St Mary's Anglican Girls' School

Organic Chemistry

CHAPTER 1 BONDING in HYDROCARBONS

1-1 COVALENT BONDING

When two atoms share a pair of valence electrons to form a chemical bond the resulting bond is called a COVALENT bond.

Since a carbon atom has four valence electrons it can form 4 covalent bonds. Hydrogen, oxygen, chlorine and fluorine are common examples of elements that can share electrons with carbon to form covalent bonds.

Carbon atoms can also form covalent bonds with other carbon atoms. The strength of a carbon – carbon bond is quite strong compared to other covalent bonds.

1-2 HYDROCARBONS

A hydrocarbon is a carbon based compound that contains only carbon atoms and hydrogen atoms. There are three distinct types of hydrocarbons:

a) ALIPHATIC HYDROCARBONS: the carbon atoms are arranged in a continuous chain

   e.g. -C-C-C-C-C-C- etc.

b) CYCLIC HYDROCARBONS: the carbon atoms form a ring or a cycle

   e.g. C-C-C

        C-C

c) AROMATIC HYDROCARBONS: these contain a ‘benzene’ ring of carbon atoms. The bonding in this type of hydrocarbon will be discussed later.

1-3 NAMING HYDROCARBONS

There are a number of strict (but highly logical) rules which are used to name hydrocarbons. These rules use the IUPAC system of conventions.

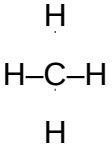
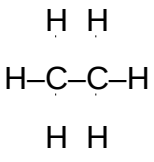
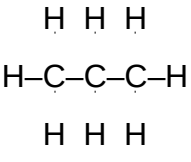
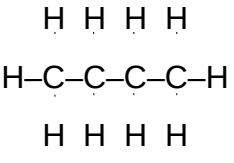
The number of carbon atoms present is indicated by a PREFIX as indicated below:

one carbon	**meth**	six carbons	**hex**
two carbons	**eth**	seven carbons	**hept**
three carbons	**prop**	eight carbons	**oct**
four carbons	**but**		
five carbons	**pent**		

The ending attached to each of these prefixes differs according to the type of bonding present. We will gradually introduce the procedure as we discuss the various hydrocarbons.

1-4 ALKANES

These are hydrocarbons in which all of the bonds between the carbon atoms are SINGLE covalent bonds.
They are described as SATURATED hydrocarbons because they cannot be made to react with hydrogen. The table below shows the first four members of the alkane family.

NAME	*FORMULA*	*STRUCTURAL FORMULA*
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	

NOTE!!

1. Alkanes are named by adding the suffix ANE to the prefix indicating the number of carbon atoms present.

   e.g. a six carbon alkane would be called HEXANE

2. The general formula for any alkane is

   $C_nH_{2n} + 2$

3. Alkanes are often used as fuels

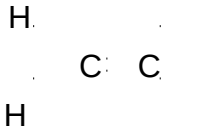
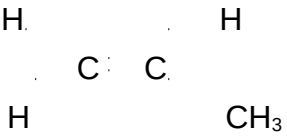
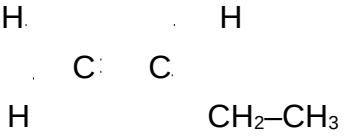
   e.g. octane is a major constituent of petrol.

SOME ALKANES

Alkane	Formula	Melting point C	Boiling point C
Methane	CH_4	-183	-161
Ethane	C_2H_6	-172	-89
Propane	C_3H_8	-190	-42
Butane	C_4H_{10}	-135	-1
Pentane	C_5H_{12}	-130	36
Hexane	C_6H_{14}	-94	68
Heptanes	C_7H_{16}	-90	98
Decane	$C_{10}H_{22}$	-30	174
Pentadecane	$C_{15}H_{32}$	10	271
Triacontane	$C_{30}H_{62}$	66	450

1-5 ALKENES

These have a DOUBLE covalent bond between carbon atoms. We say that alkenes are UNSATURATED because the carbon atoms on either side of the double bond can react with further hydrogen atoms. The presence of the double bond makes alkenes more reactive than alkenes.

NAME	*FORMULA*	*STRUCTURAL FORMULA*
Ethene	C_2H_4	
Propene	C_3H_6	
Butene	C_4H_8	

NOTE!!

1. Alkanes are named by adding the suffix **ENE** to the appropriate carbon prefix

   e.g. a five carbon alkene would be called PENTENE

2. The general formula for an alkene is

   C_nH_{2n}

3. In some larger alkenes the position of the double bond in the carbon chain can lead to molecules of a different structure.

   e.g. 

   1-butene 2-butene

   The number in front of the name is used to show the position of the double bond. Such compounds are called ISOMERS and will be discussed in a later chapter.

