4 | Understand the terms saturated and unsaturated when used to describe hydrocarbons. | 13 - 14 |  |  |  |
| N4 | Give examples of the uses of the alkenes. | 14 |  |  |  |
| N5 | State a homologous series is a set of compounds with the same general formula and similar chemical properties. | 15 |  |  |  |
| N5 | State that the alkanes and alkenes are two examples of a homologous series. | 15 |  |  |  |
| N5 | Describe how physical properties (melting point, boiling point, rate of evaporation, viscosity) relates to the size of molecule. | 17 |  |  |  |
| N5 | State the cycloalkanes are another homologous series and write the general formula. | 15 - 16 |  |  |  |
| N5 | State the physical and chemical properties of the cycloalkanes. | 17 |  |  |  |
| N5 | Write balanced formula equations for the combustion of an alkane, alkene and cycloalkane. | 17 |  |  |  |
| N5 | State isomers are molecules with the same molecular formula but have different structures. | 19 - 20 |  |  |  |
| N5 | Write the systematic name of an alkane, alkene and cycloalkane to enable the structure of the molecule to written. | 20 - 25 |  |  |  |
| N5 | Draw the full structural formula of a hydrocarbon (alkane, alkene and cycloalkane) from its systematic name. | 20 - 25 |  |  |  |
| N5 | Explain that the reactions of alkenes with bromine, hydrogen and water are addition reactions. | 26 - 30 |  |  |  |
| N5 | Name the products of the addition reaction of an alkene with bromine, hydrogen and water (steam). | 26 - 30 |  |  |  |
| N5 | Write the formula equations for the addition reactions of an alkene with bromine, hydrogen and water (steam). | 26 - 30 |  |  |  |

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| Unit 2: Nature’s Chemistry |
| Topic 2: Hydrocarbons |

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| --- | --- | --- | --- | --- | --- |
| LEVEL N4 N5 | **AFTER COMPLETING THIS TOPIC YOU SHOULD BE ABLE TO:** | NOTES (Page) | **How well I have understood (✓)** | | |
| **☺** | **😐** | **☹** |
| N4 | State fractional distillation of crude oil yields more long-chain hydrocarbons than are useful for present-day industrial purposes. | 31 - 32 |  |  |  |
| N4 | State cracking is an industrial method for producing a mixture of smaller, more useful molecules. | 32 - 33 |  |  |  |
| N4 | State a catalyst allows the reaction to take place at a lower temperature. | 33 |  |  |  |
| N4 | Describe how cracking can be carried out in the laboratory using an aluminium oxide or silicate catalyst. | 32 -33 |  |  |  |
| N4 | State cracking produces a mixture of alkanes (saturated hydrocarbons) and alkenes (unsaturated hydrocarbons). | 33 - 34 |  |  |  |

|  |  |  |
| --- | --- | --- |
| **N4** | **ALKANES** | **N4** |



**A HYDROCARBON FAMILY**

Candle wax, petrol, diesel, bottled gas are all **HYDROCARBONS** that are obtained from crude oil fractions.

All these hydrocarbons belong to a group of compounds called the **ALKANES**.



The simplest alkane is **methane**, **CH4** .

The hydrocarbon, which is in natural gas.

**ALKANE FORMULAE**

There are a number of ways to show the formula of a molecule.

|  |  |  |  |
| --- | --- | --- | --- |
| **methane** | **CH4** |  |  |
|  | **molecular formula** | **covalent bonding** | **full structural formula** |

|  |  |  |  |
| --- | --- | --- | --- |
| **ethane** | **C2H6** |  | **covalent bonding** |
|  | **molecular formula** |  | **full structural formula** |
|  |  | **CH3 CH3** | **shortened structural formula** |

|  |  |  |  |
| --- | --- | --- | --- |
| **propane** | **C3H8 molecular formula** |  | **covalent bonding** |
|  |  |  | **full structural formula** |
|  |  | **CH3 CH2 CH3** | **shortened structural formula** |

**ALKANE SERIES**

The chemistry of carbon compounds is called **ORGANIC CHEMISTRY**.

