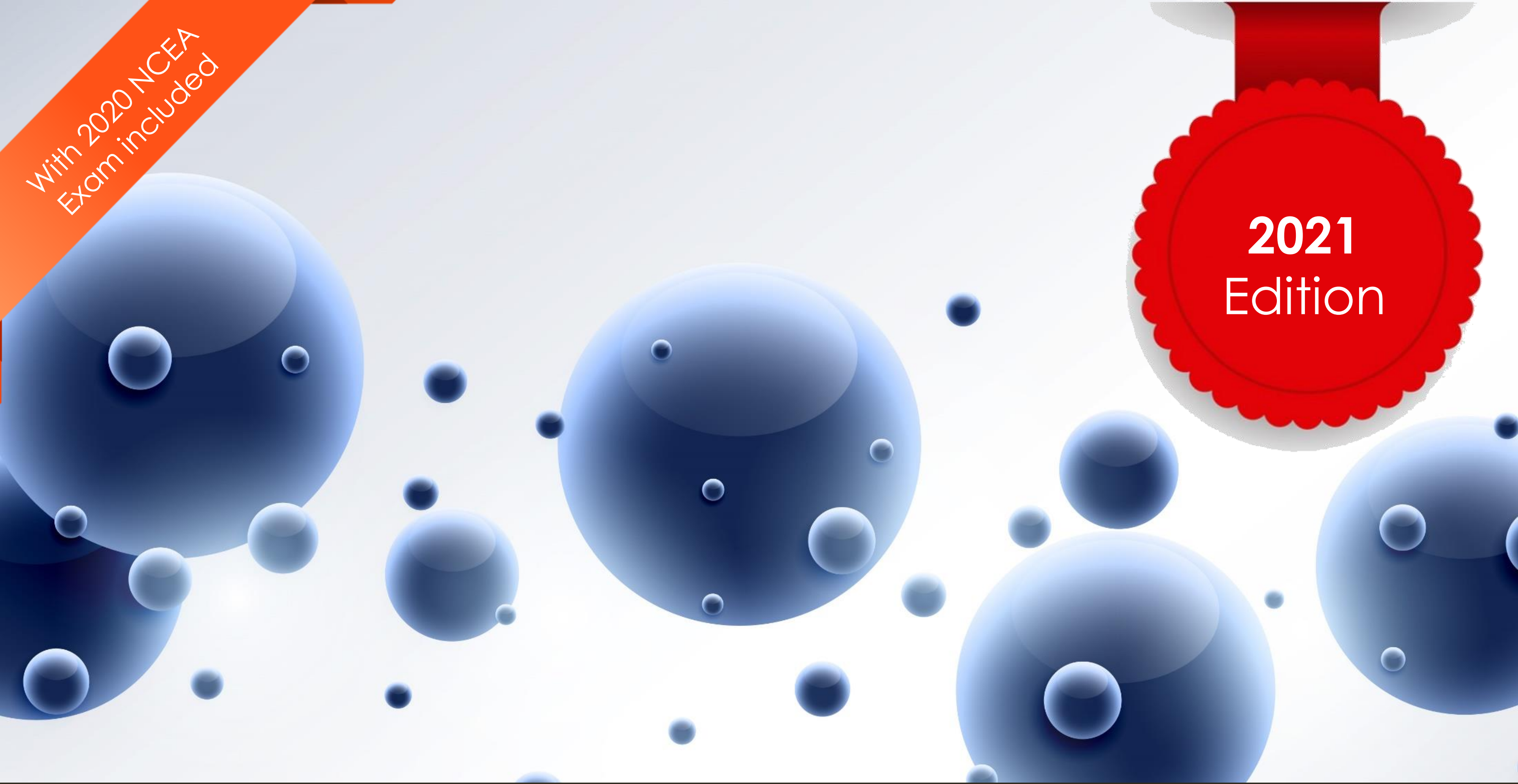
With 2020 NCEA Exam included

2021 Edition



Chemistry AS 91165
C2.5 Organic Chemistry

GZ Science Resources

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Achievement Standard

AS 91165
C2.5

This achievement standard involves demonstrating understanding of the properties of selected organic compounds.

Selected organic compounds are limited to:

- ☐ alkanes, alkenes, alkynes, haloalkanes, primary amines, alcohols, and carboxylic acids. (1. naming and drawing)

Properties are limited to:

- ☐ constitutional and geometric (*cis and trans*) isomers (2.)
- ☐ classification of alcohols and haloalkanes as primary, secondary or tertiary
- ☐ solubility, melting and boiling points (3.)
- ☐ chemical reactions.

(includes identification tests for unknown substances)

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Achievement Standard

AS 91165
C2.5

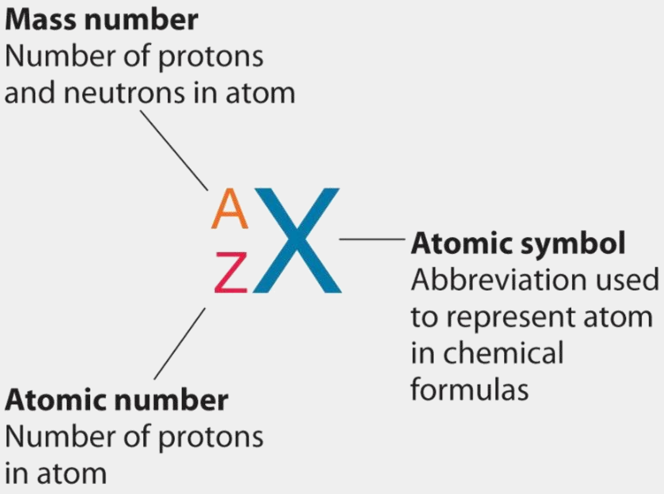
Chemical reactions are limited to:

- ☐ addition reactions of: (3.) (including identification of major and minor products on addition to asymmetric alkenes)
  - alkenes with H_2/Pt, Cl_2, Br_2, H_2O/H^+(conc. H_2SO_4/H_2O)
  - hydrogen halides
- ☐ substitution reactions of: (4.)
  - alkanes with halogens (limited to monosubstitution)
  - alcohols with hydrogen halides, PCl_3, PCl_5, $SOCl_2$
  - haloalkanes with ammonia and aqueous potassium hydroxide
- ☐ Elimination reactions of: (including identification of major and minor products for asymmetric reactants): (5.)
  - water from alcohols
  - hydrogen halides from haloalkanes
- ☐ Oxidation reactions of: (6.)
  - primary alcohols to form carboxylic acids with MnO_4^-/H^+ or $Cr_2O_7^{2-}/H^+$
  - alkenes with MnO_4^-
- ☐ Acid–base reactions of carboxylic acids and amines. (7.)
- ☐ Addition polymerisation (8.)

Background Knowledge

Organic Chemistry

We define organic chemistry *as the chemistry of compounds that contain both* ***carbon*** *and* ***hydrogen***.



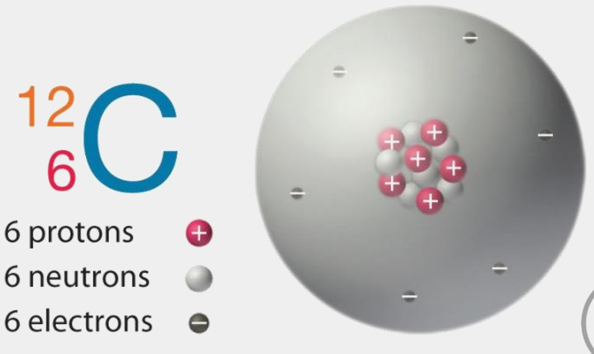
Mass number
Number of protons and neutrons in atom

$^{A}_{Z}X$

Atomic symbol
Abbreviation used to represent atom in chemical formulas

Atomic number
Number of protons in atom

Carbon has four valence electrons and forms covalent bonds, either as single, double or triple bonds, with a large number of other elements, including the hydrogen, nitrogen, oxygen, phosphorus, and sulfur.

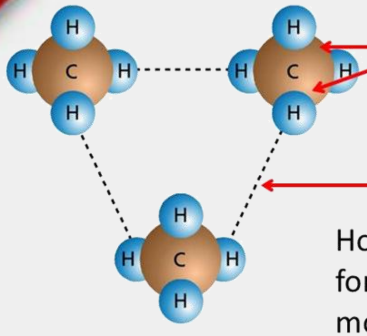


$^{12}_{6}C$

6 protons ⊕
6 neutrons ●
6 electrons ⊖

Background Knowledge

Covalent bonding between atoms



In a molecule of methane, CH_4, the four C–H covalent bonds are strong.

However, weak van der Waals' forces *between* methane molecules hold them together loosely. Therefore, methane exists as a gas at room temperature and pressure.

Covalent bonding occurs where valence electrons around atoms are shared between neighbouring atoms. This type of bonding is found between the C and H atoms in hydrocarbons and the C, H and O atoms in alcohol and is called **intramolecular** bonding. This bonding is very strong. The bonding between molecules is called **intermolecular** bonding and this is much weaker. When hydrocarbons are heated, and they change state into liquids and gases, it is this weak intermolecular bonding between molecules that is broken, **not** the covalent bonding.

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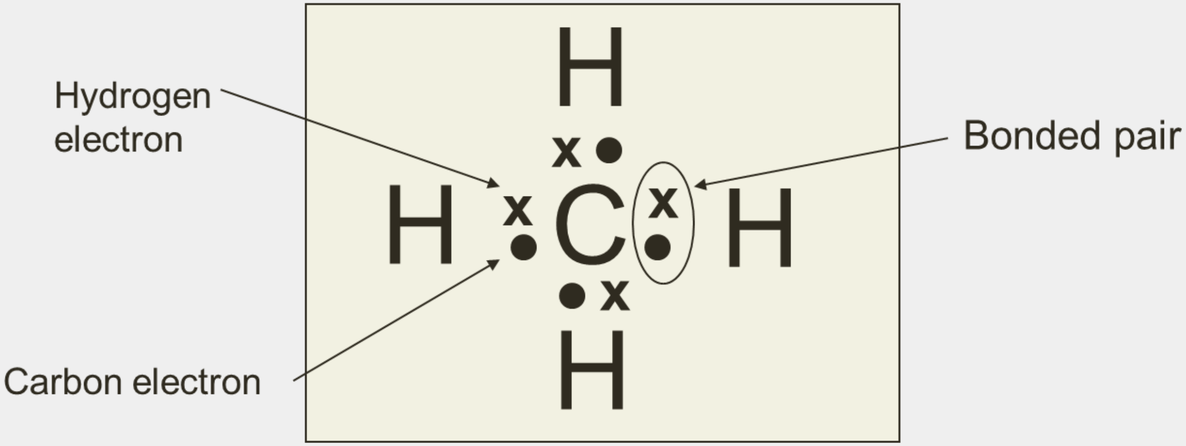
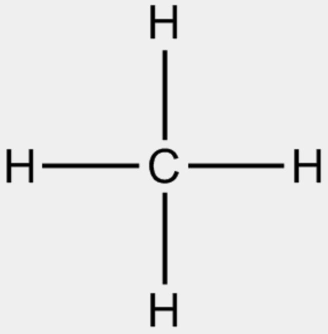
Background Knowledge

Covalent bonding between atoms

Lewis diagram of CH_4 (methane)



Lewis diagrams can be used to show how atoms are arranged in a molecule and which valence electrons are used in bonding. A bonding pair of electrons can also be shown as a line:



Organic Chemistry Formula

Molecular Formula – type and number of each atom in a molecule.