1-6 ALKYNES

These are UNSATURATED hydrocarbons which have a TRIPLE covalent bond between two carbon atoms in the chain.

NAME	*FORMULA*	*STRUCTURAL FORMULA*
Ethyne	C_2H_{42}	H–C⋮C–H
Propyne	C_3H_4	H H–C⋮C–C–H H
Butyne	C_4H_6	H H H–C⋮C–C–C–H H H

NOTE!!

1. Alkynes are named by adding the suffix YNE to the carbon prefix

   e.g. an 8 carbon alkyne would be called OCTYNE

2. The general formula for any alkyne is

   C_nH_{2n} - 2

3. For the larger alkynes the position of the triple bond can lead to the existence of isomers.

   e.g. 1-hexyne 2-hexyne 3-hexyne

DRAW

4. The most common alkyne is ethyne (acetylene) which is used in oxy-acetylene cutting flames.

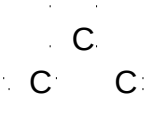
1-7 CYCLIC HYDROCARBONS

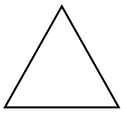
These may involve the presence of single, double or triple covalent bonds between carbon atoms. The rules for naming such hydrocarbons simply extend upon those discussed earlier.

Since drawing cyclic hydrocarbons tends to be time consuming there are a number of shorthand symbols used.

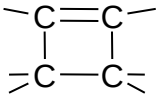
For example:

Cyclopropane

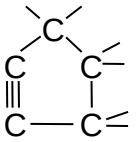


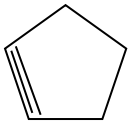


Cyclobutene



Cyclopentyne

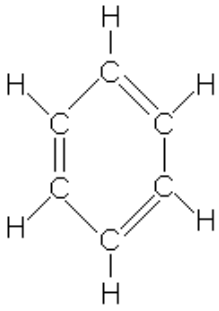




You will see that the naming procedure incorporates the ideas developed earlier but uses the ‘cyclo’ prefix to convey the cyclic nature of the bonding between the carbon atoms.

1-8 AROMATIC HYDROCARBONS

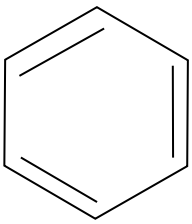
As mentioned earlier these compounds are based on a structure called a benzene ring which consists of 6 carbon atoms arranged hexagonally, each attached to one hydrogen atom (i.e. C_6H_6). The structure may be represented as

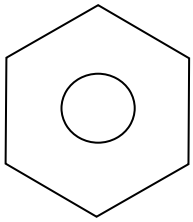


In reality the bonds are thought to be neither single nor double bonds. Some of the valence electrons are delocalised around the ring with the result that all of the bonds are identical.

The benzene ring is **very stable** (due to the presence of the delocalised electrons) and is not easily split open.

A benzene ring is commonly represented by either of the following symbols:





CHAPTER 1 REVISION QUESTIONS

1. Which of the following compounds are hydrocarbons?

   HCN, C_4H_8, C_9H_2O, CH_3OH, CO_2, C_6H_{12}

2. Draw electron dot diagrams to show the bonding in

   ethane, ethene, ethyne

3. Draw structural formulae for:

   propane, pentane, octane, 2-hexene, 1-butyne, 3-heptyne, propene, 1-pentene, hexane

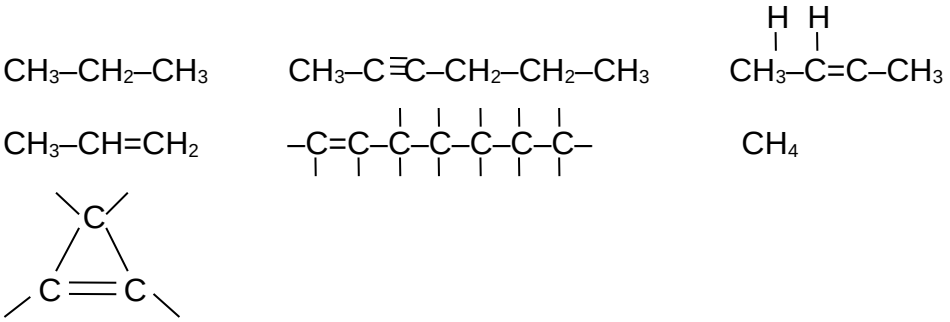
4. Classify each of the following hydrocarbons as alkanes / alkenes / alkynes

   C_3H_6, $C_{11}H_{24}$, C_9H_{16}, C_4H_6, $C_{20}H_{40}$, $C_{10}H_{22}$

5. Draw structural formulas for

   cyclopropane, cyclobutane, cyclohexane, cyclopentyne, cyclopropene, cyclohexyne

6. Name each of the following



CHAPTER 2 BRANCHED HYDROCARBONS

2-1 ALKYL GROUPS

These are groups of atoms formed by the removal of a hydrogen atom from an alkene.