The name of a compound is based on the number of carbon atoms.

|  |  |
| --- | --- |
| **Prefix** | **No. of Carbons in the Molecule** |
| meth- | 1 |
| eth- | 2 |
| prop- | 3 |
| but- | 4 |
| pent- | 5 |
| hex- | 6 |
| hept- | 7 |
| oct- | 8 |
| non- | 9 |
| dec- | 10 |

Alkanes always end their name in **–ANE.**

The first part of an alkane name (**the prefix**) tells you **how many carbon atoms** are in the molecule.

**Example: butane**

**the molecule is an alkane**

**4 carbons in the alkane**

**BUT ANE**

Complete the table on the following page with the names, molecular, full and shortened structural formula of the alkanes containing up to 6 carbon atoms.

**THE ALKANES CONTAINING 1 TO 6 CARBON ATOMS**

|  |  |  |  |
| --- | --- | --- | --- |
| **No. of C atoms** | **Alkane Name** | **Molecular Formula** | **Full Structural Formula / Shortened Structural formula** |
| 1 | methane | CH4 |  |
|  |  |  | **CH4** |
| 2 |  |  |  |
|  |  |  | **CH3 CH3** |
| 3 |  |  |  |
|  |  |  |  |
| 4 |  |  |  |
|  |  |  |  |
| 5 |  |  |  |
|  |  |  |  |
| 6 |  |  |  |
|  |  |  |  |

**GENERAL FORMULA**

Going up the alkane series each formula differs from the previous by **one carbon and two hydrogen atoms** (**CH2**).

The number of hydrogen atoms can be worked out from the number of carbon atoms.

To calculate the number of hydrogen atoms from the number of carbons atoms:

|  |
| --- |
| **DOUBLE THE NUMBER OF CARBONS AND ADD TWO.** |

This is called a **GENERAL FORMULA** and can be written as:

|  |
| --- |
| **THE GENERAL FORMULA FOR ALKANES**  **CnH2n + 2**  **n = number of carbons 1, 2, 3, . . . .** |

**PROPERTIES OF ALKANES**

Paraffin (kerosine) is a mixture of hydrocarbons, which are alkanes. Methane is also an alkane.

|  |  |  |
| --- | --- | --- |
| **PROPERTY TESTED** | **Paraffin** | **Methane** |
| **Appearance (state / colour)** |  |  |
| **Smell** |  |  |
| **Flammability** |  |  |
| **Solubility in water** |  |  |
| **pH (acidic / neutral / alkaline)** |  |  |
| **Effect on bromine solution** |  |  |

**CONCLUSION**

Paraffin and methane have similar properties. The only difference is methane is a gas and paraffin is a liquid.

Paraffin and methane do not immediately change the **orange colour of bromine solution**. This shows that all alkanes have **no immediate effect on bromine solution**.

Both paraffin and methane are **HYDROCARBONS**. When they burn the products are **WATER** and **CARBON DIOXIDE.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **WORD EQUATION FOR THE COMBUSTION OF ALL HYDROCARBONS** | | | | | | |
| **hydrocarbon** | **+** | **oxygen** |  | **water** | **+** | **carbon dioxide** |

**COMBUSTION REACTION**

**Alkanes are hydrocarbons, and therefore, burn to form WATER and CARBON DIOXIDE.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **methane** | **+** | **oxygen** |  | **water** | **+** | **carbon dioxide** |
| **CH4** | **+** | **2 O2** |  | **2 H2O** | **+** | **CO2** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **WORD EQUATION FOR THE COMBUSTION OF ALL ALKANES** | | | | | | |
| **alkane** | **+** | **oxygen** |  | **water** | **+** | **carbon dioxide** |

**USES OF ALKANES**

Alkanes are very important chemicals in industry. A number of alkanes are used as fuels. Alkanes are used to manufacture other chemicals. They are called **FEEDSTOCK** molecules.

|  |  |  |  |
| --- | --- | --- | --- |
| **FUELS** |  | **Methane – natural gas.**  **Propane and butane (LPG) – bottled gas.**  **Petrol (gasoline), kerosene (paraffin), diesel.** |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **CHEMICALS** |  | **Solvents, lubricants and waxes.** |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **FEEDSTOCK CHEMICALS** |  | **Making plastics (polymers), drugs, and pesticides.**  **Making every day chemicals ethanol (alcohol), ethanoic acid (acetic acid - vinegar)** |  |

|  |  |  |
| --- | --- | --- |
| **N4** | **ALKENES** | **N4** |



**double covalent bond**



**CH2 = CH2**

**full structural formula**

**shortened structural formula**

**ETHENE MOLECULE**

Alkenes are another family of hydrocarbons.