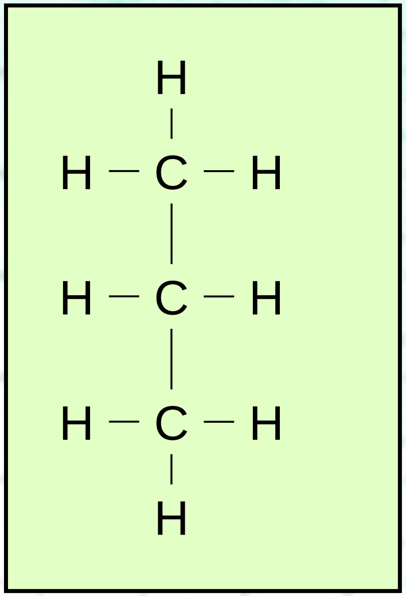
i.e. Propane C_3H_8

Structural Formula – shows the placement of each atom in a molecule

Condensed Structural Formula

$CH_3\text{-}CH_2\text{-}CH_3$

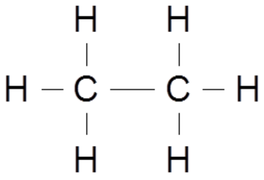
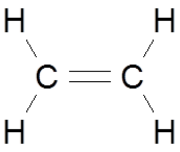
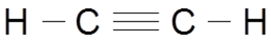
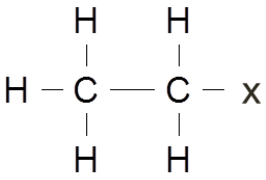
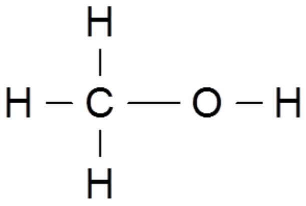
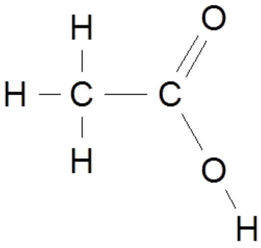
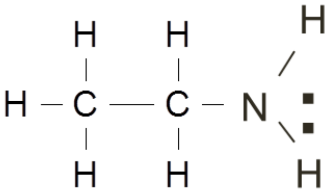
Structural **isomers** are molecules with the same molecular formula but **different** structural formula.



Names and Formula

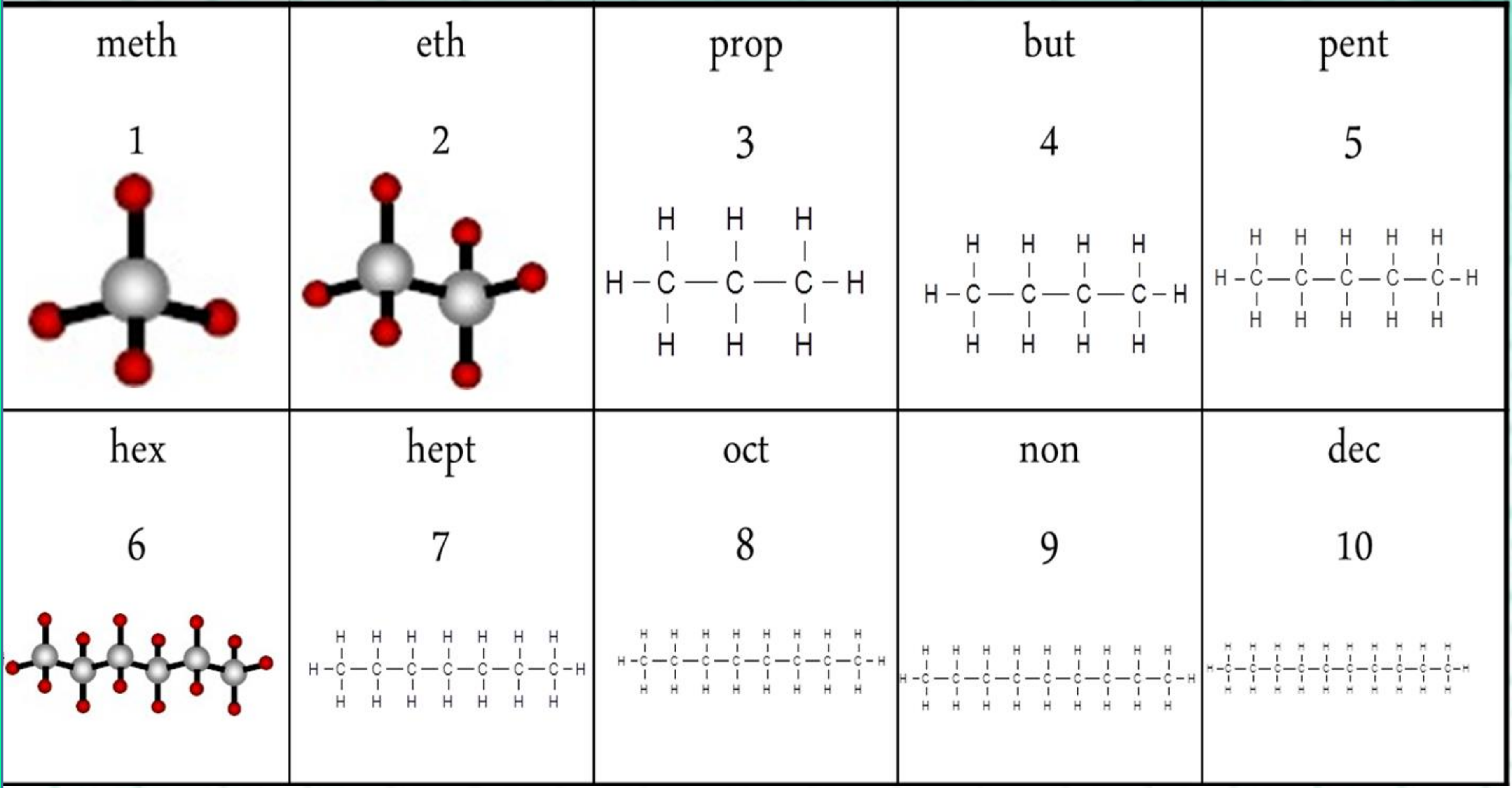
Functional groups

Organic compounds are divided into main functional groups. This is determined by the type and arrangement of atoms – this also determines chemical properties. The families of organic compounds, which have the same general formula and functional group, are called a **homologous series.** The compounds, which make up a homologous series, will have similar chemical properties. The selected functional groups covered at this level include alkanes, alkenes, alkynes, haloalkanes, primary amines, alcohols, and carboxylic acids.

Alkanes 	Alkenes 	Alkynes 	Haloalkanes 
Alcohols 	Carboxylic Acids 	Primary Amines 	

Prefixes

Prefixes are used to indicate number of carbon atoms in the longest carbon chain



meth	eth	prop	but	pent
1	2	3	4	5
hex	hept	oct	non	dec
6	7	8	9	10

Names and Formula

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Alkanes

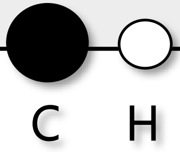
Compounds that contain only carbon and hydrogen are known as **hydrocarbons**. Those compounds that contain as many hydrogen atoms as possible, with each carbon atom having 4 bonds, are said to be *saturated*. The saturated hydrocarbons are also known as **alkanes**.

Sources of Alkanes

Alkanes are found in petroleum (either crude oil or natural gas). They are formed by the **anaerobic** decomposition of marine plant and animal organisms. The main components in New Zealand natural gas are methane (one-carbon alkanes) and carbon dioxide.

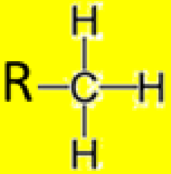
Crude oil is imported into New Zealand from other countries and contains a mixture of different hydrocarbons with different length carbon chains. The different chain length hydrocarbons are separated by a process called **fractional distillation,** as they have different boiling points.

generic formula
C_nH_{2n+2}



Alkane Functional Group

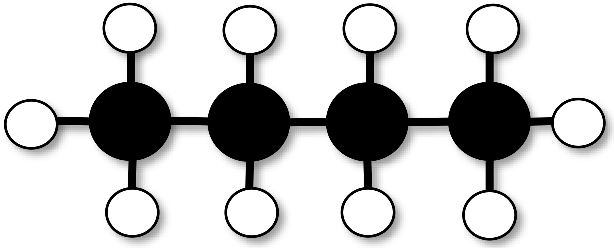
Alkanes

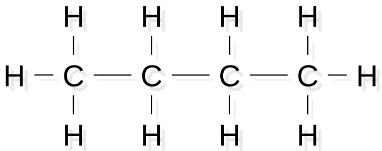


$R-CH_3$

1

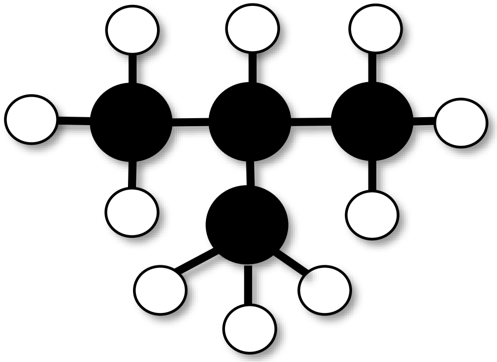
Straight-chain hydrocarbons: in which the carbon atoms form a chain that runs from one end of the molecule to the other i.e. butane

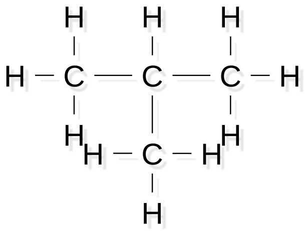




Alkanes also form **branched** structures. The smallest hydrocarbon in which a branch can occur has four carbon atoms. This compound has the same formula as butane (C_4H_{10}), but a different structure. Compounds with the same formula and different structure are called **structural isomers**.

Generic formulas can be used to "predict" what functional group an organic molecule belongs to.

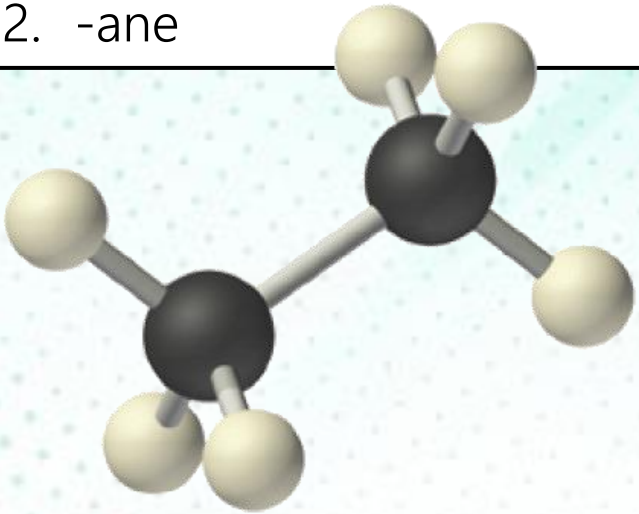




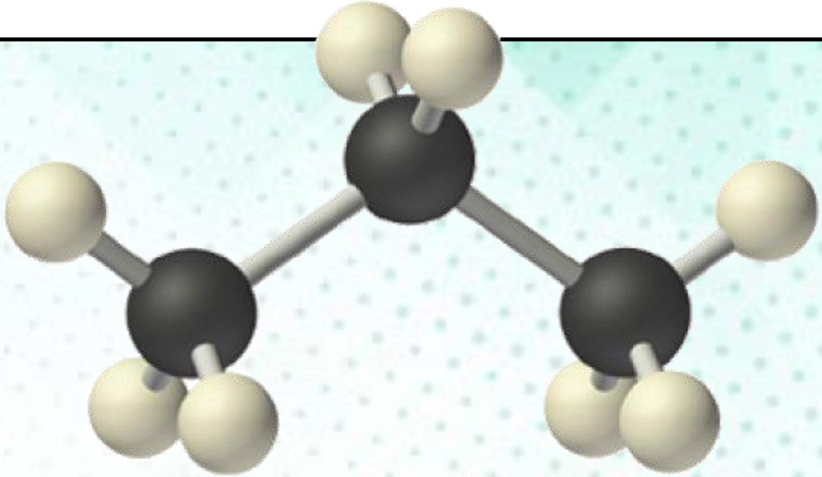
Naming straight chain alkanes

Write the name of the alkane by:

1. Identify the longest C chain
2. Write the name
    1. Prefix of long chain
    2. -ane



Ethane, C_2H_6



Propane, C_3H_8

IUPAC rules for Naming Branches

IUPAC Rules for Alkane Nomenclature

1. Find and name the longest continuous carbon chain.
2. Identify and name groups attached to this chain.
3. Number the chain consecutively, starting at the end nearest a substituent group, making sure the branches have the lowest combined total number
4. Designate the location of each substituent group by an appropriate number and name.
5. Assemble the name, listing groups in alphabetical order. The prefixes di, tri, tetra etc., used to designate several groups of the same kind, are not considered when alphabetising.

