UNIT 4 Structure, synthesis and design

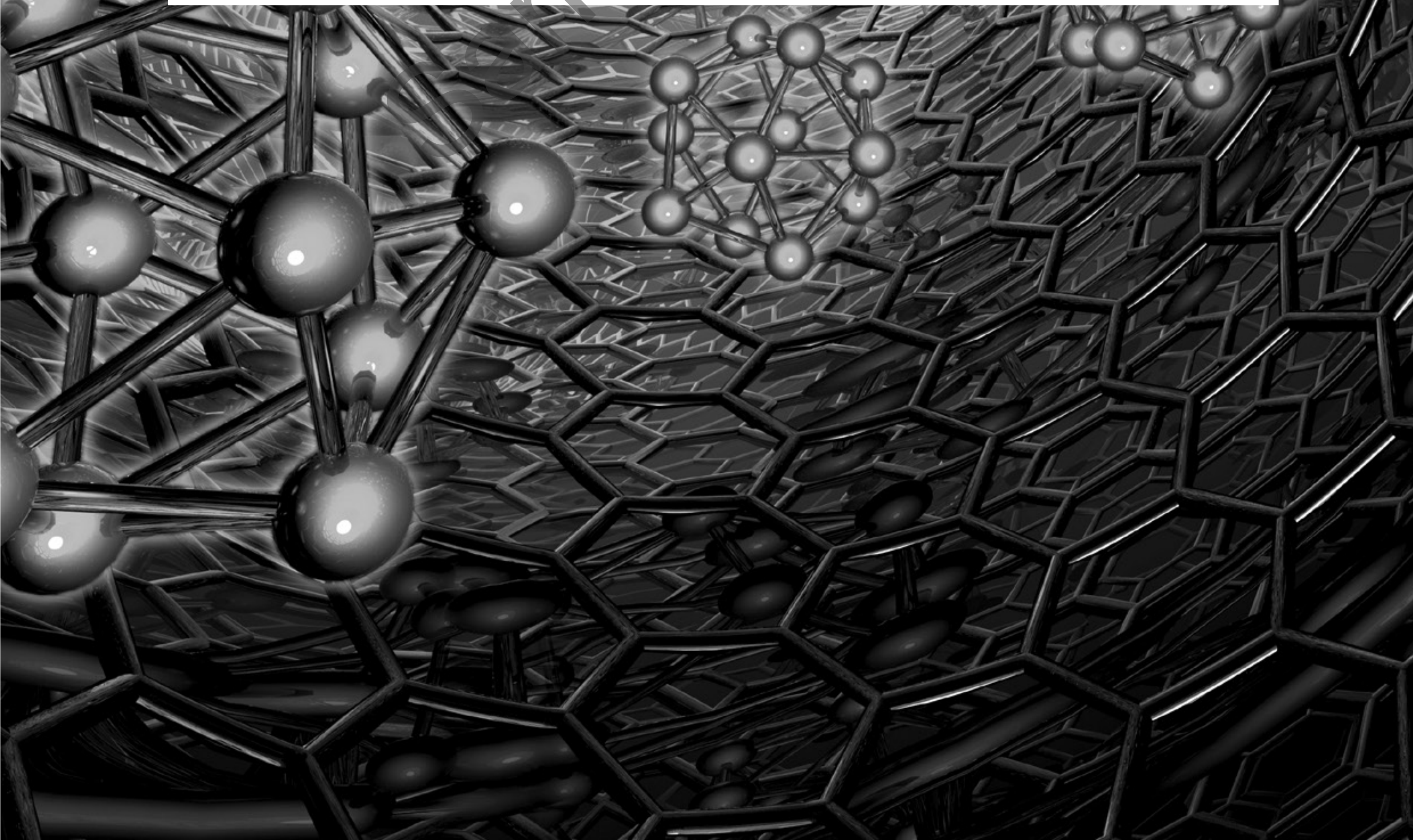
TOPIC 1 Properties and structure of organic materials

TOPIC 2 Chemical synthesis and design

Unit 4 objectives

Students will:

- describe and explain the properties and structure of organic materials and chemical synthesis and design
- apply understanding of the properties and structure of organic materials and chemical synthesis and design
- analyse evidence about the properties and structure of organic materials and chemical synthesis and design
- interpret evidence about the properties and structure of organic materials and chemical synthesis and design
- investigate phenomena associated with the properties and structure of organic materials and chemical synthesis and design
- evaluate processes, claims and conclusions about the properties and structure of organic materials and chemical synthesis and design
- communicate understandings, findings, arguments and conclusions about the properties and structure of organic materials and chemical synthesis and design.