The first member of the alkenes is called **ETHENE**.

There is a double covalent bond between the carbon atoms in ethene.

****

**C2H4**

**molecular formula**

Ethene is the smallest alkene as there must be at least 2 carbon atoms in the molecule for the double bond to exist.

**ETH ENE**

**2 carbons in the molecule**

**the molecule contains a double covalent bond between two carbons**

**ALKENE FAMILY**



**CH2 = CH CH3**

The second member of the alkenes is called **PROPENE**.



**C3H6**

Complete the table on the following page with the names, molecular, full and shortened structural formula of the alkenes containing up to 7 carbon atoms.

**THE ALKENES CONTAINING 2 TO 7 CARBON ATOMS**

|  |  |  |  |
| --- | --- | --- | --- |
| **No. of C atoms** | **Alkane Name** | **Molecular Formula** | **Full Structural Formula / Shortened Structural formula** |
| 2 | ethene | C2H4 |  |
|  |  |  | **CH2 = CH2** |
| 3 |  |  |  |
|  |  |  |  |
| 4 |  |  |  |
|  |  |  |  |
| 5 |  |  |  |
|  |  |  |  |
| 6 |  |  |  |
|  |  |  |  |
| 7 |  |  |  |
|  |  |  |  |

**GENERAL FORMULA**

|  |
| --- |
| **THE GENERAL FORMULA FOR ALKENES**  **CnH2n**  **n = number of carbons**  **n cannot equal 1** |

In the general formula **n cannot equal 1** because the minimum number of carbon atoms in an alkene molecule must be 2 for the double bond to form.

**PROPERTIES OF ALKENES**

Alkenes have a similar structure to alkanes, **EXCEPT** that one of the bonds between two of their carbons is a double bond.

|  |  |  |
| --- | --- | --- |
| **PROPERTY TESTED** | **Hexene** | **Octene** |
| **Appearance (state / colour)** |  |  |
| **Smell** |  |  |
| **Flammability** |  |  |
| **Solubility in water** |  |  |
| **pH (acidic / neutral / alkaline)** |  |  |
| **Effect on bromine solution** |  |  |

**CONCLUSION**

Alkanes and alkenes:

* have strong smells, but alkenes have stronger smells.
* are both very flammable but alkenes produce more smoke when they burn.
* are both insoluble in water – they are immiscible.
* are both neutral substances.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **WORD EQUATION FOR THE COMBUSTION OF ALL ALKENES** | | | | | | |
| **alkene** | **+** | **oxygen** |  | **water** | **+** | **carbon dioxide** |

**COMBUSTION OF AN ALKENE (ethene)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ethene** | **+** |  |  |  | **+** |  |
|  |  |  |  |  |  |  |
|  | **+** |  |  |  | **+** |  |

**ALKENES AND BROMINE SOLUTION**

When alkenes are shaken with **BROMINE SOLUTION** they immediately remove the **orange colour** and it turns colourless (**DECOLOURISES**).

This is different to the reaction with **alkanes, which do not immediately decolourise bromine solution**.