Names of (alkyl) branches

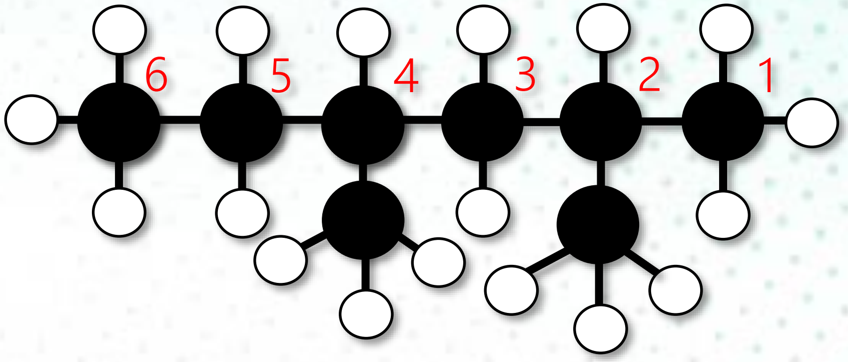
Name	methyl	ethyl	propyl
No. Carbon	1	2	3
Formula	$-CH_3$	$-CH_2CH_3$	$-CH_2CH_2CH_3$

Naming Branched chain Alkanes

1. Identify the longest C chain
2. Identify any branches,
3. Number the C atoms in longest chain so branches are on the lowest numbers
4. Write the name
    1. Location of branch
    2. Name of branch, listing groups in alphabetical order.
    3. If more than one branch use the prefixes di, tri, tetra if the same
    4. Prefix of long chain
    5. -ane

Always make sure the **longest possible chain** of carbons – and therefore the shortest possible branches – is used.

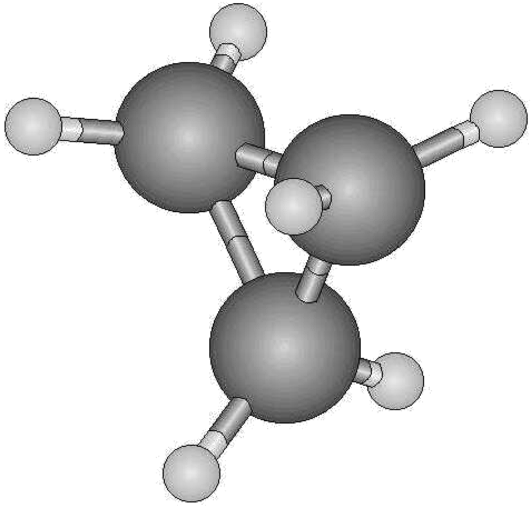
2,4-dimethyl hexane



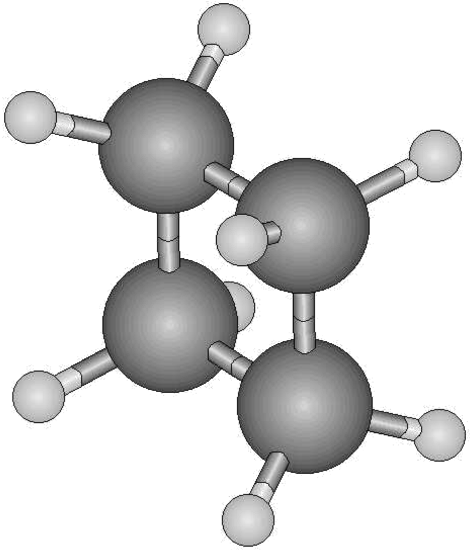
Naming cyclic Alkanes

At this level knowledge of **branched chain** cyclic alkanes is not required

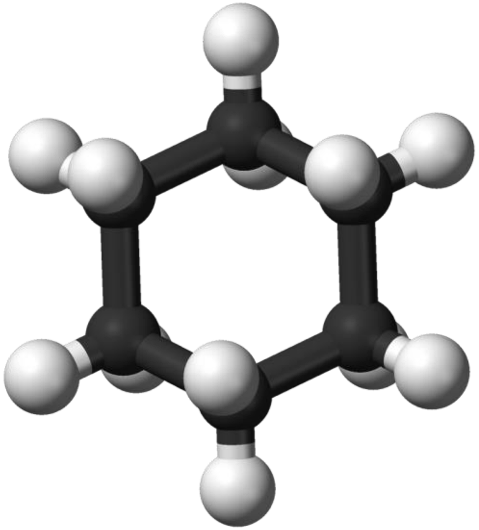
Alkanes can also form cyclic molecules. These are named by placing cyclo- in front of the longest chain.



cyclopropane



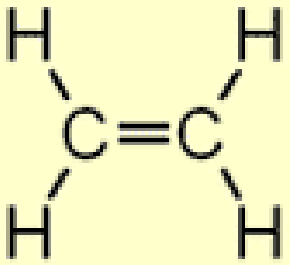
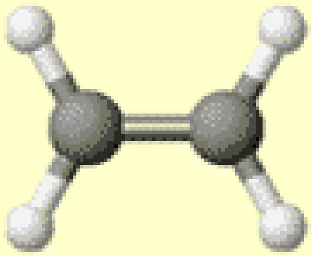
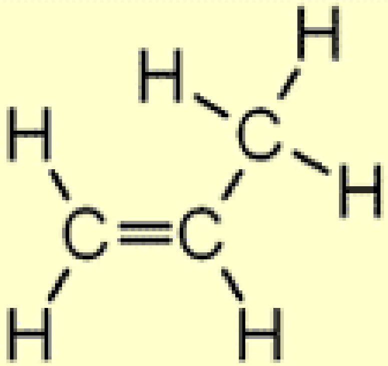
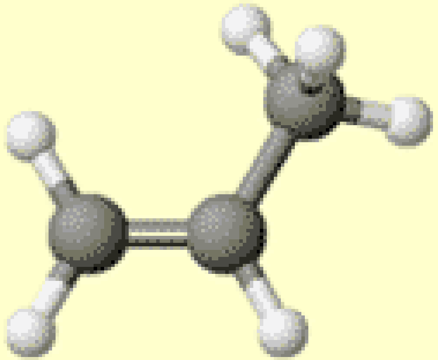
cyclobutane



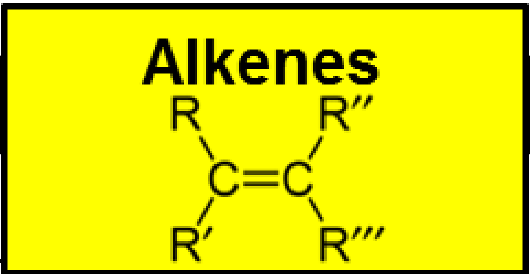
cyclohexane

Alkenes

Alkenes are known as *unsaturated* hydrocarbons. The carbons do not contain as many hydrogen atoms as possible because two or more carbons are joined by a double bond. Each carbon atom involved in the bond shares two of its valance electrons therefore four electrons (in two pairs) are involved in the covalent bond.

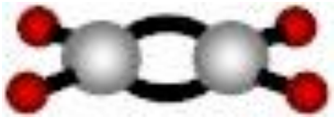
ethene C_2H_4		
propene C_3H_6		

Alkene Functional group



Functional Group – One double carbon-carbon bond C=C

A **functional** group is the part of the molecule responsible for reactions typical of the homologous series.

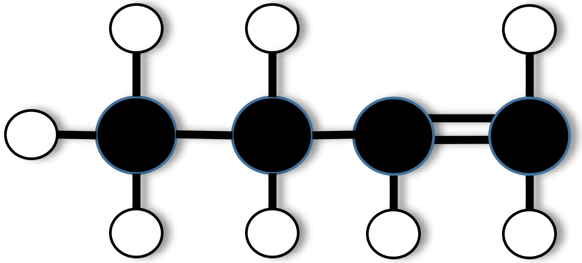


Alkene naming

Alkenes are named in a similar way to alkanes, *but the longest continuous carbon chain is numbered to give the carbon atoms in the double bond the lowest possible numbers*.

The position of the double bond is given by the smaller number of the two carbon atoms involved.

The name of the molecule to the right is
But-1-ene not but-2-ene.
Alkenes smaller than butene, i.e. propene and Ethene, do not need to have the placement of the Double bond identified in the name – as there is no other possibility.
The molecules with the same molecular formula, but different structural formula are called **isomers**



generic formula
C_nH_{2n}

Naming Straight Chain alkenes

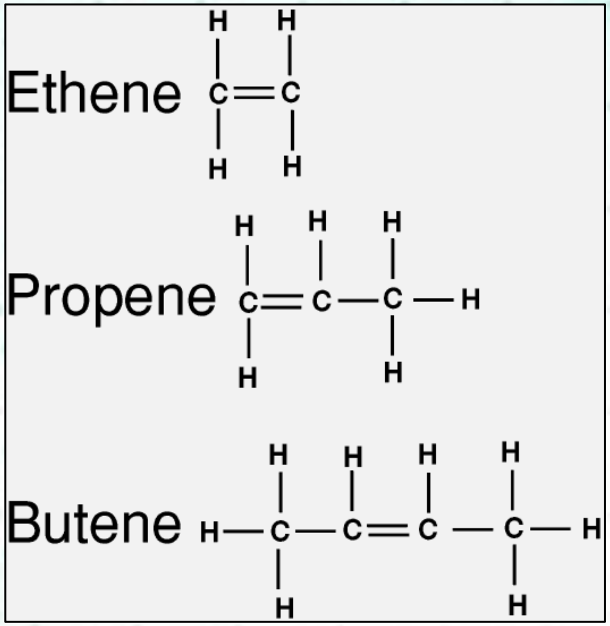
1

Write name as

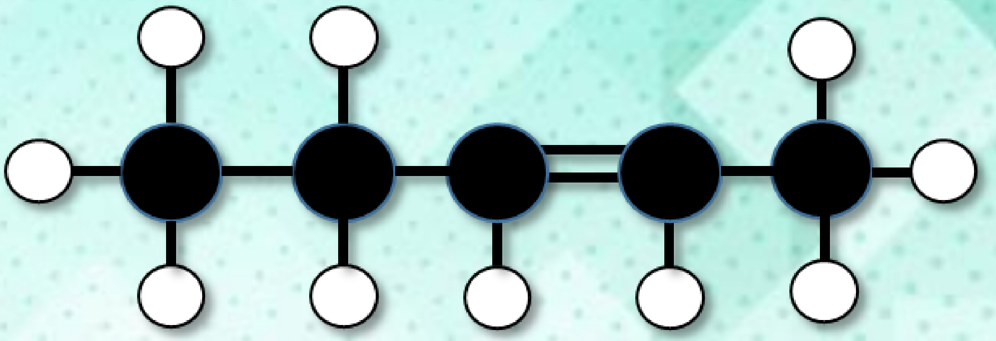
1. Prefix of long chain

2. Location of C=C

3. –ene



Pent-2-ene

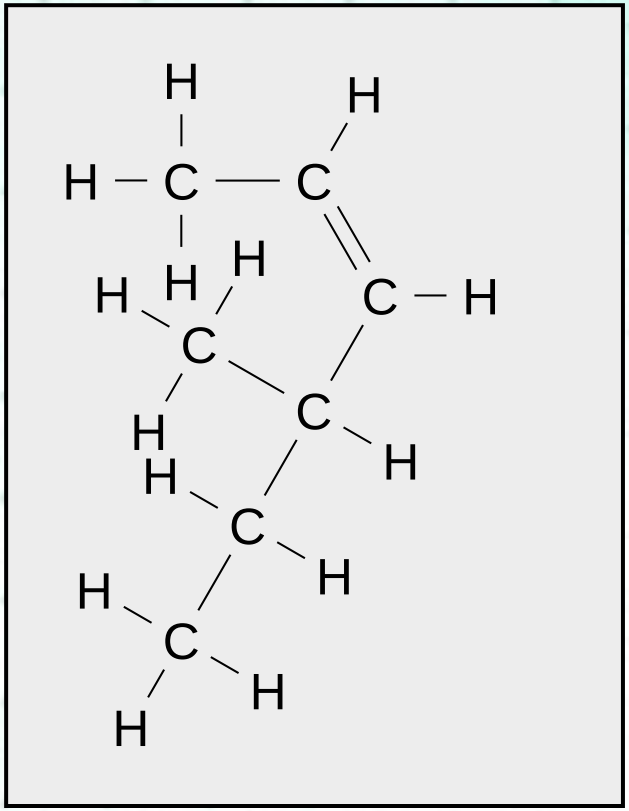


Number carbons so double bond has the lowest number.

Naming Branched Alkenes

Number carbons so double bond has the lowest number.

The Alkene shown below is found to be 4-methylhex-2-ene by numbering the chain C1-C2=C3-C4-C5-C6.