TOPIC 1

Properties and structure of organic materials

- ☐ Worksheet 4.1.1 Knowledge preview—molecular shape and intermolecular forces

STRUCTURE OF ORGANIC COMPOUNDS

- ☐ Worksheet 4.1.2 Families of hydrocarbons—alkanes, alkenes and alkynes
- ☐ Worksheet 4.1.3 Families examined—properties and structure
- ☐ Practical activity 4.1.1 Reactions and properties of organic compounds
- ☐ **Mandatory practical 4 Modelling hydrocarbons, functional groups and organic reactions**

PHYSICAL PROPERTIES AND TRENDS

- ☐ Worksheet 4.1.3 Families examined—properties and structure
- ☐ Worksheet 4.1.4 Observing organics—properties of functional groups

ORGANIC REACTIONS AND REACTION PATHWAYS

- ☐ Worksheet 4.1.3 Families examined—properties and structure
- ☐ Worksheet 4.1.5 Converting chemicals—organic reaction pathways
- ☐ Worksheet 4.1.6 Focus on functional groups—effect on chemical reactions
- ☐ Practical activity 4.1.2 Oxidation of alcohols
- ☐ Practical activity 4.1.3 Action of enzymes

ORGANIC MATERIALS: STRUCTURE AND FUNCTION

- ☐ Worksheet 4.1.7 Proteins—structure and function
- ☐ Worksheet 4.1.8 Carbohydrates, fats, soaps and polymers—structure and function

ANALYTICAL TECHNIQUES

- ☐ Worksheet 4.1.9 Solving a chemical mystery using spectroscopy
- ☐ Worksheet 4.1.10 Forensic testing—blood alcohol concentration

- ☐ Worksheet 4.1.11 Literacy review—reviewing organic chemistry
- ☐ Worksheet 4.1.12 Thinking about my learning
- ☐ **Topic review 4.1**

 ISBN 978 1 4886 1968 7

Key knowledge

Carbon is a unique element. It has the unusual property of bonding strongly to itself, by covalent bonds, to form long chains or rings of carbon atoms. It also bonds covalently to other non-metals such as hydrogen, nitrogen, oxygen and the halogens to form millions of different compounds. The study of these compounds is called organic chemistry.

Structure of organic compounds

Organic molecules have a hydrocarbon skeleton, which forms the basic structure of these compounds. **Hydrocarbons** are compounds that contain only carbon and hydrogen. They are commonly found in petroleum deposits in the form of crude oil and natural gas. Hydrocarbons were formed millions of years ago from the decomposition of marine plants and animals. When used as fuels, they are often referred to as **fossil fuels**. Fossil fuels produce greenhouse gases (CO_2 and H_2O) when burnt and are non-renewable.

SATURATED HYDROCARBONS

Saturated hydrocarbons are compounds of carbon and hydrogen that have only carbon–carbon single bonds. They belong to a **homologous series** called the **alkanes**, with a general chemical formula of C_nH_{2n+2}. A homologous series is a group of organic compounds whose members differ by one CH_2 unit. The simplest saturated hydrocarbon is methane, CH_4.

Branches on a chain formed from alkanes have the formula $-C_nH_{2n+1}$, and are called **alkyl groups**. Alkyl groups (alkanes with one hydrogen atom removed) are often found in organic molecules. They are named on the basis of the parent alkane, but with a '-yl' suffix.

Table 4.1.1 gives the names and formulas of the first ten alkanes and the corresponding alkyl groups.

TABLE 4.1.1 Homologous series of alkanes and alkyl groups

Name of alkane	Formula	Name of alkyl group	Formula
methane	CH_4	methyl	$-CH_3$
ethane	CH_3CH_3	ethyl	$-CH_2CH_3$
propane	$CH_3CH_2CH_3$	propyl	$-(CH_2)_2CH_3$
butane	$CH_3(CH_2)_2CH_3$	butyl	$-(CH_2)_3CH_3$
pentane	$CH_3(CH_2)_3CH_3$	pentyl	$-(CH_2)_4CH_3$
hexane	$CH_3(CH_2)_4CH_3$	hexyl	$-(CH_2)_5CH_3$
heptane	$CH_3(CH_2)_5CH_3$	heptyl	$-(CH_2)_6CH_3$
octane	$CH_3(CH_2)_6CH_3$	octyl	$-(CH_2)_7CH_3$
nonane	$CH_3(CH_2)_7CH_3$	nonyl	$-(CH_2)_8CH_3$
decane	$CH_3(CH_2)_8CH_3$	decyl	$-(CH_2)_9CH_3$

UNSATURATED HYDROCARBONS

Unsaturated hydrocarbons are compounds of carbon and hydrogen that contain at least one carbon–carbon double bond or a carbon–carbon triple bond. Hydrocarbons with one double bond belong to a homologous series called the **alkenes** (general formula C_nH_{2n}). The names of the alkenes end in '-ene'. Hydrocarbons with one triple bond belong to the **alkynes** (formula C_nH_{2n-2}). The names of the alkynes end in '-yne'. Table 4.1.2 lists the first nine members of the alkenes and alkynes.