For example:

CH_4	forms	CH_3 (methyl group)
C_2H_6	forms	C_2H_5 (ethyl group
C_3H_8	forms	C_3H_7 (propyl group)

Each of these groups CANNOT exist on their own since they contain a carbon atom with only 7 valence electrons in the outer shell. However, they are often found joined to large chains of carbon atoms.

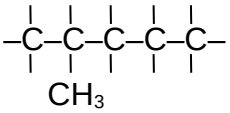
2-2 NAMING BRANCHED HYDROCARBONS

There are 2 basic rules which need to be applied:

1. Select the longest continuous carbon chain in the molecule (this becomes the basic structure for deducing the name)
2. Using the LOWEST numbers possible, identify the alkyl groups attached to the main carbon chain.

This may seem complicated but with practice it can be easily mastered.
You should study each of the following examples very closely:

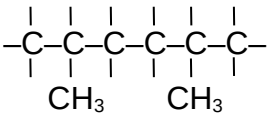
Example 1



2-methylpentane

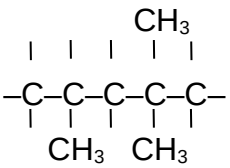
where group longest chain

Example 2



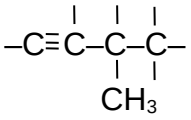
2,5-dimethylhexane

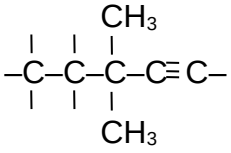
Example 3



2,2,4-trimethylpentane

Branched alkenes and alkynes are named in a similar manner except that the double (or triple) bond is always given preference when the numbers for each carbon are determined.

Example 4  3-methyl-1-butene

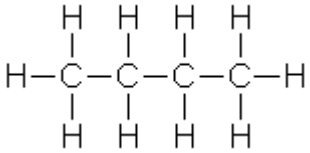
Example 5  3,3-dimethyl-1-pentyne

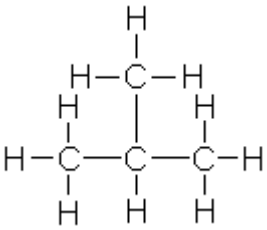
Just a quick point to remember!!!!
Commas are used between NUMBERS whereas dashes are used between NUMBERS and WORDS.

2-3 ISOMERS

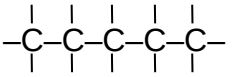
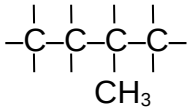
Two or more compounds which have the same molecular formula but with a different structural arrangement of atoms are called **ISOMERS**.

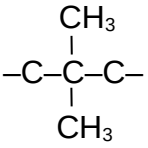
A simple example would be the two alkanes shown below, both of which have the molecular formula C_4H_{10}.

butane 

2-methylpropane 

It is possible to deduce the number of isomers in a logical way. For example there are three isomers having the molecular formula C_5H_{12}:

 pentane  2-methylbutane

 2,2-dimethylpropane

The greater the number of carbon atoms in the molecule the greater the number of possible isomers. For example the alkane C_9H_{20} has 35 possible isomers.

Isomers also exist for alkenes and alkynes for a variety of reasons:

1. the position of the double/triple bond may be varied along the carbon chain

   e.g. 1-butyne and 2-butyne

2. Alkyl groups may be attached in different places along the carbon chain

   e.g. 1 butene and 2-methylpropene are isomers both having the same molecular formula C_4H_8

3. Alkenes may exist as GEOMETRIC isomers due to the fact that rotation of atoms about a DOUBLE bond is not possible.

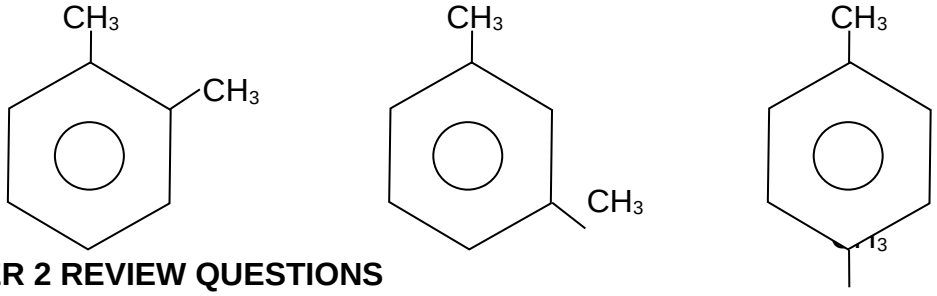
   For example, consider 2-butene

   The first structure cannot be converted into the second without breaking the double bond (and thus forming a total different compound) so they are actually distinct molecular structures.