The **double bond (C=C)** in the alkene molecule is responsible for the **rapid decolourisation** of **bromine solution.**

**Bromine solution** is used to detect the presence of **C=C** in a molecule, i.e. it can detect alkenes.

**SATURATED / UNSATURATED**

Carbon based molecules where all the carbon-to-carbon covalent bonds **are SINGLE** (**C-C**) are classified as being **SATURATED.**

If one or more of the carbon-to-carbon covalent bonds is a **DOUBLE** (**C=C**) the molecule is classified as being **UNSATURATED.**

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
| Butane contains only C-C and is a **SATURATED HYDROCARBON**  **Alkanes are saturated.** |  | Pentene contains a C=C and is an **UNSATURATED HYDROCARBON**  **Alkenes are unsaturated.** |

|  |
| --- |
| **Bromine solution** is used to detect the presence of **C=C** in a molecule. Therefore, bromine solution can be used to distinguish between a **saturated** and **unsaturated** hydrocarbon. |

**USES OF ALKENES**

Alkenes are very important chemicals in industry. The C = C makes their molecules reactive. Alkenes are used to manufacture other chemicals. They are called **FEEDSTOCK** molecules.



Ethene (known as **ethylene** in industry) has the highest worldwide production of any organic compound.

Ethene (ethylene) is used to make

* Plastics (polymers) e.g. polythene, polystyrene,  
  man-made rubber.
* Ethanol (alcohol) for use as a solvent.
* Chemicals for making medicines, detergents,



Ethene (ethylene) is used to ripen fruit e.g. bananas. Fruit are picked before they ripen, and are stored in conditions to prevent them ripening for their long journey to the UK. Before being sent to the shops, the fruit is exposed to ethene to start ripening. This ensures the fruit is in the best condition for the customer.

|  |  |
| --- | --- |
|  | To practise naming and writing the formulae of alkanes / alkenes, and writing the equations for combustion of hydrocarbons, do the **HYDROCARBONS** examples on **pages 2 & 3** of the **Practice Examples Booklet**. |

|  |  |  |
| --- | --- | --- |
| **N5** | **HOMOLOGOUS SERIES** | **N5** |

**ALKANES GENERAL FORMULA**

**CnH2n + 2**

The **alkanes** are a family of carbon-based compounds for which a general formula can be written.



The alkanes are an example of a **HOMOLOGOUS SERIES.**

|  |
| --- |
| **DICTIONARY - HOMOLOGOUS SERIES**  A **HOMOLOGOUS SERIES** is a family of carbon-based compounds, which are **CHEMICALLY SIMILAR** and can have a **GENERAL FORMULA** written for the family. |

The **alkenes** are another homologous series.



**ALKENES GENERAL FORMULA**

**CnH2n**

**CYCLOALKANES**

Carbon atoms can join to form **RINGS** of carbons. The smallest ring contains 3 carbons.

**C3H6**

**molecular formula**

The simplest molecule is called



**full structural formula**



**shortened structural formula**

**CYCLOPROPANE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Carbon atoms are joined in a ring.** |  | **Molecule has 3 carbon atoms.** |  | **All the carbon-to-carbon bonds are single (C-C).** |

**THE CYCLOALKANES CONTAINING 4 TO 6 CARBON ATOMS**

Name the cycloalkanes with 4 to 6 carbon atoms and draw the full structural / shortened structural formula of each molecule.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |

|  |
| --- |
| **THE GENERAL FORMULA FOR CYCLOALKANES**  **CnH2n**  **n = 3, 4, 5, ….** |

**PROPERTIES OF CYCLOALKANES**

The structure of cycloalkanes are similar to alkanes i.e. they all contain **C-C**. This means cycloalkanes are **saturated hydrocarbons**.

|  |  |
| --- | --- |
| **PROPERTY TESTED** | **Cyclohexane** |
| **Appearance (state / colour)** |  |
| **Smell** |  |
| **Flammability** |  |
| **Solubility in water** |  |
| **pH (acidic / neutral / alkaline)** |  |
| **Effect on bromine solution** |  |

**CONCLUSION**

Cycloalkanes have similar properties to alkanes.

**COMBUSTION OF A CYCLOALKANE (cyclohexane)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **cyclohexane** | **+** |  |  |  | **+** |  |
|  |  |  |  |  |  |  |
|  | **+** |  |  |  | **+** |  |

Cycloalkanes are another **HOMOLOGOUS SERIES**.

**HOMOLOGOUS SERIES & PHYSICAL PROPERTIES**

The physical properties of the molecules in a homologous series all change as the number of carbon atoms in the molecules increase.