TABLE 4.1.2 Homologous series of alkenes and alkynes

Name of alkene	Formula	Name of alkyne	Formula
ethene	C_2H_4	ethyne	C_2H_2
propene	C_3H_6	propyne	C_3H_4
butene	C_4H_8	butyne	C_4H_6
pentene	C_5H_{10}	pentyne	C_5H_8
hexene	C_6H_{12}	hexyne	C_6H_{10}
heptene	C_7H_{14}	heptyne	C_7H_{12}
octene	C_8H_{16}	octyne	C_8H_{14}
nonene	C_9H_{18}	nonyne	C_9H_{16}
decene	$C_{10}H_{20}$	decyne	$C_{10}H_{18}$

ISOMERISM

Isomers are compounds that have the same molecular formula (same number of each type of atom), but differ in the way the atoms are arranged. There are two types of isomers: structural isomers and stereoisomers.

Structural isomers

Structural isomers are isomers that differ in the way the atoms are bonded to each other. They may have similar—but not identical—properties. Figure 4.1.1(a) on page 112 shows two isomers of butane, butane ($CH_3CH_2CH_2CH_3$) and 2-methylpropane ($(CH_3)_3CH$), which have the same molecular formula (C_4H_{10}) but have their carbon chains arranged differently. The two isomers of butene in Figure 4.1.1(b) have a different position of the functional group (the carbon–carbon double bond) and different molecular shapes.

Stereoisomers

All the atoms in **stereoisomers** are connected in the same order, but the orientation in space of some of the atoms is different.

Some unsaturated compounds form a type of stereoisomer called a **geometric isomer**. These isomers have the same molecular formula but different orientations of groups with respect to the carbon–carbon double bond. Whereas there is free rotation around C–C single bonds, rotation is not possible around a double bond.

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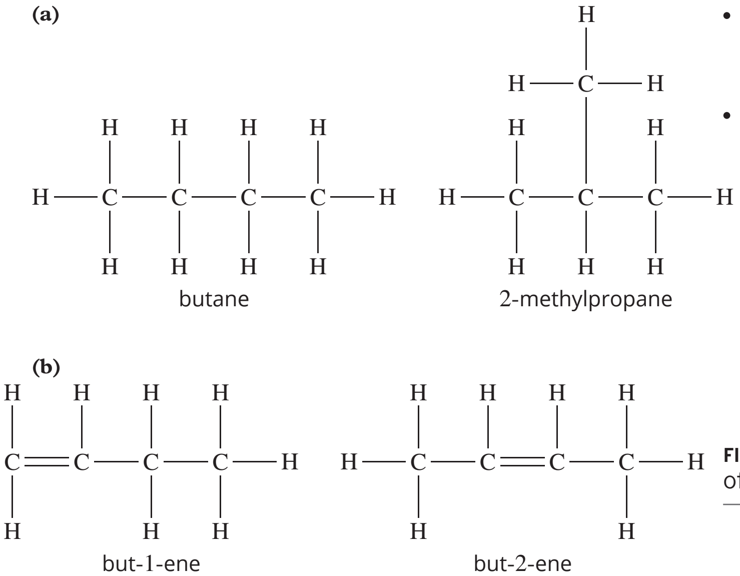

FIGURE 4.1.1 Structural isomers of (a) butane and (b) butene

Figure 4.1.2 shows the two ways groups can be arranged at the ends of a carbon–carbon double bond to form geometric isomers. There must be two different groups at each end of a double bond for a pair of geometric isomers to occur.

- The ***trans*-isomer** has two identical groups at the ends of the double bond, which are on the opposite side of the plane of the C=C bond.
- The ***cis*-isomer** has two identical groups at the ends of the double bond, which are on the same side of the plane of the C=C bond.

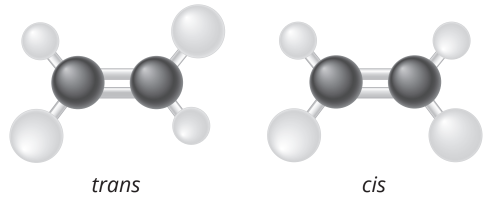

FIGURE 4.1.2 Geometric isomers differ in the arrangement of groups around a C=C bond.

This naming system can be extended to include non-identical alkyl groups. When the longest alkyl groups are on the same side, the isomer is labelled '*cis*'. If the longest alkyl groups are on opposite sides, the isomer is labeled '*trans*'.

IUPAC NOMENCLATURE

To name hydrocarbons unambiguously, the International Union of Pure and Applied Chemistry (IUPAC) has developed the set of rules listed in Table 4.1.3.