   This is an example of “cis and trans” isomerism. We would name each of the above compounds as

   cis-2-butene and trans-2-butene

   Aromatic compounds also show isomerism. For example there are 3 different compounds having the general name of dimethylbenzene. They are drawn below, see if you can name them correctly!!

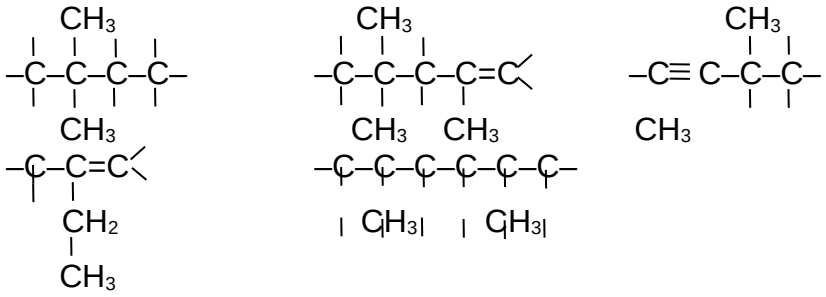


CHAPTER 2 REVIEW QUESTIONS

1. Draw each of the following:

   2-methylpentane 2,3-dimethylhexane
   2,3,3-trimethyloctane 3-ethylheptane
   methyl benzene 3-methyl-2-pentene
   3,4-dimethyl-hexene 1,4-diethylbenzene

2. Name each of the following:



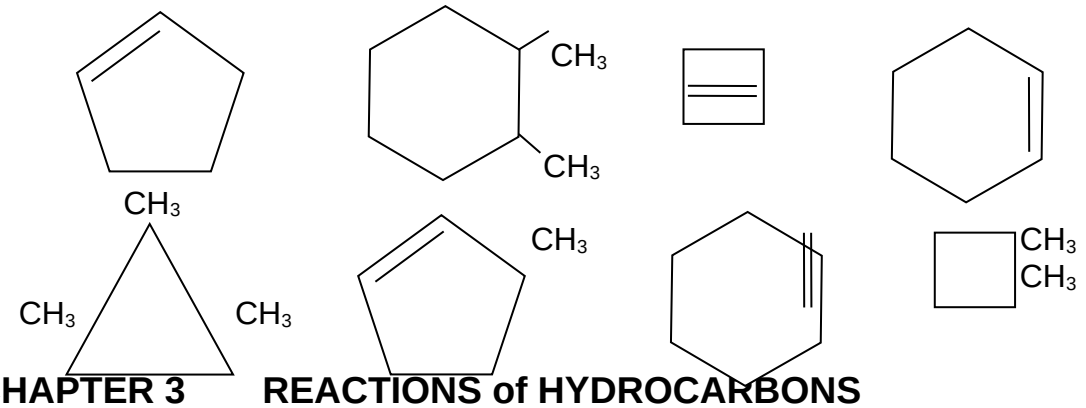
3. What is wrong with the name 2,3-dimethyl-2-butene?

4. Draw and name all of the isomers of C_6H_{14}.

5. Draw and name all of the isomers of C_5H_{10}.

6. There are 3 isomers of the compound ‘dichloroethene”
Draw their structures and give their IUPAC names.

7. Name each of the following cyclic hydrocarbons:



CHAPTER 3 REACTIONS of HYDROCARBONS

3-1 COMBUSTION

Whenever a hydrocarbon is burnt in excess oxygen or air carbon dioxide and water vapour are always produced. The reactions are very exothermic and hence many hydrocarbon are used as fuels.

e.g. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
$CH_3 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

3-2 SUBSTITUTION REACTIONS

These are relatively slow reactions that occur between saturated hydrocarbons and halogens (chlorine, iodine, fluorine and bromine) and involve the replacement or substitution of a hydrogen atom.