The melting and boiling points, the viscosity of the alkanes, alkenes and cycloalkanes all show an increase going up the series as the number of carbon atoms in their molecules increase.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **HYDROCARBONS** | | |  |
|  |  |  |  |  |
| **ALKANES** |  | **ALKENES** |  | **CYCLOALKANES** |
|  |  |  |  |  |
| **General Formula**  **CnH2n + 2** |  | **General Formula**  **CnH2n** |  | **General Formula**  **CnH2n** |
|  |  |  |  |  |
| 1. Flammable - all produce H2O + CO2 2. Immiscible in H2O 3. pH = neutral (7) 4. Bromine solution. No immediate effect. |  | 1. Flammable - all produce H2O + CO2 2. Immiscible in H2O 3. pH = neutral (7) 4. Bromine solution. Immediately decolourises. |  | 1. Flammable - all produce H2O + CO2 2. Immiscible in H2O 3. pH = neutral (7) 4. Bromine solution. No immediate effect. |

|  |  |
| --- | --- |
|  | To practise naming and writing the formulae of alkanes / alkenes, and writing the equations for combustion of hydrocarbons, do the **HYDROCARBONS** examples on **pages 2 & 3** of the **Practice Examples Booklet**. |

|  |  |  |
| --- | --- | --- |
| **N5** | **ISOMERS** | **N5** |

**ALKANE ISOMERS**

When alkanes have **four or more carbon atoms**,they can join in different ways to give **different structures.**



Butane, C4H10, has two possible structures**.**



**The two structures of butane.**



**These different structures of butane are called ISOMERS.**

|  |
| --- |
| **DICTIONARY - ISOMERS**  **ISOMERS** are molecules with the **SAME MOLECULAR FORMULA** but have **DIFFERENT STRUCTURES.**  Isomers in the alkane family only occur in molecules with 4 or more carbons.  The more carbons in a molecule the more isomers are possible. |

The term **isomer** is made from two Greek words, **isos which means equal**, and **meros, which means part**.

**THE ISOMERS OF PENTANE, C5H12**

Pentane has 3 isomers. Draw the full structural formula of each isomer.

|  |
| --- |
|  |

|  |
| --- |
|  |

|  |
| --- |
|  |

**SYSTEMATIC NAMING - ALKANES**

The naming of alkanes needs to be improved, to allow the different isomer structures to be given a name, which describes their structure.



**1**

**2**

**3**

**4**

**butane**

**RULE 1**

The longest chain of carbons gives the main part of the name.

When all the carbon atoms lie in a line, the molecule is called a **STRAIGHT CHAIN MOLECULE**.

|  |  |  |
| --- | --- | --- |
| **This is a methyl group.** |  | This is called a **BRANCHED CHAIN MOLECULE**.  Branches are called **ALKYL GROUPS**.  **1**  **2**  **3** |

**RULE 2**

The location of a branch is given by a number.

**2-methylpropane**

The main name is **propane**.

The **methyl** group is on carbon **2**. The **2** is separated from the **methyl** with a hyphen, **2-methyl**, and this is placed in front of the main name.

|  |  |
| --- | --- |
| **ISOMERS OF BUTANE, C4H10** | |
| **butane** | **2-methylpropane** |

**NAMING THE ISOMERS OF PENTANE, C5H12**



**2,2-dimethylpropane**

There are **2 methyl groups** on carbon **2.** Therefore, **2,2-dimethyl** will be placed in front of the main name.

**RULE 3**

When numbering a chain start from the end nearest the branch.

**3**

**2**

**1**

**pentane**

**1**



**2**

**3**

**4**

**5**



**1**

**2**

**3**

**4**

**2-methylbutane**

**Numbering from the right puts the methyl branch on carbon 2.**

**4**

**3**

**2**

**1**

**RULE 4**

Every branch must be numbered. Separate numbers with commas. Use the prefix di- ,tri-, etc, when a branch appears more than once.