TABLE 4.1.3 IUPAC rules for naming hydrocarbons

Rule	Example	Name
1 Choose the longest carbon chain and name according to the alkane with the same number of carbon atoms. This chain should contain a C=C or C≡C bond, if one is present.	$CH_3CH_2CH_2CH_2CH_2CH_3$	hexane
2 If there is a C=C, replace '-ane' with '-ene' and number from the end that gives the smallest number for the first carbon atom involved in the bond.	$CH_3CH{=}CHCH_2CH_2CH_3$	hex-2-ene (not hex-4-ene)
3 If there is a C≡C bond, replace '-ane' with '-yne' and number from the end that gives the smallest number for the first carbon atom involved in the bond.	$CH_3C{\equiv}CCH_2CH_3$	pent-2-yne (not pent-3-yne)
4 When there is a branch and numbers have not already been established (such as by a double bond), number from the end that gives the smallest number to the branch.	$CH_3CH_2CH(CH_3)CH_3$	2-methylbutane (not 3-methylbutane)
5 Number all branches. Use prefixes such as 'di-', 'tri-' and 'tetra-' if branches are identical.	$CH_3CH(CH_3)CH(CH_3)CH_3$	2,3-dimethylbutane
6 If different alkyl branches are present, write them in alphabetical order.	$CH_3CH(CH_3)CH(CH_2CH_3)CH_2CH_3$	3-ethyl-2-methylpentane

Functional groups

A **functional group** is an atom or group of atoms that determines the properties of a molecule. The functional group changes the way the molecule reacts and behaves. A homologous series (or class) of organic molecules that contains the same functional group is given a particular name. For example, molecules containing the hydroxyl functional group (–OH) belong to the homologous series called alcohols.

Table 4.1.4 lists common functional groups. The systematic naming of compounds with functional groups follows the same general rules for hydrocarbons. The presence of the functional group is indicated using specific prefixes or suffixes. The rules for naming compounds containing functional groups are listed in Table 4.1.5 on page 114.

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TABLE 4.1.4 Common functional groups

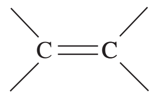
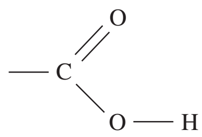
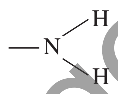
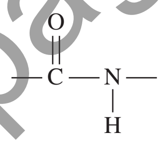
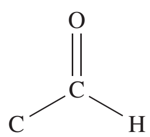
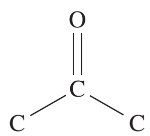
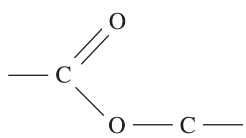
Name of functional group	Name of homologous series (or class) to which they belong	Structure	Prefix or suffix used in naming
double bond	alkenes	–C=C– 	-ene
triple bond	alkynes	–C≡C–	-yne
hydroxyl	alcohols	–OH	-ol
carboxyl	carboxylic acids	–COOH 	-oic acid (The carbon atom in this group is always numbered as carbon 1 and never given in the name because its presence is understood.)
halo	halohydrocarbons	–F, –Cl, –Br, –I	fluoro-, chloro-, bromo-, iodo-
amino	amines	$–NH_2$ 	-amine
amide	amides (also present in proteins, where they are called peptides)	–CONH– 	-amide
nitrile	nitriles	–C≡N	-nitrile (The carbon atom in this group is always numbered as carbon 1 and never given in the name because its presence is understood.)
carbonyl	aldehydes (if the carbonyl group, C=O, is bonded to a hydrogen atom)	–CO  A carbonyl group in an aldehyde	-al (The carbonyl group in aldehydes is at the end of the carbon chain.)
carbonyl	ketones (if the carbonyl group is in the middle of the chain)	–CO  A carbonyl group in a ketone	-one
ester	esters	–COOC– 	The name has two parts: the part singly bonded to oxygen is written in front of the parent name and ends in '-yl', and the parent name ends in '-oate'.

TABLE 4.1.5 Rules for naming organic compounds with functional groups

Rule	Example	Name
1 For alcohols, replace the '-e' of the hydrocarbon with '-ol' at the end of the hydrocarbon name. Indicate the position of the hydroxyl group with a number before the '-ol' ending.	$CH_3CH_2CH_2OH$ $CH_3CH_2(OH)CH_3$	propan-1-ol propan-2-ol
2 For amines, replace the '-e' of the hydrocarbon with '-amine' at the end of the hydrocarbon name. Indicate the position of the amino group with a number before the '-amine' ending.	$NH_2CH_2CH_2CH_3$ $CH_3CH(NH_2)CH_3$	propan-1-amine propan-2-amine
3 For haloalkanes, insert 'fluoro-', 'chloro-', 'bromo-' or 'iodo-' at the front of the hydrocarbon name. Indicate the position of the group with a number before the halo name.	$CH_3CH_2CH_2Cl$ CH_3CHFCH_3	1-chloropropane 2-fluoropropane
4 For carboxylic acids, replace '-e' with '-oic acid'. Remember, the carbon atom doubly bonded to oxygen is always counted as carbon 1.	CH_3CH_2COOH	propanoic acid
5 Esters can be regarded as being made from an alcohol and a carboxylic acid. To name an ester, the first part of the name comes from the alcohol, replacing '-anol' with '-yl' , and the second part of the name comes from the carboxylic acid, replacing '-oic' acid with '-oate'.	$CH_3CH_2COOCH_2CH_2CH_2CH_3$	butyl propanoate

When there are two functional groups in a molecule, IUPAC nomenclature indicates an order of priority (Table 4.1.6).