For example:

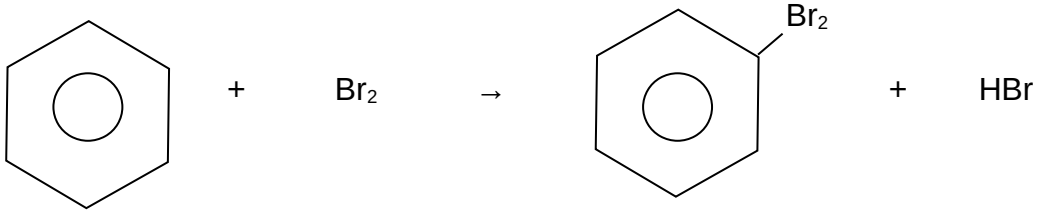
$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$
methane chloromethane

$CH_3\text{-}CH_3 + Br_2 \rightarrow CH_3\text{-}CH_2Br + HBr$
ethane bromoethane

In some cases substitution reactions may lead to a mix of isomeric products. For example the reaction between propane and fluorine will produce both 1-fluoropropane and 2-fluoropropane depending on where the substitution actually occurs.

Because of the high stability of the bonding within a benzene ring it is common to find substitution reactions among aromatic compounds.

e.g. benzene + bromine → bromobenzene + HBr



3-3 ADDITION REACTIONS

Due to the presence of the double bond, alkenes are much more reactive than alkanes. The double bond can be broken to form a single bond and so new atoms can 'add' to the existing molecule. Such reactions are called **ADDITION** reactions.

e.g. $CH_2=CH_2 + H_2 \rightarrow CH_3–CH_3$
ethene ethane

$CH_3–CH=CH_2 + H_2 \rightarrow CH_3–CH_2–CH_3$
propene propane

$CH_2=CH_2 + Br_2 \rightarrow CH_2Br–CH_2Br$
ethene 1,2-dibromoethane

NOTE!!!

1. Addition reactions provide a simple means of identifying whether a given hydrocarbon is an alkene or alkane. By looking for a **rapid** reaction with bromine water the presence of an unsaturated hydrocarbon can be inferred.

2. Alkynes also undergo addition reactions but more **slowly** than alkenes. The reaction usually involves two stages; the triple bond is converted to a double bond and then to a single bond.

   e.g. $H–C\equiv C–H + H_2 \rightarrow CH_2=CH_2$
   ethyne ethene

   then $CH_2=CH_2 + H_2 \rightarrow CH_3–CH_3$
   ethene ethane

3-4 COMPARING ADDITION and SUBSTITUTION

The chart below compares some of the important aspects of the two types of reactions:

	FEATURE	*SUBSTITUTION*	*ADDITION*
1.	Involves	alkanes and aromatics	alkenes and alkynes
2.	Rate	usually slow	usually rapid
3.	Changes	replace h by x	add two x atoms to molecule
4.	Number of products	two	one

3-5 HYDROCARBONS AS FUELS

As discussed in 3-1 the combustion of hydrocarbons in air produces carbon dioxide, water vapour and large amounts of **energy in the form of heat and or light**.

Small hydrocarbons are more volatile than larger ones and are therefore more flammable. Some common fuels are discussed below:

1. NATURAL GAS (mainly methane with small amounts of ethane and propane)

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \quad \Delta H = -890$ kJ

It is used for domestic cooking and heating.

2. LIQUID PETROLEUM GAS(LPG) is mainly propane gas.

   $C_3H_8 + 5O_2 \rightarrow 2CO_2 + 4H_2O \quad \Delta H = -220$ kJ

   It is used as a portable energy source for BBQ's and camping uses.

3. BUTANE (cigarette lighter fuel)

   $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O \quad \Delta H = 02879$ kJ

4. PETROL (mainly octane)

   $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O \quad \Delta H = -5471$ kJ

5. ETHYNE (used as a welding gas called acetylene)

   $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O \quad \Delta H = -1300$ kJ

6. KEROSENE (mainly a mixture of alkanes/alkenes in the range C_8 to C_{16})

The suitability of a given fuel depends on such factors as:

a) the rate at which it burns

b) the cleanliness of the combustion process

c) the cost

d) the energy output per mole (or per gram)

e) the relative proportions of the heat and light formed.

REVIEW QUESTIONS FOR CHAPTER 3

1. Write balanced equations to show the combustion of

   ethane, pentane, hexane, propene, benzene

2. Write a balanced equation to show the reaction of ethene with bromine water. what would you expect to see?

3. Write equations for the following and state whether the reaction involves **addition** or **substitution**.

   a) propene and chlorine
   b) methane and bromine
   c) 1-pentene and hydrogen
   d) ethene and fluorine
   e) benzene and chlorine
   f) ethyne and bromine
   g) propane and fluorine
   h) propene and HCl
   i) cyclohexane an chlorine
   j) cyclohexene and bromine

ORGANIC TASK 1

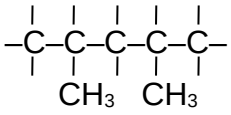
1. Draw neat structural formulas for:

   a) propane
   b) ethene
   c) 2-pentene
   d) methane
   e) 3-hexyne
   f) propyne
   g) cyclobutane
   h) 2-methylbutane
   i) ethyl benzene
   j) 2,3-dimethylpentane
   k) 2-methyl-2-butene
   l) cyclohexene
   m) 2,3,3-trimethyloctane