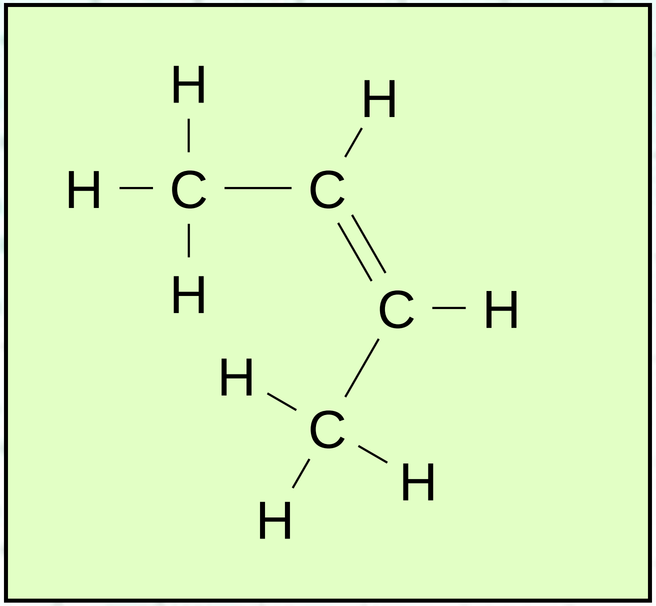


Write name as

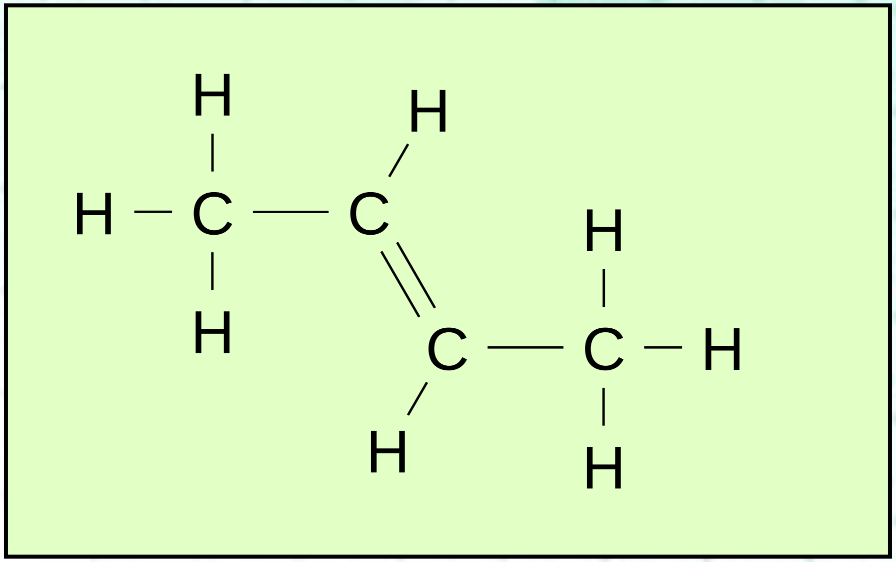
1. Location of branches
2. Name of branch, listing groups in alphabetical order.
3. If more than one branch use the prefixes di, tri, tetra if the same
4. Prefix of long chain
5. Location of C=C
6. -ene

Cis – Trans Isomerism (geometric isomers)

Geometric isomers of an alkene can occur because carbon-carbon **double bonds do not rotate**. Each carbon on the double bond must have **two different groups** attached.
Cis isomers have the same groups on the same side of the molecule. Trans isomers have the same groups on opposite sides of the double bond.
Geometric isomers have different physical properties, but usually the same chemical properties.



Cis but-2-ene

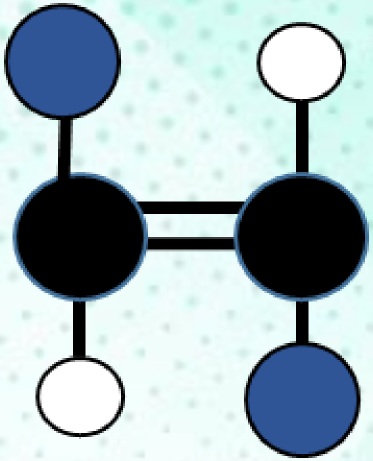


Trans but-2-ene

Names and Formula

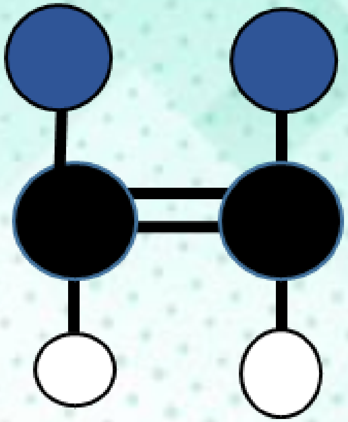
Alkenes – Geometric Isomers

The double bond prevents the carbons on either end rotating like single bonds do and therefore the groups coming off the carbons remain “fixed” on their respective sides



Trans ethene

Cis ethene



SUMMARY

Cis if chain on **same** side of C=C (shaped like a C)

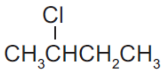
Trans if on **different** sides (a transverse line)

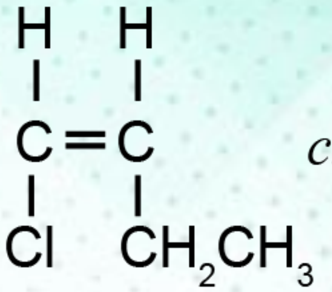
NCEA 2013 Cis Trans Isomers

Excellence Question

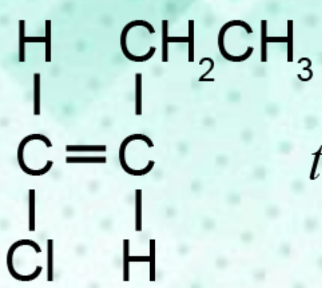
Question 1c: Molecule **D** can exist as geometric (*cis* and *trans*) isomers.
Draw the geometric (*cis* and *trans)* isomers for molecule **D** in the boxes below.
Justify why molecule **D** can exist as geometric (*cis* and *trans)* isomers.
Your answer should include:

- an explanation of the requirements for *cis* and *trans* isomers
- reference to the structure of molecule **D**.

A  $CH_3CH(Cl)CH_2CH_3$	**B** $CH_3CH_2CH_2Cl$
C $CH_3CH_2CHCCl_2$	**D** $CH_3CH_2CHCHCl$
E $CH_3CH_2CH_2CHCl_2$	**F** $CH_3CH_2CH_2CH_2Cl$



cis



trans

Cis-trans isomers can occur in molecules that have (carbon to carbon) double bond because atoms are not free to rotate around (the axis of) the double bond. They must also have two different groups attached to each carbon (involved in the double bond).

This molecule has a carbon-carbon double bond. One carbon of the double bond is attached to a hydrogen atom and an ethyl group. The other is attached to a hydrogen atom and a chlorine atom.

Names and Formula

NCEA 2014 Cis Trans Isomers

Achieved Question

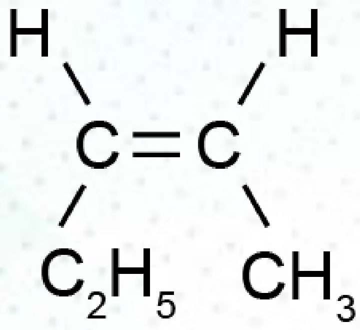
Question: 2b:

The structures of three organic compounds are shown below. Explain why compound A can exist as geometric (*cis* and *trans*) isomers, but compounds B and C cannot.

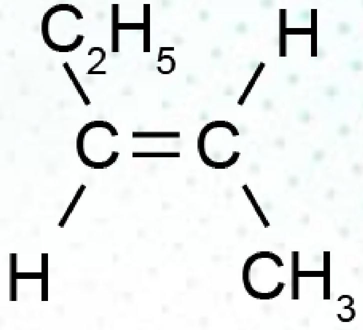
In your answer you should:

☐ draw the geometric (*cis* and *trans*) isomers of compound A

Compound **A**	$CH_3-CH_2-CH=CH-CH_3$
Compound **B**	$CH_3-CH_2-CH_2-CH=CH_2$
Compound **C**	$CH_3-CH_2-CH_2-CH_2-CH_3$



cis



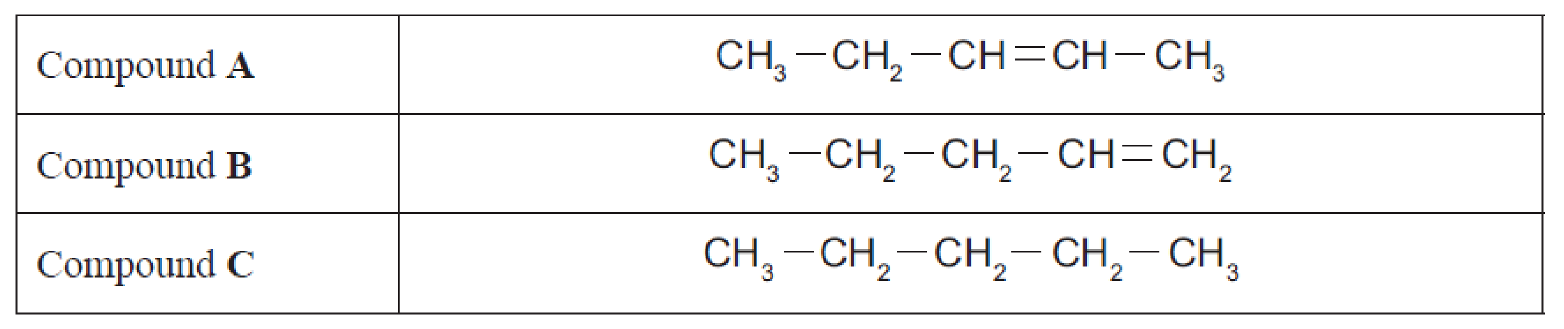
trans

NCEA 2014 Cis Trans Isomers

Excellence Question

Question: 2b:

- ☐ explain the requirements for geometric (*cis* and *trans*) isomers by referring to compounds A, B, and C.



Compound **A**	$CH_3-CH_2-CH=CH-CH_3$
Compound **B**	$CH_3-CH_2-CH_2-CH=CH_2$
Compound **C**	$CH_3-CH_2-CH_2-CH_2-CH_3$

For *cis* and *trans* isomers to occur a **carbon-carbon double bond** must be present as this prevents any rotation about this bond, and the atoms or groups of atoms attached to the two carbon atoms are therefore fixed in position. This means that molecule C cannot have *cis* and *trans* isomers as it does not have a double bond.

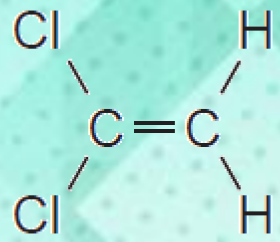
For compound B one of the carbon atoms in the double bond has two of the same atom attached to it (two H's). Therefore it cannot have *cis* and *trans* isomers because if these two H atoms swapped position it would still be the same molecule. **Is NOT asymmetric.**

Therefore only compound A can have *cis* and *trans* isomers as it does have a double bond preventing free rotation, and it does not have one of the carbons in the double bond with two of the same atom or groups of atoms attached to it.

NCEA 2015 Cis Trans Isomers

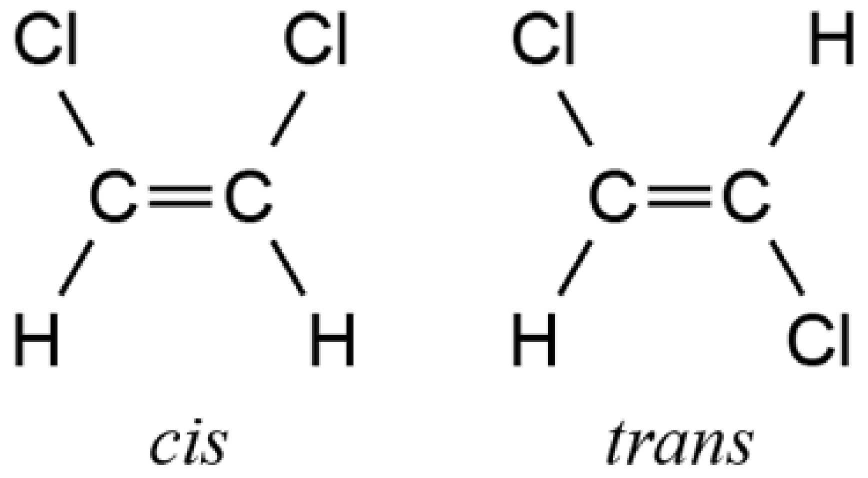
Merit Question

Question: 2a: (ii) Explain why 1,1-dichloroethene cannot exist as a *cis-trans* isomer.