- The functional group with the higher priority determines the parent name of the molecule.
- The presence of a functional group with the lower priority is shown by a prefix in front of the parent name; a number indicates its position in a molecule.

TABLE 4.1.6 IUPAC table of priority for functional groups

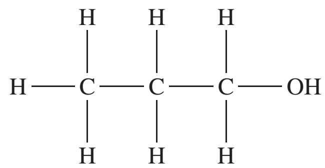
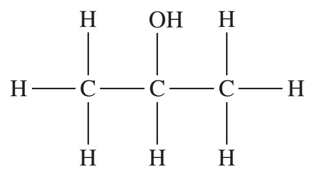
Functional group priority order	Parent name
carboxyl	-oic acid
hydroxyl	-ol
amine	-amine
alkene	-ene
alkyne	-yne
halo	halo- (prefix)

For example, the name of $CH_3CH(OH)CH_2COOH$ is 3-hydroxybutanoic acid and $CH_3CHClCH(OH)CH_3$ is 3-chlorobutan-2-ol. Note that the highest priority functional group is a carboxyl group.

Types of formulas

An **extended structural formula** shows the arrangement of atoms in space and all the bonds between atoms. **Condensed structural formulas** show the atoms that are connected to each carbon atom but do not show the bonds (Table 4.1.7).

TABLE 4.1.7 Examples of formulas of organic compounds

Name	Molecular formula	Condensed structural formula	Extended structural formula
propan-1-ol	C_3H_8O	$CH_3CH_2CH_2OH$	
propan-2-ol	C_3H_8O	$CH_3CH(OH)CH_3$	

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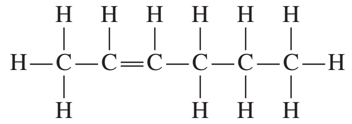
WORKSHEET 4.1.2

Families of hydrocarbons—alkanes, alkenes and alkynes

The structural formulas of fifteen hydrocarbon compounds are shown below.

A


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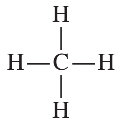

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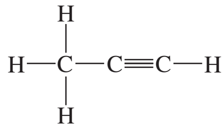

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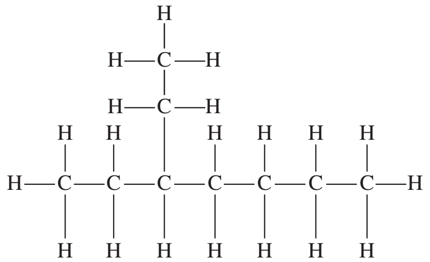

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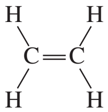

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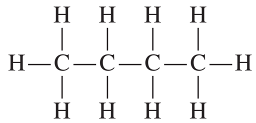

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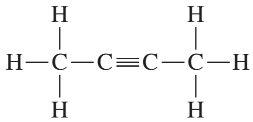

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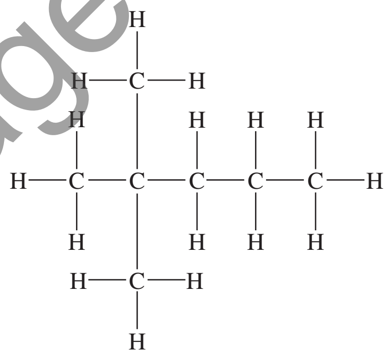

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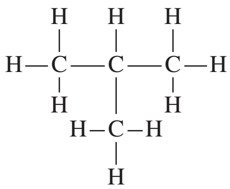

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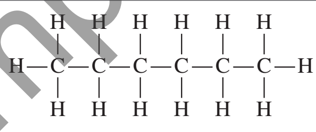

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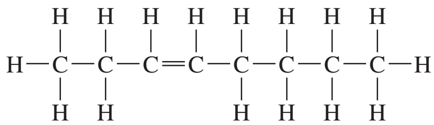

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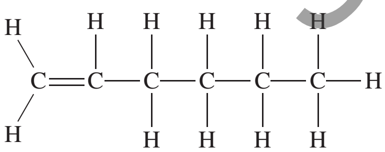

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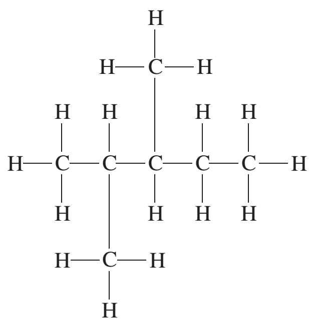

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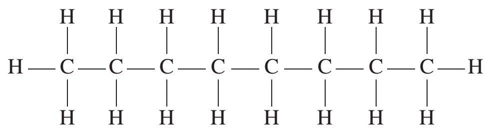

1 List the letters of all compounds that are unbranched alkanes.

2 List the letters of all compounds that are branched alkanes.

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3 List the letters of all the compounds that are alkenes.

4 List the letters of all the compounds that are alkynes.

5 a State the meaning of the term ‘homologous series’.

b Show the condensed formulas of the two members of the homologous series that follow the molecule with the formula CH_3CH_2OH.