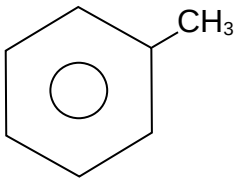
2. Name each of the following:

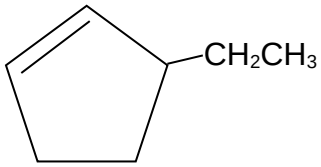
   a) $CH_3–C\equiv C–H$

   b) $CH_3–CH=CH-CH_3$

   c) 

   d) $CH_2=CH_2–CH_3$

   e) 

   f) 

3. Explain what is meant by the term ISOMER.

   There are 3 isomers having the formula C_5H_{12}. Name and draw them.

4. Draw and name all of the isomers having the general name of dichlorobenzene.

5. How many different isomers have the formula C_4H_6? Name and draw them all.

6. Name and draw all the isomers of dibromobutene.

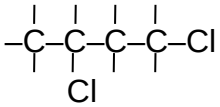
7. What is the general formula for a cycloalkane?

ORGANIC TASK 2

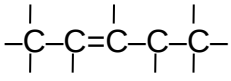
1. Draw structures for the following:

   a) trichloromethane
   b) 4,4-dimethyl-2-pentene
   c) 1-bromo-1-pentene
   d) 1,1,1-trichloroethane
   e) 1,2,3-tribromopropane
   f) 1,3-dimethylcyclobutan
   g) 3-heptyne
   h) 4-methyl-2-chloro-1-hexene

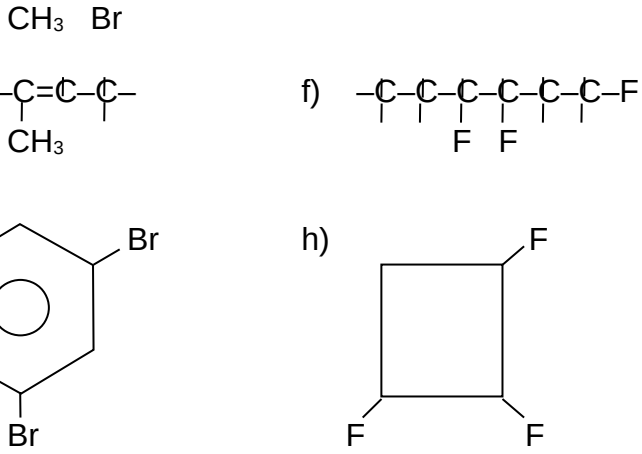
2. Give the IUPAC name for each of the following:

   a) 

   b) $F–C\equiv C–CH_3$

   c) 

   d) $CH_2=CH–CHCl_2$



3. For each of the following state whether an addition or substitution reaction occurs, write the balanced equation and name the organic product formed.

a) ethane and bromine gas
b) propene and hydrogen gas
c) 1-butene with chlorine
d) cyclopropane with fluorine gas
e) propane with fluorine
f) benzene with iodine
g) 1-hexene with hydrogen
h) cyclobutyne with bromine

Organic Compounds with Functional Groups

Compounds other than hydrocarbons are classified by the nature of a functional group which largely determines the properties of the substance.

We are interested in the properties of

alcohols	like	ethanol
aldehydes	like	methanal
carboxylic acids	like	acetic acid
ketones	like	propanone (acetone)
esters	like	ethyl acetate
amines	like	ethanamine
alkyl halides	like	chloromethane

We shall consider the structure and naming of these groups first and then look in detail at some of their properties.

<u>Alcohols</u>

R-OH

e.g.	CH_3OH	C_2H_5OH	C_3H_7OH	$C_5H_{11}OH$
	methanol	ethanol	1-propanol	1-pentanol

These are all classified as **primary alcohols**. The OH group (hydroxyl) is positioned on a carbon atom which is, in turn, bonded to only one other carbon.
The OH group may be located on any carbon atom in the chain thus many isomers of alcohols are possible.

- Draw structures for the alcohols listed above

- Draw structures for isomers of propenol and pentanol.

- Are the isomer you have drawn all primary alcohols?

- Suggest which may be secondary or tertiary and why.

- What type of intermolecular force would be most significant between alcohol molecules?

- Describe some of the physical properties associated with these forces.

- List some uses of the more common alcohols.

<u>Aldehydes</u>

RCHO

CH_3CHO	C_2H_5CHO	C_4H_9CHO	$C_7H_{15}CHO$
ethanal	propanal	pentanal	octanal

- Draw structures for ethanal, methanal and pentanal.