1,1-dichloroethene

1,1-dichloroethene cannot exist as a geometric isomer because, although there is a double bond, the atoms / groups on each of the carbons of the double bond are the same (2 Cl on one C and 2 H on the other C).



cis *trans*

1,2 dichloroethene

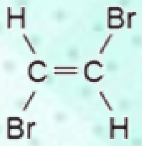
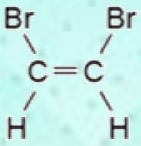
Question: 2a: (iii) A structural isomer of 1,1-dichloroethene **can** exist as *cis-trans* isomers. Draw and name the *cis-trans* isomers.

Names and Formula

NCEA 2016 Cis Trans Isomers

Excellence Question

Question: 1c: Some alkenes are able to form *cis* and *trans* (geometric) isomers.
(i) Complete the names of structures **A** and **B** in the table below.

A	**B**
	
trans 1,2-dibromoethene	*cis* 1,2-dibromoethene

(ii) Elaborate on the structure of the organic compound 1,2-dibromoethene to explain why it is able to form *cis* and *trans* (geometric) isomers.

1,2-dibromoethene can form *cis* and *trans* isomers because it has a double bond. The double bond between two carbon atoms does not allow any rotation of atoms around it.

As well as the double bond, the C atoms directly attached to it must have two different atoms or groups attached to them. For 1,2-dibromoethene, both the C atoms on the double bond have an H and a Br atom bonded to them.

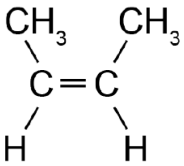
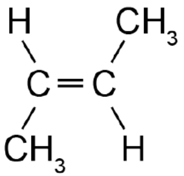
When these two requirements are met, two alkenes can have the same molecular formula and the same sequence of atoms in the formula, but a different arrangement in space (a different 3D formula), hence they are *cis* and *trans* isomers.

Names and Formula

NCEA 2017 Cis and Trans isomers

Excellence Question

Question: 2c: (ii) Identify the compounds that are *cis* and *trans* (geometric) isomers from the table above.
Justify your choices, and explain why only these two compounds are *cis* and *trans* (geometric) isomers.

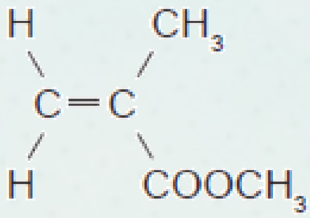
	cis	**trans**
Number		

To form *cis* and *trans* isomers, a carbon-carbon double bond is required, and the atoms / groups on each of the C atoms of the double bond must be different.
Structure 3 and 4 above, both have a carbon-carbon double bond. This bond is rigid, so does not allow rotation to occur around it. Both structure 3 and 4 also have two different atoms / groups on each of the C atoms of the double bond, an H atom and a CH_3 group.
In structure 3, both the CH_3 groups / H atoms are on the same side of the double bond, so it is the *cis* isomer, whereas in structure 4 both the CH_3 groups / H atoms are on different sides of the double bond, resulting in a *trans* isomer.

NCEA 2018 Cis and Trans isomers

Excellence Question

Question: 1c: (ii) Justify whether or not the **monomer** used to produce Perspex® is a geometric (cis-trans) isomer by explaining the features required for this type of isomerism.



The monomer forming perspex is not a geometric isomer. A geometric isomer must have a double bond between two carbon atoms which prevents rotation. This monomer does have this, but the other feature of a geometric isomer is that the carbon atoms of the double bond must have two different atoms or groups of atoms attached to them. One of the carbons on the monomer has a methyl group and a different group of atoms, but the other carbon has two hydrogen atoms. Therefore, it can't have a cis and trans form.

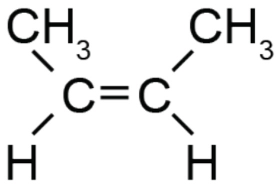
NCEA 2019 Cis and Trans isomers

Excellence Question

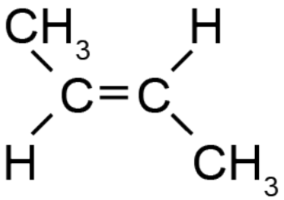
Question: 1c: Refer to the compounds in the table below to answer parts (i) to (iv).

A	$CH_3-CH=CH-CH_3$
B	$CH_3-CH_2-CH_2-CH_3$

(i) Draw and name the two geometric (*cis*-*trans*) isomers of compound **A**.



cis-but-2-ene



trans-but-2-ene

(ii) Explain why compound **A** exists as geometric (*cis*-*trans*) isomers while compound **B** does not.

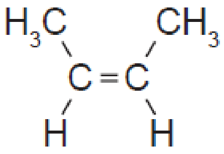
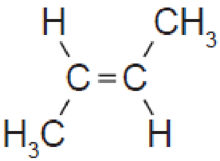
Compound **A** is a geometric isomer because it has the two required features. It has a double bond which prevents rotation. Compound **B** doesn't have this. Compound **A** also has different atoms / groups of atoms on each carbon on the double bond. Both carbons have a methyl group and a hydrogen atom that can be arranged differently in space.

Names and Formula

NCEA 2020 Cis and Trans isomers

Achieved Question

Question: 2b: The C_4H_8 (butene) molecule can display different forms of isomerism.

A	B	C
$CH_2{=}CHCH_2CH_3$		

(i) Circle the form of isomerism that exists between molecules A and B.

[✓ constitutional / structural] geometric

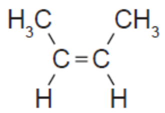
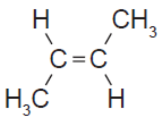
(ii) Circle the form of isomerism that exists between molecules B and C.

constitutional / structural [✓ geometric]

NCEA 2020 Cis and Trans isomers

Excellence Question

Question: 2b: The C_4H_8 (butene) molecule can display different forms of isomerism. (iii) Compare and contrast the two forms of isomerism. In your answer, you should: explain the requirements for each form of isomerism and refer to molecules A, B, and C.

A	B	C
$CH_2{=}CHCH_2CH_3$		

Constitutional isomers have the same molecular formula, but a different arrangement of their atoms.

All three molecules have a formula of C_4H_8 / but **A** has a double bond on the first carbon, whereas **B** and **C** have their double bond on the second carbon / **A** is named but-1-ene, whereas **B / C** are named but-2-ene.
To form geometric isomers, a carbon-carbon double bond is required, and the atoms / groups and on each of the C atoms of the double bond must be different. Both **B** and **C** have a methyl CH_3 (group) and H (atom) attached on each of the C atoms of the double bond. The carbon-carbon double bond is rigid / fixed, so does not allow rotation to occur around it. Molecules have a different spatial arrangement. When both the CH_3 groups / H atoms are on the same side of the double bond, it is the *cis* isomer. This is molecule **B**. When both the CH_3 groups / H atoms are on different sides of the double bond, it is the *trans* isomer. This is molecule **C**. Molecule **A** is not a geometric isomer because the atoms on the first carbon of the double bond are the same.

Names and Formula

Alkynes

$H-C\equiv C-H$

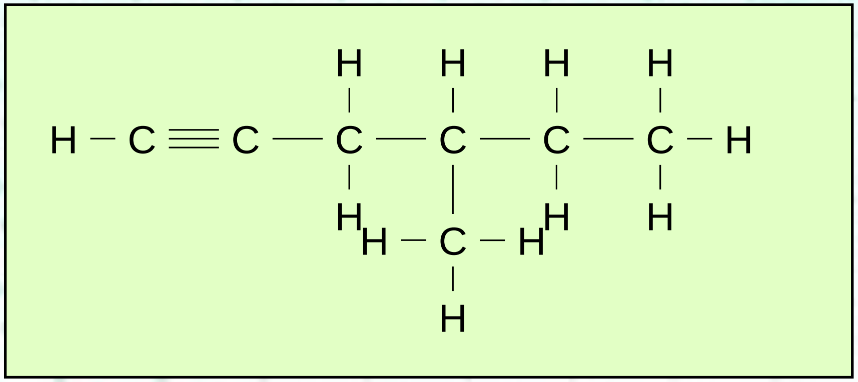
Alkyne Functional group

generic formula
*C*n*H*2*n* - 2

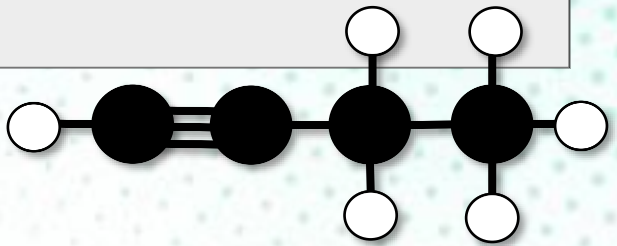
Functional Group – One Triple carbon-carbon bond C=C

A **functional** group is the part of the molecule responsible for reactions typical of the homologous series.

The Alkyne shown below is named 4-methylhex-1-yne by numbering the chain C1-C2-C3-C4-C5-C6.



Write name as
1. Location of branch
2. Name of branch, listing groups in alphabetical order.
3. If more than one branch use the prefixes di, tri, tetra if the same
4. Prefix of long chain
5. Location of C≡C
6.-yne



Addition reactions of Alkynes are similar to Alkene

First break triple bond to double bond- adding atoms and forming Alkene

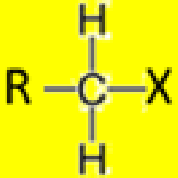
Next break double bond – adding atoms and forming Alkane

Haloalkanes (alkyl halides) Functional Group

Haloalkanes have one or more halogens bonded as a branch to an alkane molecule. Naming indicates the position of the halogen given by the appropriate number of the carbon that it is attached to in the chain.
The Boiling Point (due to the halogen group) are considerably higher than those of the hydrocarbons of comparable molecular mass. As we go down in homologues series of haloalkanes, the forces of attraction becomes stronger due to increase in molecular size and it's mass, hence the boiling point increases down the homologues series. But the boiling point decreases with branching.

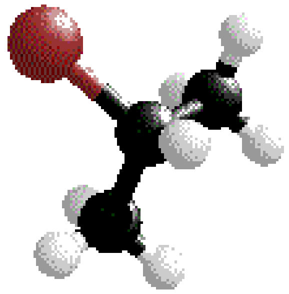
Haloalkanes are slightly soluble in water. This is because of the relatively larger amount of energy required to break bond between halogen and carbon and the smaller amount of energy released, when bond is formed after dissolution ion and water.

Haloalkanes



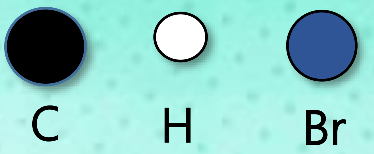
$R-\overset{H}{\underset{H}{C}}-X$

A halogen is an element found in group 17 of the periodic table and includes chlorine (Cl), fluorine (F), iodine (I) and bromine (Br)



Names and Formula

Naming Haloalkanes



1. Location of branches,

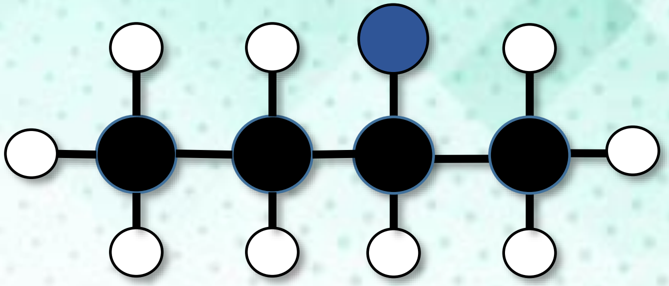
2. Name of branches (bromo-, chloro-, fluoro-, iodo-), listing groups in alphabetical order.