6 List the letters of all the compounds that are unsaturated.

7 List the letters of all the compounds that are saturated.

8 Explain the meaning of the terms ‘saturated’ and ‘unsaturated’.

9 Identify the compound you would expect to have the lowest boiling point and explain your answer.

10 Identify the compounds you would expect to decolourise bromine and explain your answer.

11 Identify structural isomers in the compounds shown above.

12 Indicate the systematic name of each compound.

A ______ F ______ K ______

B ______ G ______ L ______

C ______ H ______ M ______

D ______ I ______ N ______

E ______ J ______ O ______

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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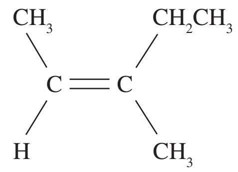
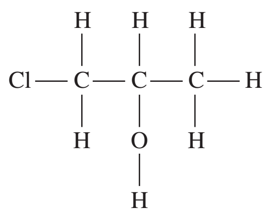
WORKSHEET 4.1.3

Families examined—properties and structure

Show the missing condensed and extended structural formulas in the following table, and identify the missing molecule names. State whether each statement is true or false in the last column.

Name of molecule	Condensed structural formula	Extended structural formula	Statement	True or false?
ethanol			Is soluble in water and dissolves by forming hydrogen bonds.	
			Has the general formula C_nH_{2n}.	
			Is formed by a substitution reaction between NaOH and chloroethane.	
			Undergoes an elimination reaction to produce an alkene.	
hexan-2-one			Contains a C=C bond.	
			Is the product of oxidation of hexan-2-ol.	
			Contains a carbonyl group.	
			Is a ketone.	
butanamide			Is insoluble in water.	
			Does not have significant acid–base properties.	
	$CH_3CH_2CH(OH)CH_3$		Is a primary alcohol.	
			Does not form hydrogen bonds.	
			Is a saturated alcohol.	
	$CH_3CH_2CH_2COOH$		Is soluble in water.	
			Partially dissociates in water to form H_3O^+.	
			Is a member of the homologous series of alcohols.	
			Has only dispersion forces between molecules.	
	$CH_3CH_2COOCH_3$		Is a polar molecule.	
			Forms dipole–dipole forces between molecules.	
			Is formed by the reaction of methanoic acid with propan-1-ol in the presence of sulfuric acid.	
2-chloropentane			Is an isomer of 2-chloro-2-methylbutane.	
			Undergoes substitution reactions.	
			Is a saturated compound.	

WORKSHEET 4.1.3

Name of molecule	Condensed structural formula	Extended structural formula	Statement	True or false?
	$CH_3CHC(CH_3)CH_2CH_3$		Undergoes addition reactions.	
			Belongs to the homologous series of alkanes.	
			Dissolves in water by forming hydrogen bonds.	
	$CH_3CH_2CH_2NH_2$		Is more volatile than longer chain amines.	
			Is an unsaturated compound.	
			Acts as a base in water.	
			Dissolves in water by forming hydrogen bonds.	
			The final oxidation product would be a carboxylic acid.	
			Is a saturated compound.	
			Is a polar molecule.	
			Is soluble in water.	
	CH_3CH_2CHO		Will oxidise to form propanoic acid.	
			Forms hydrogen bonds between similar molecules.	
			Is soluble in water.	
			The boiling point is lower than the alkane with the same parent name.	
	CH_3CN		Contains a triple bond between C and N.	
			The two C atoms and the N atom in the molecule are linear.	
			Is a polar molecule.	

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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WORKSHEET 4.1.4

Observing organics—properties of functional groups

The following table shows the results of several experiments testing the properties of samples of each of the following types of organic chemicals: saturated and unsaturated hydrocarbons, alcohols, carboxylic acids and esters.

Compound	Observations
A	fruity smelling liquid; flammable; slightly soluble in water
B	white powder; soluble in water; reacted with $NaHCO_3(aq)$ to produce a gas that was shown to be carbon dioxide
C	clear liquid; soluble in water; flammable; reacted with compound B to produce a sweet-smelling liquid similar to A; reacted with a mixture of orange $K_2Cr_2O_7(aq)$ and $H_2SO_4(aq)$ to produce a green solution
D	clear liquid; insoluble in water; flammable; changed colour immediately when bromine solution was added
E	clear liquid; insoluble in water; flammable; did not change colour when bromine solution was added

1 Using the information given, state the type of organic compound to which compound B belongs. Explain your answer.

2 Show a general equation for the reaction of compound B with $NaHCO_3$ solution.

3 Using the information given, state the type of organic compound to which compound C belongs. Explain your reasoning.

4 Show a general equation for the reaction of B and C to produce a compound similar to A.

5 For compound A, identify what type of compound it is.

6 Show a general equation for the reaction involving $K_2Cr_2O_7(aq)$, $H_2SO_4(aq)$ and compound C. Show only the organic reactant and product.