**NAMING BRANCHES (ALKYL GROUPS)**

**Branches** (**alkyl groups**) names are based on alkane names.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| **methane, CH4** |  | **methyl group, CH3-** |  | **ethane, C2H6** |  | **ethyl group, C2H5-** |

|  |  |
| --- | --- |
| **2**  **1**  **3**  **4**  **5**  **6**  **7** | There is a **methyl group** on carbon **2**, and an **ethyl group** on carbon **4**.  **Alphabetical order** is used to place the alkyl groups in front of the main name.  Numbers are separated from letters by inserting hyphens. |
| **4-ethyl-2-methylheptane** |  |

**NAMING ALKENES ISOMERS**

The **C=C** in an alkene molecule is located by inserting a number in the name.

**alk – number – ene**

|  |  |
| --- | --- |
| **1**  **2**  **3**  **4** | **1**  **2**  **3**  **4** |
| **but-1-ene** | **but-2-ene** |

**The C=C in an alkene molecule is called its FUNCTIONAL GROUP as it gives the molecule its chemical properties, i.e. it makes the molecule function as an alkene.**

**RULE 5**

When numbering a molecule with a functional group, the functional group has priority for numbering. The functional group must be given the lowest possible number.

**BRANCHED ALKENES**

|  |  |
| --- | --- |
| **2**  **1**  **3**  **4**  **5** | **The alkene has 5 carbon atoms and the C=C is on carbon 1.**  **There is a methyl group on carbon 4.** |
| **4-methylpent-1-ene** |  |

|  |  |
| --- | --- |
| **The alkene has 6 carbon atoms and the C=C is on carbon 2.**  **There are 2 methyl groups on carbon 5.** | **1**  **2**  **3**  **4**  **5**  **6** |
|  | **5,5-dimethylhex-2-ene** |

**BRANCHED CYCLOALKANES**

Cycloalkanes also have branched molecules.

|  |  |
| --- | --- |
|  | The ring has 6 carbon atoms. This is **cyclohexane.**  There is a **methyl branch** on the ring**. When there only one branch on a ring, it does not require a number to locate it.** |
| **methylcyclohexane** |  |

**CYCLOALKANES – MORE THAN ONE BRANCH**

|  |  |
| --- | --- |
|  | When there is more than one alkyl group on a ring of carbon atoms, they are located by their positions relative to each other.  The carbon atoms of ring are numbered so the alkyl groups are near each other.  This ring has 5 carbon atoms. This is **cyclopentane.**  There are **2 methyl groups** on the ring **(dimethyl).** The ring is numbered from the first methyl group.  The **2 methyl groups** are located oncarbons **1** and **3**. |
| **1,3-dimethylcyclopentane** |  |

|  |  |
| --- | --- |
|  | To practise systematic naming of alkanes, alkenes and cyclokalkanes, do the **ISOMERS & SYSTEMATIC NAMING** examples on **page 4** of the **Practice Examples Booklet**. |

**ALKENE / CYCLOALKANE ISOMERS**

Alkenes and cycloalkanes with the same number of carbon atoms are isomers.

|  |  |  |
| --- | --- | --- |
|  | **The two structures of C3H6.** |  |
| **propene** |  | **cyclopropane** |
|  | **The ISOMERS of C3H6.** |  |

**ISOMERS OF C4H8**

There are 5 isomers of C4H8. Draw the full structural formula of each isomer and name the molecule.

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| --- | --- | --- |
| **N5** | **ALKENE REACTIONS** | **N5** |

Bromine (**Br2**) can be used to detect a **C=C** in a molecule. This means bromine can detect if a molecule is **UNSATURATED**.

Alkenes (unsaturated hydrocarbons), rapidly decolourise bromine solution.

The bromine molecule reacts with the **C=C**, breaking it open and then adds onto the molecule.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **+** |  |  |  |
| **ethene** | **+** | **bromine** |  | **1,2-dibromoethane** |
|  | **+** |  |  |  |
| **C2H4** | **+** | **Br2** |  | **C2H4Br2** |
|  |  | **(orange)** |  | **(colourless)** |

The bromine atoms **“ADD ACROSS”** the double bond **C=C** changing it back to a single bond **C-C**. The reaction is called an **ADDITION REACTION**.