- Is it possible for the –CHO group to be situated anywhere apart from on the end of the hydrocarbon chain? Explain your answer.

Carboxylic acids

RCOOH

CH_3COOH	C_2H_5COOH	C_3H_7COOH
acetic acid	propanoic acid	butanoic acid

- Draw the structures of the acids listed above.

- What do these acid structures have in common with the aldehyde structures?

- And also?

Ketones

R-CO-R

CH_3COCH_3	$CH_3COCH_2CH_3$	$C_2H_5COC_2H_5$
propanone (acetone)	butanone	3-pentanone

- Draw structures for these ketones.

- Draw isomers for pentanone.

- What does the ketone structure have in common with the structure of aldehydes and carboxylic acids?

Esters

RCOOR

CH_3COOCH_3	$C_2H_5COCH_3$	$C_2H_5COOC_2H_5$
methyl acetate	methyl propanoate	ethyl propanoate

These compounds are named as though they were salts of carboxylic acids. Esters derived from acetic acid are acetates, from propanoic acid are propanoates etc.

- Draw these structures.

- Draw the isomers of ethyl propanoate which are also esters.

- Do esters contain a carbonyl group?

Amines

RNH_2

CH_3NH_2	$C_2H_5NH_2$	$C_6H_5NH_2$
methanamine	ethanamine	aminobenzene

Amines have structures similar to that of ammonia.

- Draw the structure of the pyramidal methanamine molecule.

- How would the presence of a lone pair of electrons on the nitrogen atom influence the chemical properties of this amine?

Alkyl halides (haloalkanes)

R-X

CH_3Cl	C_2H_5I	C_3H_7F	C_6H_5Br
chloromethane	iodethane	fluoropropane	bromobenzene

Organic Task 3

1. Copy and complete the following table which describes some aspects of the chemistry of hydrocarbons.

Name	Formula	Reacts by	Products of this reaction
methane			
	C_2H_2		
		addition	1,2-dichloroethane
			1,1-dichloroethane

2. Draw structural formulae for each of the following compounds.
dichloromethane, bromoethane, propyne, methyl butane, ethyl pentane, 4-methyl-2-hexene, 2,2,4-trimethyl pentane.

3. Describe the intermolecular forces that exist between molecules in a solid alkane.

4. Write a general equation to describe the complete combustion of alkanes.

5. Explain how alkenes are capable of exhibiting geometric (cis-trans) isomerism whilst alkanes are not.

6. Draw structural formulae for the following
cis-2-butene, 4,4-dimethyl-trans-2-pentene

7. Write equations for the following reactions.
The chlorination of propene
The hydration of ethene
The bromination of ethane.

8. Two important derivatives of benzene are phenol and toluene. Draw their structures and state their IUPAC names.

Reactions of organic compounds with functional groups

<u>Amines</u>

Amines, based on the ammonia structure, having a lone pair of electrons on the nitrogen atom, are readily hydrolysed to form basic solutions.

$R\text{-}NH_2 + H_2O \rightarrow R\text{-}NH_3^+ + OH^-$

<u>Carboxylic acids</u>

These acids are weak. They perform the usual reactions of dilute acids such as those with metals, carbonates, bases etc.

$2CH_3COOH + Mg \rightarrow 2CH_3COO^- + Mg^{2+} + H_2$

Carboxylic acids also react with alcohols, in the presence of conc. sulfuric acid, to form ester (described in detail under reactions of alcohols)

Alcohols

Alcohols react with the **strong reducing metals** like sodium.

$2R\text{-}OH + 2Na \rightarrow 2R\text{-}O^-Na^+ + H_2$
$2C_2H_5OH + 2Na \rightarrow 2C_2H_5O^-Na^+ + H_2$
ethanol sodium ethoxide

alcohols undergo **esterification** when reacted with carboxylic acids. Such reactions proceed most readily if the reagents are heated slightly and if the reaction is carried out in the presence of conc. sulfuric acid.
Esters are fruity smelling, oily liquids. They occur naturally as oils in fruit and vegetables and are responsible for the perfume emitted by many plants.

$C_2H_5OH + CH_3COOH \rightarrow CH_3COOC_2H_5 + H_2O$
ethanol acetic acid ethyl acetate

$CH_3OH + C_2H_5COOH \rightarrow C_2H_5COOH_3 + H_2O$
methanol propanoic acid methyl propanoate

STAWA Exp't

Alcohols may be **oxidised** by common oxidising agents like acidified MnO_4 and $Cr_2O_7^{2-}$.