7 State whether compound C has been oxidised or reduced.

8 For the reaction in question 6, identify to what type of compound the organic product belongs.

9 For compounds D and E, state to which group of organic compounds these belong. Explain your answer.

10 Determine an appropriate safety statement for a student performing these experiments that includes directions for the safe disposal of the organic materials.

11 Develop a conclusion for these experiments, which includes a list of the general properties and types of reactions observed for saturated and unsaturated hydrocarbons, alcohols, carboxylic acids and esters.

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PRACTICAL ACTIVITY 4.1.3

Action of enzymes

Suggested duration: 30 minutes

Research and planning

AIM

- To demonstrate the action of an inorganic catalyst and an enzyme present in potato and liver.
- To show that an enzyme present in potato acts as a catalyst that may be denatured by heating.

RATIONALE

By performing this experiment, you will investigate catalysis by both inorganic compounds and an enzyme. Hydrogen peroxide decomposes slowly, forming water and oxygen gas. The decomposition process is very slow, so hydrogen peroxide may be safely stored in sealed containers. The reaction is represented by the equation:

$$2H_2O(aq) \rightarrow 2H_2O(l) + O_2(g)$$

A catalyst such as manganese dioxide, or the enzyme present in potato or liver, will speed up this process so that it may be readily observed. The enzyme in potato is known as catalase and its function is to destroy the hydrogen peroxide produced during reactions in cells, thus preventing the accumulation of this toxic substance. A single catalase molecule can decompose five million hydrogen peroxide molecules in one second!

Enzymes are proteins that catalyse specific biochemical reactions. Their mode of action is related to their shape. Heating may permanently alter the shape of an enzyme, preventing it from performing its function. An enzyme treated in this way is said to have been denatured.

MATERIALS

- 70 mL × 20 volume hydrogen peroxide solution, H_2O_2
- manganese dioxide powder, MnO_2
- half a potato
- a sample of liver, about the size of a 10 cent coin
- ice
- 7 test tubes, 25 mm × 180 mm
- test-tube rack
- 4 × 250 mL beakers (for water baths)
- 10 mL measuring cylinder
- spatula
- 2 Bunsen burners, tripod, stands and gauze mats
- 2 bench mats
- 4 thermometers, –10 to 110°C
- knife and cutting board
- kettle
- safety glasses and gloves

SAFETY

PRE-LAB SAFETY INFORMATION

Material used	Hazard	Control
manganese dioxide	skin and eye irritation; harmful if inhaled	Wear gloves, safety glasses and a laboratory coat.
hydrogen peroxide	strong oxidising agent	Avoid contact with skin and eyes.

Please indicate that you have understood the information in the safety table.

Name (print): ______________________________

I understand the safety information (signature): ______________________________

METHOD

Part A—Action of catalysts on hydrogen peroxide

1 Place 10 mL of hydrogen peroxide solution in each of three test tubes. To one add a small amount of manganese dioxide. Record your observations in Table 1.

2 Finely chop up the potato and then chop up the liver into larger pieces (small pieces of liver can be difficult to remove from the sink later).

3 Add a small amount of finely chopped potato to the second test tube and add chopped liver to the third. Record your observations in Table 1.

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PRACTICAL ACTIVITY 4.1.3

Part B—Effect of temperature on enzyme activity

1 Set up four water baths at temperatures of about 0°C (ice water), 20°C, 37°C (body temperature) and 80°C. Measure and record the exact temperature of each bath in Table 2.

2 Place finely chopped potato to a depth of 2 cm in each of the four test tubes and place a test tube in each of the water baths. Allow the test tubes to remain in the baths for 5 minutes.

3 Add 10 mL of hydrogen peroxide solution to each test tube and leave them in the water baths for a further 5 minutes.

4 Measure and record the height of the foam in each test tube in Table 2.

VARIABLES

i Identify the independent variables: ______

ii Identify the dependent variable: ______

iii Identify any controlled variables: ______

Analysing

RAW DATA

TABLE 1 Observations

H_2O_2 solution + manganese dioxide	H_2O_2 solution + potato	H_2O_2 solution + liver

TABLE 2 H_2O_2 solution and potato at different temperatures

Water bath	Exact temperature (°C)	Height of foam column (cm)
0°C (ice water)		
20°C		
37°C (body temperature)		
80°C		

ANALYSIS

1 Assess the reason for the effect, in each case, of adding manganese dioxide, liver and potato to the H_2O_2 solution.

______

2 Explain why the liver and potato are chopped before use in this experiment.

______

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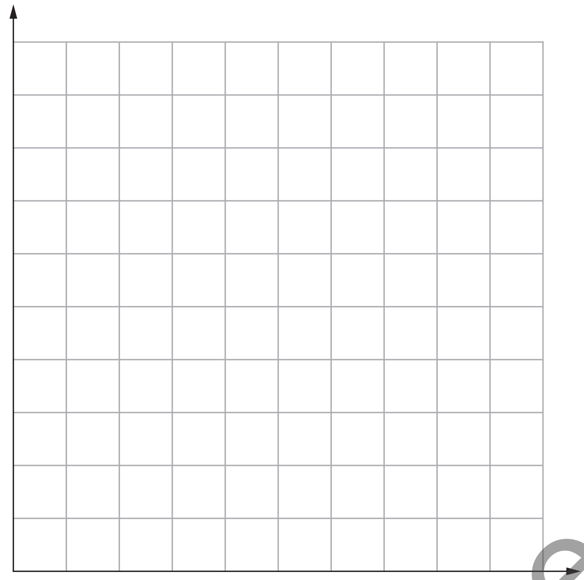
PRACTICAL ACTIVITY 4.1.3

3 Draw a graph of foam height against temperature. The height of the foam is a measure of the rate of oxygen production during the decomposition of hydrogen peroxide.