3. If more than one branch use the prefixes di, tri, tetra if the same

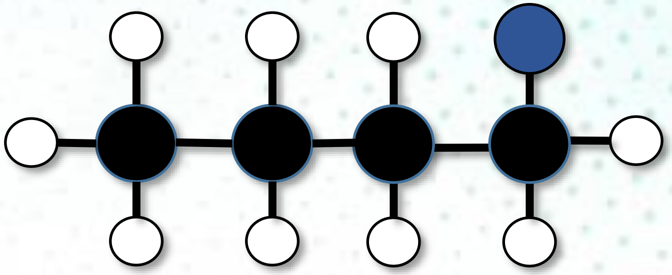
4. Prefix of long chain

5. -ane

Atom	Name used in haloalkane
Bromine	bromo
Chlorine	chloro
Fluorine	fluoro
iodine	iodo



2-bromo butane



1-bromo butane

Primary, Secondary and tertiary Haloalkanes

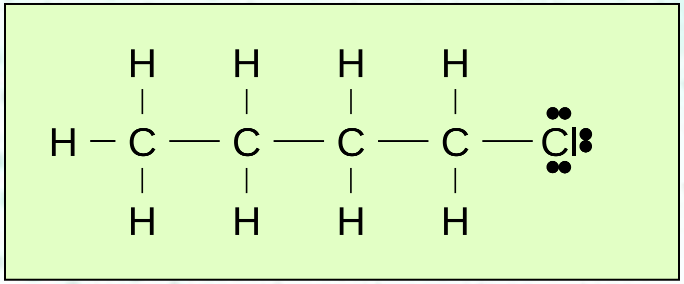
Haloalkanes are classified according to the position of the halogen atom bonded in the molecule.

This leads to the existence of

☐ primary (1°) – bonded to a C that is bonded to only 1 other C

☐ secondary (2°) – bonded to a C that is bonded to 2 other C

☐ tertiary (3°) – bonded to a C that is bonded to 3 other C

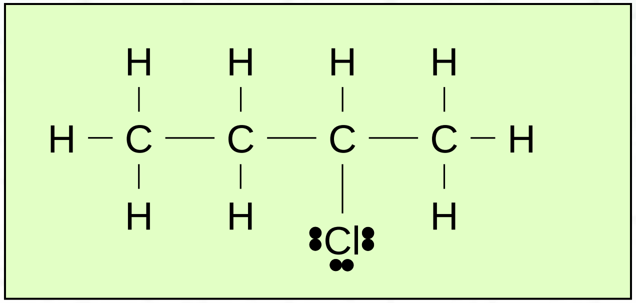


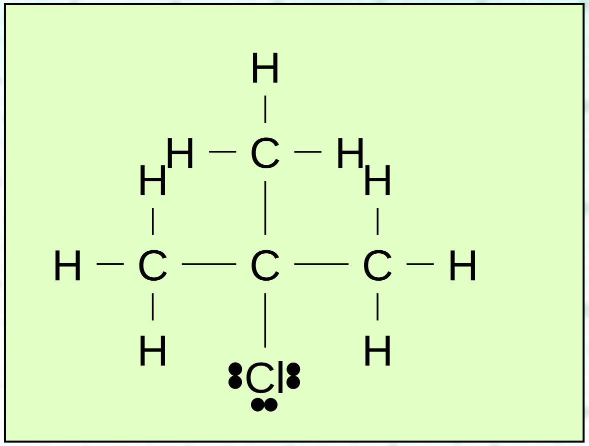
1-chlorobutane

(1° haloalkane)

2-chlorobutane

(2° haloalkane)





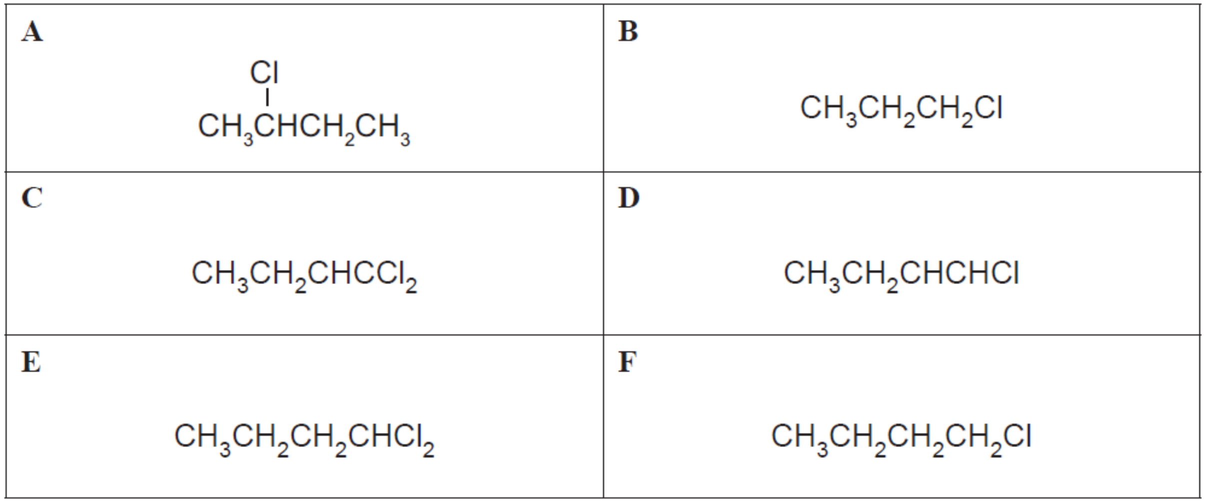
2-chloro-2-methyl propane

(3° haloalkane)

NCEA 2013 Primary, Secondary or Tertiary

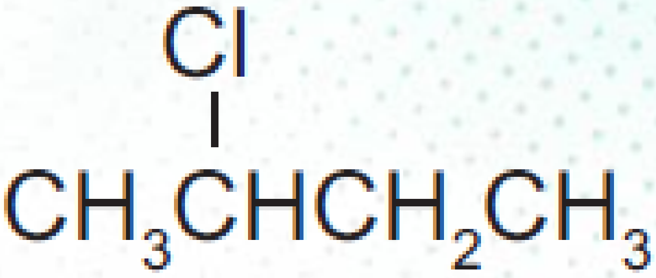
Achieved Question

Question: 1a: (i) The structures of some organic compounds containing chlorine are shown below. Write the letter of the molecule that is a secondary chloroalkane. (ii) Describe why you chose the molecule



A $CH_3\overset{\overset{Cl}{\vert}}{C}HCH_2CH_3$	**B** $CH_3CH_2CH_2Cl$
C $CH_3CH_2CHCCl_2$	**D** $CH_3CH_2CHCHCl$
E $CH_3CH_2CH_2CHCl_2$	**F** $CH_3CH_2CH_2CH_2Cl$

Secondary alcohol: A
Chlorine/the functional group is attached to a C atom (C2), which has two other C atoms attached to it.

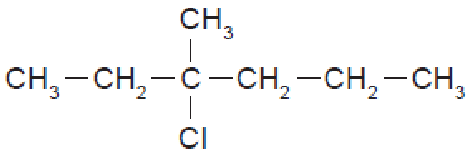
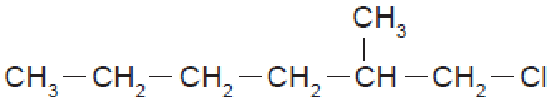
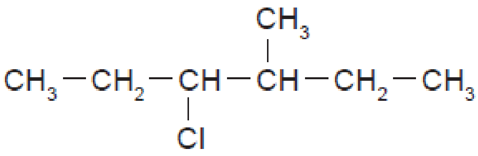


$CH_3\overset{\overset{Cl}{\vert}}{C}HCH_2CH_3$

NCEA 2016 Primary, Secondary or Tertiary

Achieved Question

Question: 1b: (i) Classify the following haloalkanes as primary, secondary or tertiary.

	Haloalkane	**Classification**
A	 $CH_3-CH_2-C(CH_3)(Cl)-CH_2-CH_2-CH_3$	Tertiary (or 3°)
B	 $CH_3-CH_2-CH_2-CH_2-CH(CH_3)-CH_2-Cl$	Primary (or 1°)
C	 $CH_3-CH_2-CH(Cl)-CH(CH_3)-CH_2-CH_3$	Secondary (or 2°)

Merit Question

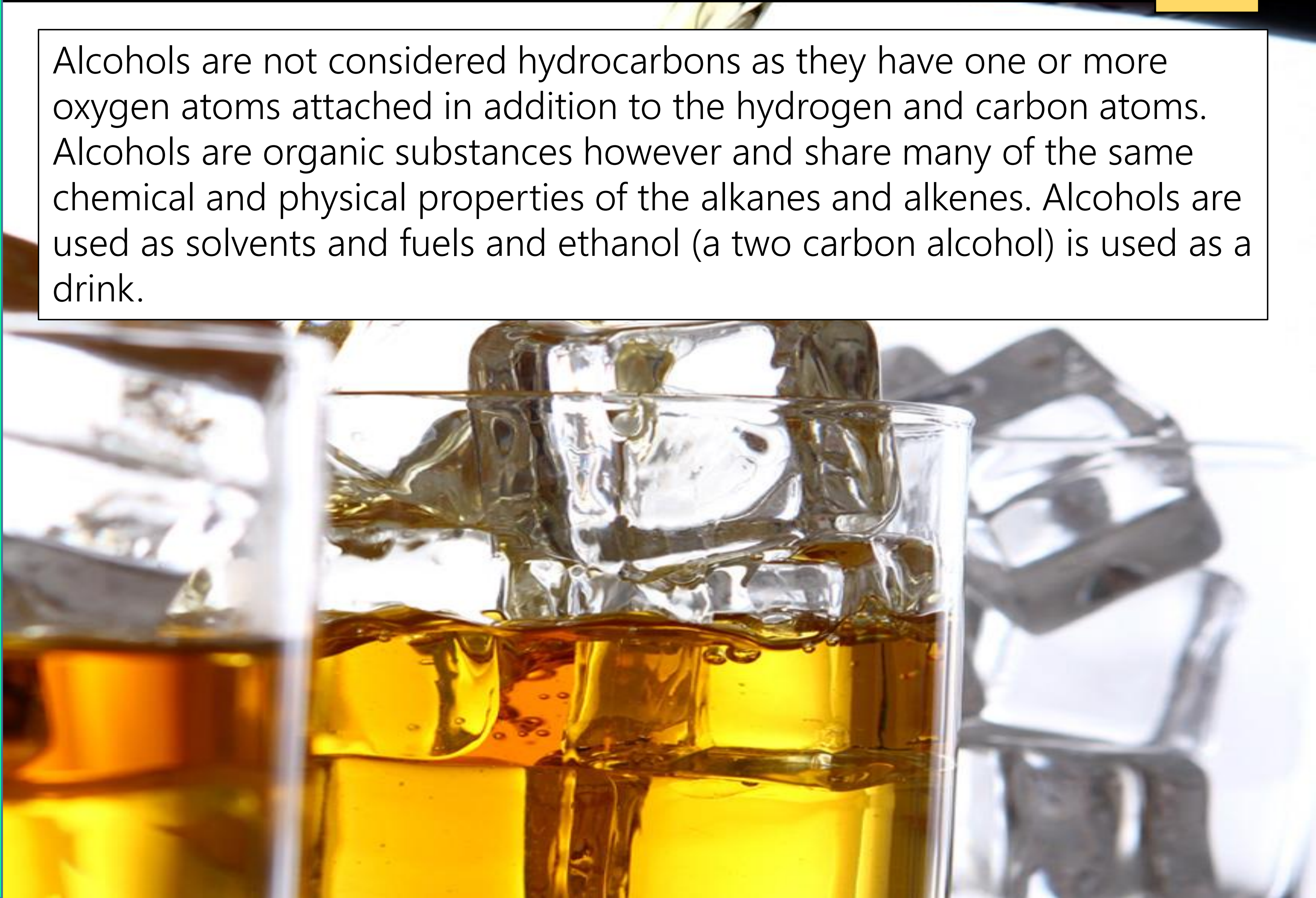
(ii) Explain your choice for haloalkane **A**.

Classifying haloalkanes as primary, secondary, or tertiary requires counting the number of C or H atoms bonded to the C atom to which the halogen is attached.

If the C atom bonded to the halogen has 3 other carbon atoms (or 0 H atoms) bonded to it, the haloalkane is a tertiary (3°) alkane.

Alcohol Functional group

Alcohols are not considered hydrocarbons as they have one or more oxygen atoms attached in addition to the hydrogen and carbon atoms. Alcohols are organic substances however and share many of the same chemical and physical properties of the alkanes and alkenes. Alcohols are used as solvents and fuels and ethanol (a two carbon alcohol) is used as a drink.