The product molecule, **dibromoethane**, ends in **– ANE** because the molecule contains only **C-C** bonds.

During the reaction the colour changes from **orange** to **colourless,** as **dibromoethane** is **colourless.**

|  |
| --- |
| **DICTIONARY - ADDITION REACTION**  Alkenes react with bromine by an **addition reaction**. The double bond between the carbon atoms **C=C** breaks open, changing back to a single bond **C-C**.  The bromine atoms then **add** onto the carbon atoms. (i.e. the **bromine** atoms **add across the double bond**.) The product of the reaction is a **dibromo**alkane. |

**PROPENE + BROMINE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **propene** | **+** | **bromine** |  | **1,2-dibromopropane** |
|  | **+** |  |  |  |
| **C3H6** | **+** | **Br2** |  | **C3H6Br2** |
|  |  | **(orange)** |  | **(colourless)** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **WORD EQUATION FOR THE ADDITION REACTION OF BROMINE WITH AN ALKENE** | | | | |
| **alkene** | **+** | **bromine** |  | **dibromoalkane** |
| **CnH2n** | **+** | **Br2** |  | **CnH2nBr2** |

All **halogen molecules** **(F2, Cl2, Br2, I2)** undergo an **addition reaction** with alkenes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **pent-2-ene** | **+** | **chlorine** |  | **2,3-dichloropentane** |
|  | **+** |  |  |  |
| **C5H10** | **+** | **Cl2** |  | **C5H10Cl2** |

**MORE ADDITION REACTIONS – HYDROGEN**

Hydrogen molecules can add across a **C=C** given the right reaction conditions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **+** |  |  |  |
| **ethene** | **+** | **hydrogen** |  | **ethane** |
|  | **+** |  |  |  |
| **C2H4** | **+** | **H2** |  | **C2H6** |

When an **ALKENE** reacts with **HYDROGEN** the product of the reaction is an **ALKANE**

The **ADDITION REACTION** of **HYDROGEN** across **C=C** is called **HYDROGENATION**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **WORD EQUATION FOR THE ADDITION REACTION OF HYDROGEN WITH AN ALKENE (HYDROGENATION)** | | | | |
| **alkene** | **+** | **hydrogen** |  | **alkane** |
| **CnH2n** | **+** | **H2** |  | **CnH2n + 2** |

**BUTENE + HYDROGEN**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **but-2-ene** | **+** | **hydrogen** |  | **butane** |
|  | **+** |  |  |  |
| **C4H8** | **+** | **H2** |  | **C4H10** |

**MORE ADDITION REACTIONS – WATER (STEAM)**

**Water** molecules as **steam**, can add across a **C=C**, producing an **ALCOHOL (ALKANOL)** molecule.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **+** |  |  |  |
| **ethene** | **+** | **water** |  | **ethanol** |
|  | **+** |  |  |  |
| **C2H4** | **+** | **H2O** |  | **C2H5OH** |

The **–OH** group of atoms is called the **HYDROXYL GROUP**. All alcohol (alkanol) molecules have this group of atoms.

Ethanol is **common alcohol**. Ethanol is made in the oil industry by reacting **ethene** with **steam**. This is called **INDUSTRIAL ALCOHOL (ETHANOL)**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **WORD EQUATION FOR THE ADDITION REACTION OF WATER (STEAM) WITH AN ALKENE** | | | | |
| **alkene** | **+** | **water** |  | **alkanol (alcohol)** |
| **CnH2n** | **+** | **H2O** |  | **CnH2n + 1OH** |

**PROPENE + WATER (STEAM)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **propene** | **+** | **water** |  | **propan-1-ol** |
|  | **+** |  |  |  |
| **C3H6** | **+** | **H2O** |  | **C3H7OH** |

|  |  |
| --- | --- |
|  | To practise writing formula equations for addition reactions, and writing the equations for combustion of hydrocarbons, do the **ADDITION REACTIONS** examples on **page 5** of the **Practice Examples Booklet**. |

|  |  |  |
| --- | --- | --- |
| **N4** | **CRACKING** | **N4** |

**SUPPLY AND DEMAND**

All crude oil undergoes **FRACTIONAL DISTILLATION** to separate out the **fractions.**

The following graph shows the supply of the fractions from crude oil and the world demand for each fraction.