4 Explain the shape of the following sections of your graph in terms of enzyme activity.

a 0–37°C: ____________________

b 37–70°C: ____________________

Interpreting and communicating

CONCLUSION

5 In a few sentences, explain how your results address the aim.

EVALUATION

6 Identify any errors that might have occurred as you conducted this experiment. How might they have affected the results?

IMPROVEMENTS

7 If you were to repeat this experiment, identify how you could change the method in order to improve the results. Explain your answer.

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MANDATORY PRACTICAL 4

Modelling hydrocarbons, functional groups and organic reactions

Suggested duration: Up to 90 minutes, depending on the number of molecules constructed

Research and planning

AIM

- To examine the bonding, shape and nomenclature of a number of organic molecules with common functional groups.
- To investigate the concept of structural isomers.
- To model reactions involving common functional groups.
- To write equations for organic reactions.

RATIONALE

This activity will help you to visualise and appreciate the three-dimensional structures of organic compounds, common functional groups and structural isomers. Upon completion of this task, you will be able to identify and explain the role of functional groups, discuss the effect that they have on the bonding and solubility of organic compounds, and construct reaction pathways, including writing equations.

METHOD

Part A—Functional groups

For each of the molecules in Part A of the materials list, or as directed by your teacher:

1 Write the condensed structural formula.

2 Draw the extended structural formula.

3 State the type(s) of bonding between molecules.

Complete your answers in Table 1.

Part B—Structural isomers

Draw the extended structural isomers and construct models of all isomers of the following molecules. Write the systematic name of each isomer where possible.

1 dichloroethene

2 pentane

3 butanol

4 propanone

Complete your answers in Table 2.

MATERIALS

This activity requires a molecular model building kit for constructing the following molecules.

Part A

- alkanes: methane, butane
- alkenes: ethene, propene, but-1-ene, but-2-ene
- chloroalkanes: 1,1-dichloroethane
- alcohols: ethanol, butan-2-ol
- carboxylic acids: methanoic acid, propanoic acid
- esters: ethyl propanoate
- amines: ethanamine
- amides: ethanamide
- aldehydes: ethanal
- ketones: propanone

Part B

- dichloroethene
- pentane
- butanol
- hydroxybutanoic acid
- pentan-2-one

Part C

- ethane and chlorine
- ethene and hydrogen chloride
- ethene and hydrogen
- ethene and chlorine
- ethene and water
- ethanol and ethanoic acid

MANDATORY PRACTICAL 4

Part C—Reactions

Do the following for each of the pairs of reactants in the Part C materials list.

1 Construct a three-dimensional model of each organic reactant.

2 Rearrange the atoms in the reactants to form models of the products.

3 Complete your answers in Table 3 by writing equations for the organic reactions.

VARIABLES

i Identify the independent variables: ______________________________

ii Identify the dependent variable: ______________________________

iii Identify any controlled variables: ______________________________

Analysing

RAW AND PROCESSED DATA

TABLE 1 Functional groups

Name	Condensed structural formula	Extended structural formula	Type of bonding between molecules
methane			
butane			
ethene			
propene			
but-1-ene			
but-2-ene			

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Name	Condensed structural formula	Extended structural formula	Type of bonding between molecules
1,1-dichloroethane			
ethanol			
butan-2-ol			
methanoic acid			
propanoic acid			
ethyl propanoate			
ethanamine			
ethanamide			
ethanal			
propanone			

MANDATORY PRACTICAL 4

TABLE 2 Structural isomers

dichloroethane	
pentane	
butanol	
propanone	

TABLE 3 Equations for the reactions in Part C

ANALYSIS

1 State what type of bonding is present within the molecules. ______________________

2 In Table 4, name the functional groups present in the organic molecules that are the focus of this activity.

TABLE 4 Names of functional groups in Part A

Homologous series	Functional group present	Homologous series	Functional group present
alkanes		esters	
alkenes		amines	
chloroalkanes		amides	
alcohols		aldehydes	
carboxylic acid		ketones	

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3 Define the term 'structural isomers'.

4 Draw extended structural formulas to show the reactants and products for each reaction in Part C.

Interpreting and communication

CONCLUSION

5 Explain how functional groups affect the bonding and solubility of organic compounds.

EVALUATION

6 Identify any errors that might have occurred as you conducted this experiment. How might they have affected the results?

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