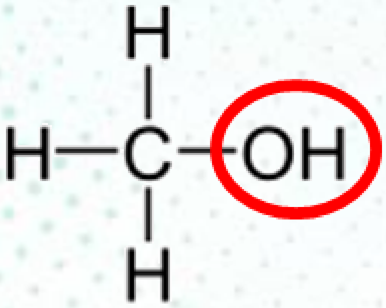


Naming Straight chain Alcohol

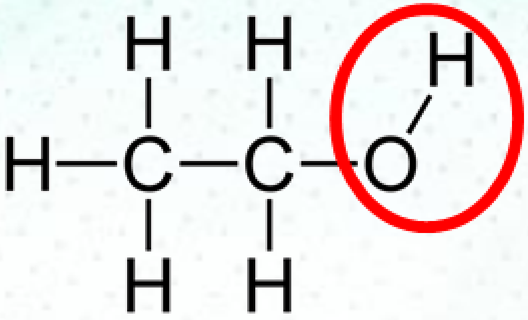
Functional group is the hydroxyl group –OH (not a hydroxide)

Naming alcohols

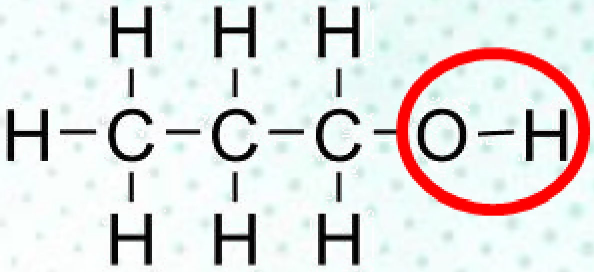
1. Prefix of long chain
2. an-
3. Location of OH
4. - ol



Methanol



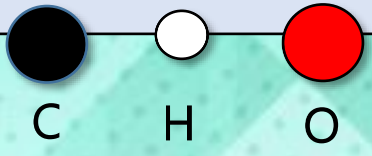
Ethanol

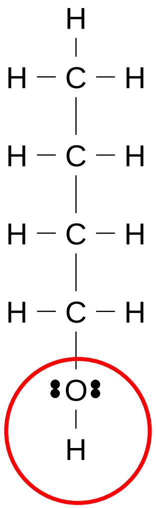


Propanol

Naming Branched Alcohol

Functional group is the hydroxyl group –OH (not a hydroxide)

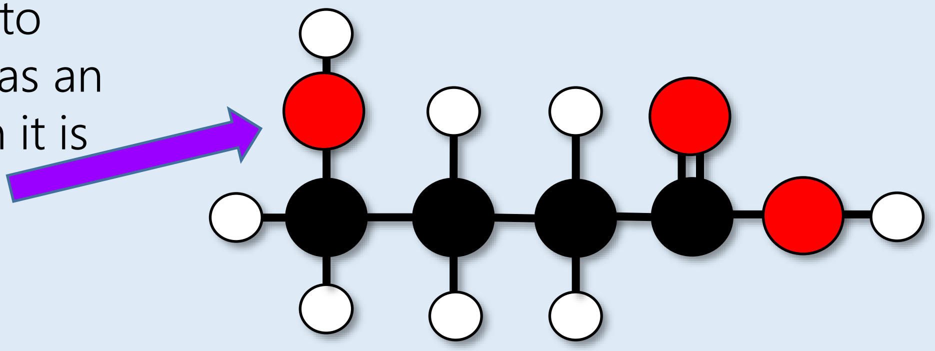




Butan-1-ol

1. Location of branch
2. Name of branch, listing groups in alphabetical order.
3. If more than one branch use the prefixes di, tri, tetra if the same
4. Prefix of long chain
5. an-
6. Location of OH (if multiple di, tri, tetra)
7. -ol

If an alcohol group is attached to another functional group such as an alkene or a carboxylic acid then it is named as a **hydroxyl** branch



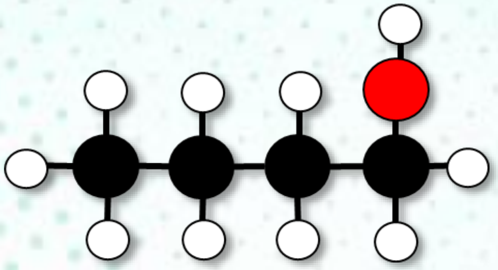
i.e. 1-hydroxl propanoic acid

Primary, secondary or Tertiary Alcohol

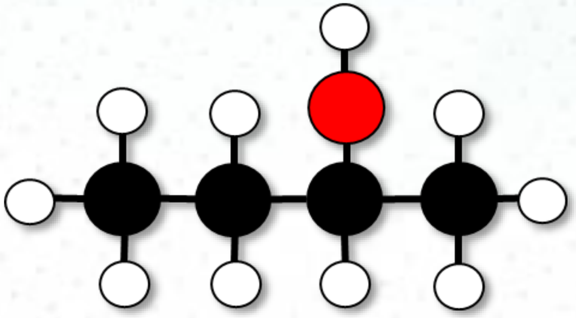
Alcohols are classified according to the position of the hydroxyl group bonded in the molecule.

This leads to the existence of

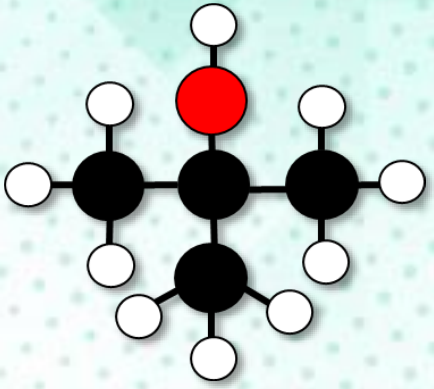
- >primary (1°) – bonded to a C that is bonded to only 1 other C
- >secondary (2°) – bonded to a C that is bonded to 2 other C
- >tertiary (3°) – bonded to a C that is bonded to 3 other C



Primary alcohol
Butan-1-ol



Secondary alcohol
Butan-2-ol

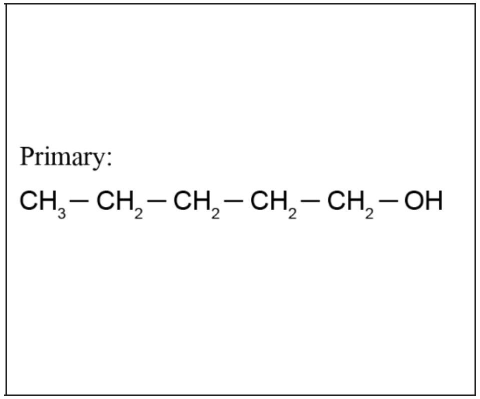


Tertiary alcohol
Methyl propan-2-ol

NCEA 2014 Alcohol Isomers

Achieved Question

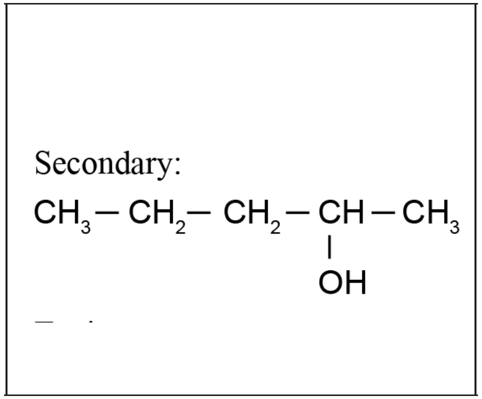
Question: 1a: Draw a primary, a secondary, and a tertiary alcohol for the molecule $C_5H_{11}OH$.



Primary:

$CH_3-CH_2-CH_2-CH_2-CH_2-OH$

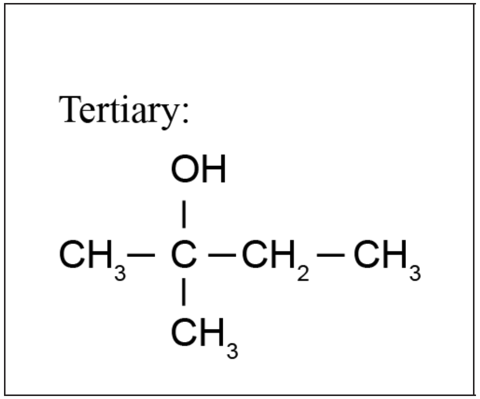
Primary



Secondary:

$CH_3-CH_2-CH_2-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

Secondary



Tertiary:

$CH_3-\overset{\displaystyle OH}{\overset{|}{\underset{\displaystyle CH_3}{\underset{|}{C}}}}-CH_2-CH_3$

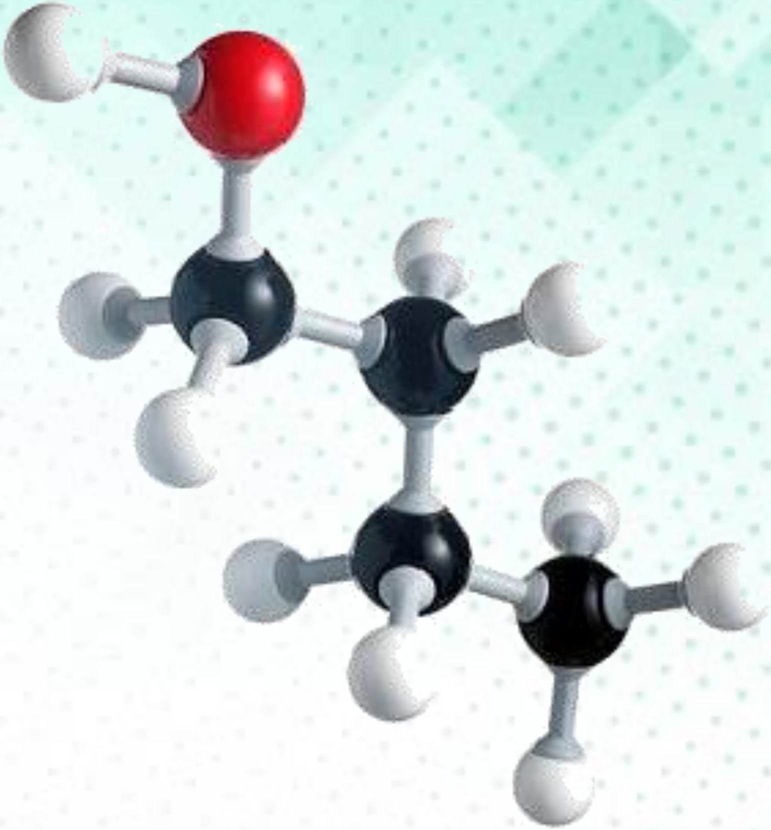
Tertiary

NCEA 2015 Alcohol isomers

Merit Question

Question: 1b: (i) Butan-1-ol has the molecular formula $C_4H_{10}O$. Its structural formula is: CH_3 CH_2 CH_2 CH_2 OH
(i) Define the term constitutional (structural) isomer.

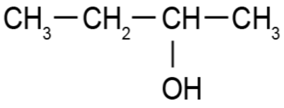
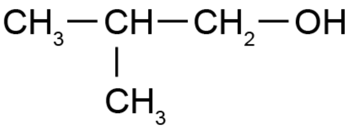
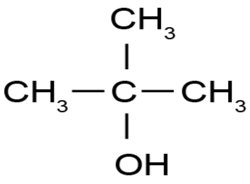
Answer: A constitutional (structural) isomer has the same molecular formula, but a different arrangement of atoms / different structural formula.



NCEA 2015 Alcohol isomers

Merit Question

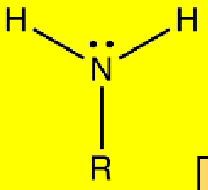
Question: 1b: (ii) Draw THREE other constitutional (structural) isomers of $C_4H_{10}O$.

Alcohol	Structural formula
[✓ A]	 $CH_3-CH_2-\underset{\overset{\vert}{OH}}{CH}-CH_3$ butan-2-ol Butan-2-ol is secondary because the carbon atom that is attached to the OH group is bonded to either two other carbon atoms or to only one hydrogen atom.
B	 $CH_3-\underset{\overset{\vert}{CH_3}}{CH}-CH_2-OH$ 2 methylpropan-1-ol
C	 $CH_3-\overset{\overset{CH_3}{\vert}}{\underset{\overset{\vert}{OH}}{C}}-CH_3$ 2 methylpropan-2-ol

(iii) Choose a **secondary** alcohol from the structures above and give a reason for your choice.