Oxidation of primary alcohols

1° alcohol → aldehyde → carboxylic acid

- Work out the oxid'n and red'n half equations and hence develop the overall equations for the complete oxidation of ethanol with acidified potassium permanganate solution.

Oxid'n

Red'n

Overall

- Work out the oxid'n and red'n half equations and hence develop the overall equations for the incomplete oxidation of propenol with acidified potassium dichromate solution.

Oxid'n

Red'n

Overall

Secondary alcohols are similarly oxidised to form **ketones**.

- Work out the oxid'n and red'n half equations and hence develop the overall equations for the oxidation of 2-propanol with acidified potassium dichromate solution.

Oxid'n

Red'n

Overall

- Work out the oxid'n and red'n half equations and hence develop the overall equations for the oxidation of 3-pentanol with acidified potassium permanganate solution.

Oxid'n

Red'n

Overall

STAWA Exp't

Organic Task 4

1. Draw structures for the following compounds
   2-chloropropane, bromocyclohexane, 2-chloro-1-propanol, 2-methyl phenol, methanamine, 2-butanone, ethyl butanoate.

2. Branching of the hydrocarbon chains in alcohol lowers their boiling points. Explain why this is so.
   Draw structures of four isomeric alcohols of formula $C_4H_{10}O$ and match these structures with the boiling points 83°C, 100°C, 108°C and 118°C.

3. Ethanol and ethanamine have similar molecular weights but remarkably different boiling points. State which compound has the higher boiling point and explain why this is so.

4. Write equations for the following reactions
   sodium with 2-propanol
   water with 2-methyl-2-butene
   acetic acid with calcium carbonate
   methanoic acid with ethanol
   ethanal with acidified potassium dichromate solution

5. Draw structures for

3-hydroxybutanal, 2-methyl-3-pentanone, 4-fluorohepanoic acid, propyl butanoate, 5-hydroxy-3-methyl pentanal

Organic Chemistry Revision

1. Give names and clearly draw the structures of the following compounds. (Show all hydrogen atoms)

   a) CH_3CH_2OH

   b) CH_3CHO

   c) CH_3COOH

   d) $C_2H_5NH_2$

2. Draw structural formulae for all the isomeric dichloro-benzenes.

3. Name the functional groups presents in each of the following compounds.

   a) $CH_3CH_2CH_2CHO$

   b) CH_3OH

   c) CH_3CH_2COOH

   d) $C_6H_5NH_2$

   e) $CH_3COOC_2H_5$

4. Draw and name all of the esters with the molecular formula $C_4H_8O_2$.

5. Draw structures for these compounds and state which compound is **not** isomeric with the other four.

   a) 1-butene
   b) cis-2-butene
   c) trans-2-butene
   d) 2-methyl propene
   e) cyclobutene

6. Arrange these compounds in order of **increasing** solubility in water.

CH_3Cl CCl_4 CH_3CHO CH_3COCH_3 CH_3CH_2OH

7. Write structural formulae for all carboxylic acids that are isomeric with ethyl ethanoate.

8. a) When 4.60 g of an organic compound containing C, H and O were burned in oxygen, 8.80 g of CO_2 and 5.40 g of H_2O were obtained.
What is the empirical formula of the compound?

b) When the compound is heated to 100°C at a pressure of 101 kPa is it gaseous and has a density of 1.50 gL^{-1}.
Calculate the molecular formula of the compound and suggest one possible, named, structure for it.

9. Ethanol can be prepared from the following series of reactions

$$C_3H_8 \rightarrow CH_4 + C_2H_4$$
$$C_2H_4 + H_2SO_4 \rightarrow C_2H_5HSO_4$$
$$C_2H_5HSO_4 + H_2O \rightarrow C_2H_5OH + H_2SO_4$$

If the reaction is 90% efficient what weight of alcohol is produced from 1.12 L of propane measured at STP?

10. Write balanced equations for each of the following reactions. In each case state one observation that you would expect to make.

a) methanol and ethanoic acid are warmed together in the presence of conc. sulfuric acid.

b) acidified potassium permanganate is added to a sample of 2-pentanol.

c) propane gas is bubbled through bromine water.

d) sodium metal is added to ethanol.

e) acidified potassium dichromate solution is added to methanal.

11. Describe how you could use a **chemical** test to distinguish between the following pairs of substances. You should describe the observations that make the distinction between the compounds.

a) ethanol and ethanal

b) cyclobutene and cyclobutane

c) 2-butanol and 2-methyl propenol

d) propanoic acid and ethyl ethanoate

e) propanone and propenol

12. When ethanol is treated with acidified potassium permanganate solution a redox reaction occurs. Write the oxidation and reduction halves of the equation and hence develop the overall balanced equation.

Oxid'n

Red’n

Working

Overall