**Percentage in North**

**Sea crude oil**

**World demand for**

**the fraction**

**KEY:**

**CONCLUSION**

The three fractions, which have greater demand than supply in crude oil, are **fuel gas**, **petrol** and **diesel**.

These fractions are the fuels, which are commonly used. There is a big difference between the supply and demand for petrol.

The big demand is for molecules with a small number of carbon atoms in their molecules.

To meet the demand for smaller molecules, oil refineries break up large molecules into smaller molecules in a process called **CRACKING**.

**LABORATORY CRACKING OF HYDROCARBONS**

In an oil refinery the fractions that are in greater supply than there is a demand (large molecules) are broken down into smaller molecules in a process called **CRACKING.**

Cracking involves **passing the hydrocarbon vapour over a hot catalyst**.



**ceramic wool soaked in liquid paraffin**

**HEAT**

**aluminium oxide**

**(catalyst)**

**bromine**

**solution**

**A CATALYST is a substance, which speeds up a reaction but does not get used by the reaction.**

|  |
| --- |
| **SAFETY NOTE**  The delivery tube has to be removed from the bromine solution **IMMEDIATELY** after heating stops to prevent **“SUCK- BACK”** of the cold water into the hot test tube, which could shatter the glass. |

**RESULTS**

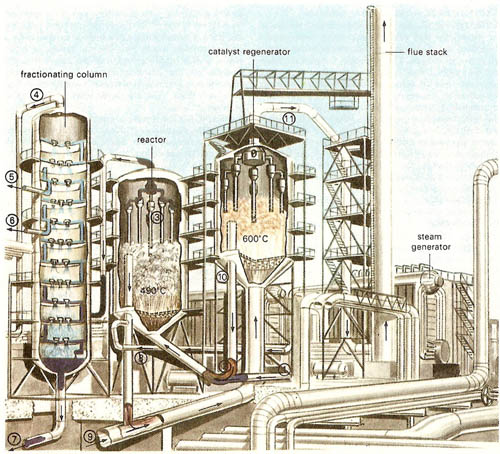
Liquid paraffin is a **colourless viscous liquid**, which does **not decolourise bromine solution**.

The products of cracking are **gases**, which **rapidly decolourise bromine solution**.

**CONCLUSION**

Liquid paraffin contains large molecules as it is a viscous liquid, and all the bonds between the carbon atoms are single bonds, **C – C**, i.e. a **saturated hydrocarbon**.

The products of cracking are small molecules as they are gases. The molecules contain carbon-to-carbon double bonds, **C=C**, as they rapidly decolourise bromine solution. The products contain **unsaturated hydrocarbons**.

****

**INDUSTRIAL CRACKING**

|  |
| --- |
| **DICTIONARY - CRACKING**  **CRACKING** is the breaking down of a large hydrocarbon molecule into smaller molecules.  Cracking always produces a mixture of alkanes and alkenes. |

After cracking, **FRACTIONAL DISTILLATION** is carried out to separate the different smaller molecules.

Cracking produces **small alkanes**, which are used as fuels and **small alkenes**, which are very important industrial molecules.

|  |
| --- |
| The catalyst in cracking makes the reaction go faster at a lower temperature. This means that less energy is required, which makes the process less expensive to carry out.  When a catalyst is used in cracking the process is called **CATALYTIC CRACKING**. |

**CRACKING REACTION**

The following equations show the possible products obtained during the cracking of hexane.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  | **+** |  |
|  |  | **methane CH4** |  | **pent-1-ene C5H10** |
| **hexane C6H14** |  |  | **+** |  |
|  | **ethane C2H6** |  | **but-1-ene C4H8** |
|  |  | **+** |  |
| It is impossible to produce two alkanes from cracking, as there are not enough hydrogen atoms in the starting molecule to make two smaller alkanes. |  | **propane C3H8** |  | **propene C3H6** |
|  |  | **+** |  |
|  | **butane C4H10** |  | **ethene C2H4** |