Amine (primary) Functional group

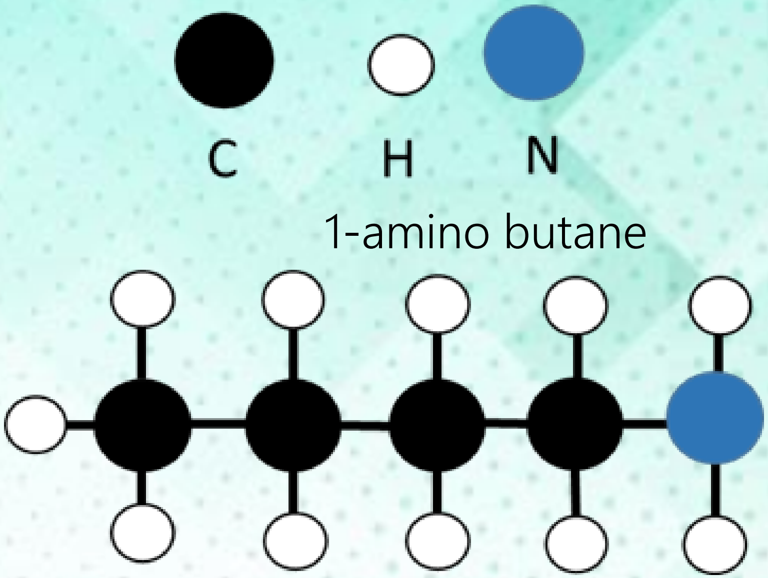
1° Amines



Functional group is the amino group –NH_2

Amines are found in many natural products, as well as used in many industrial processes.

Amines have an unpleasant "fishy" smell. The smaller amines, up to C5, are soluble in water but larger amino alkanes are insoluble, as the size of the non-polar hydrocarbon chain cancels out the effect of the polar amino functional group.



1-amino butane

☐ polar molecules as short chains ~ non-polar molecules as long chains
☐ boiling points and melting points increase with chain length
☐ turn red litmus blue as amines are **weak bases**
☐ conduct electricity in solution (weakly)
☐ Are proton acceptors

Naming Primary Amines

Write name as –

1. Identify the longest C chain -Identify any branches
2. Number the C atoms in longest chain so number Carbon 1 attached to amino group (NH_2)
3. Write the name
    1. Location of branch
    2. Name of branch
    3. Amino-
    4. Prefix of long chain
    5. -ane

e.g. 1-aminobutane (4C)

Alternative naming method

1.Identify the longest C chain - Identify any branches

2.Number the C atoms in longest chain so number Carbon 1 attached to amino group (NH_2)

3.Write the name

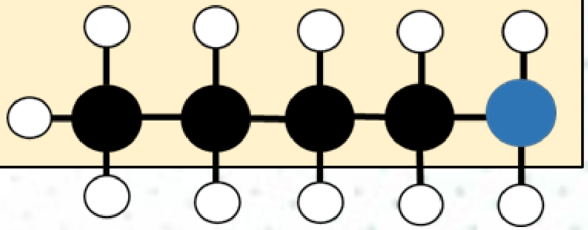
1.Location of branch

2.Name of branch

3.Prefix of long chain

4.-anamine

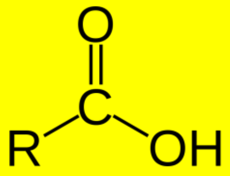
e.g. butanamine (4C)



Either will be accepted in NCEA assessments

Carboxylic Acid Functional group

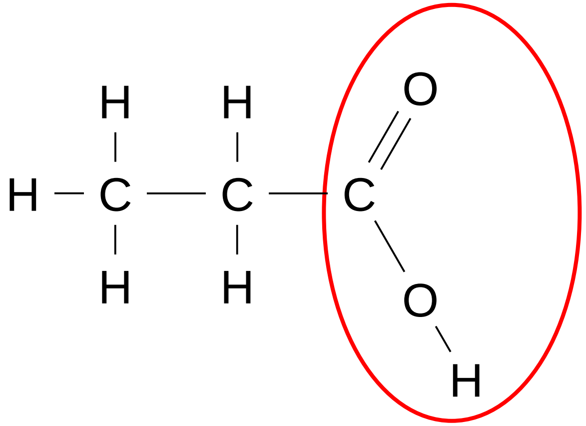
Carboxylic Acids



1

Functional group is the carboxyl group –COOH

propanoic acid

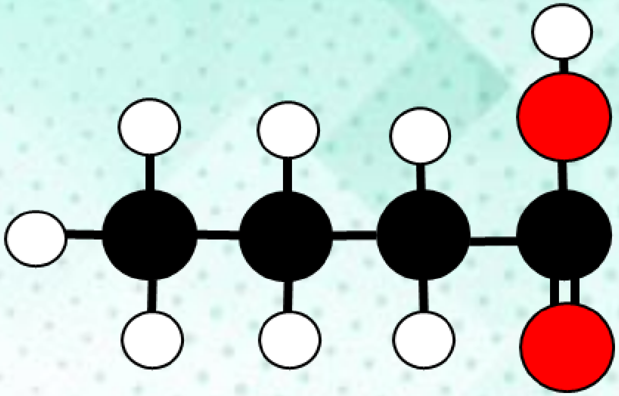


Naming

1. Longest –C chain with –COOH
2. Identify branches
3. No. 1 C is the C in –COOH
4. Location of branches
5. Name branch, listing groups in alphabetical order. 6. If more than one branch use the prefixes di, tri, tetra if the same
7. Prefix
8. -anoic acid

Carboxylic Acid properties

All the simple, straight-chain carboxylic acids up to ten carbons are liquids at room temperature. The liquids have sharp pungent odours and all have high boiling points.
Smaller molecules, less than 10 carbons, are completely miscible in water due to the formation of hydrogen bonds with the water.

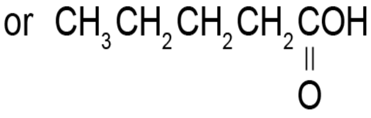
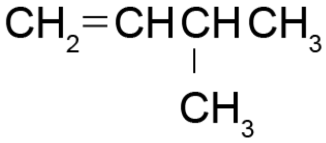
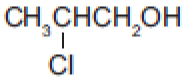
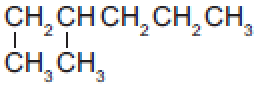


- ☐ polar molecules as short chains ~ non-polar molecules as long chains
- ☐ boiling points and melting points increase with chain length
- ☐ turn blue litmus red as carboxylic acids are **weak acids**
- ☐ conduct electricity in solution (weakly)
- ☐ react with metal to form salt and H_2
- ☐ react with metal oxides to form salt and H_2O
- ☐ react with metal carbonates to form salt and H_2O and CO_2

Names and Formula

NCEA 2013 Structural Formula and Name

Achieved Question

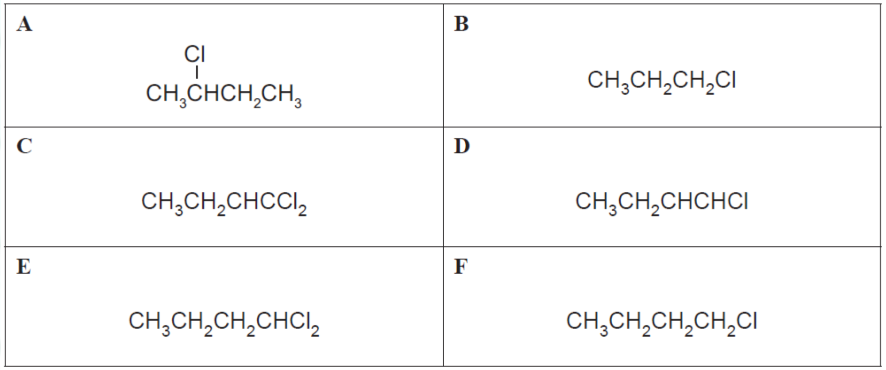
Structural formula	IUPAC (systematic) name
$CH_3CH_2CH_2CH_2COOH$ or  $CH_3CH_2CH_2CH_2\underset{\underset{O}{\Vert}}{C}OH$	pentanoic acid
 $CH_2{=}CH\underset{\underset{CH_3}{\vert}}{CH}CH_3$	3-methylbut-1-ene
$CH_3CH_2CH_2NH_2$	1-propanamine / 1-aminopropane
 $CH_3\underset{\underset{Cl}{\vert}}{C}HCH_2OH$	2-chloropropan-1-ol
 $\underset{\underset{CH_3}{\vert}}{CH_2}\underset{\underset{CH_3}{\vert}}{CH}CH_2CH_2CH_3$	3-methylhexane

Question 1d: Complete the following table to show the structural formula and IUPAC (systematic) name for each compound.

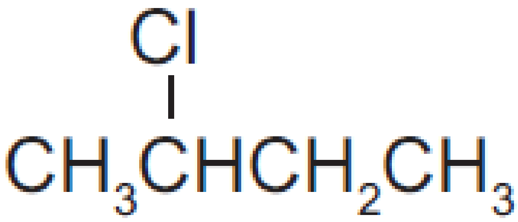
NCEA 2013 Structural Formula and Name

Excellence Question

Question 1b: Identify two molecules from the table in (a) that are constitutional (structural) isomers of each other.
Justify your choice.



A $CH_3\overset{\overset{Cl}{\vert}}{C}HCH_2CH_3$	**B** $CH_3CH_2CH_2Cl$
C $CH_3CH_2CHCCl_2$	**D** $CH_3CH_2CHCHCl$
E $CH_3CH_2CH_2CHCl_2$	**F** $CH_3CH_2CH_2CH_2Cl$



$CH_3\overset{\overset{Cl}{\vert}}{C}HCH_2CH_3$

$CH_3CH_2CH_2CH_2Cl$

A and F

Constitutional / structural isomers have the same molecular formula (they have the same type and number of atoms) but different constitutional / structural formulae (atoms are arranged differently).

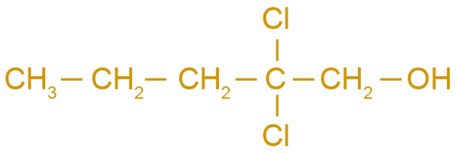
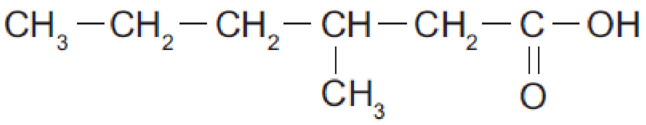
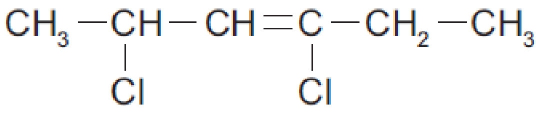
These molecules both have the same number and type of atoms but the atoms are arranged differently; C_4H_9Cl / the chlorine is on a different carbon atom.

NCEA 2014 Structural Formula and Name

Achieved Question

Question: 2a:

❑ Complete the following table to show the structural formula and IUPAC (systematic) name for each compound.

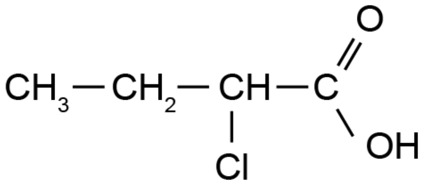
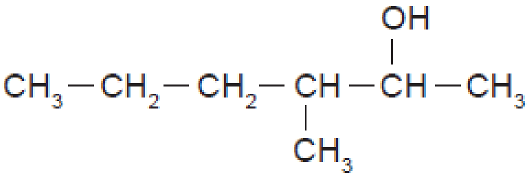
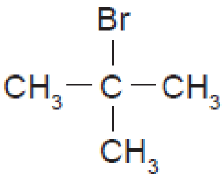
Structural formula	**IUPAC (systematic) name**
$CH_3-CH_2-C\equiv CH$	But-1-yne
 $CH_3-CH_2-CH_2-\overset{\overset{Cl}{\vert}}{\underset{\underset{Cl}{\vert}}{C}}-CH_2-OH$	2,2-dichloropentan-1-ol
$CH_3-CH_2-CH_2-CH_2-CH_2-NH_2$	Pentanamine or pentylamine or 1-aminopentane
 $CH_3-CH_2-CH_2-\underset{\underset{CH_3}{\vert}}{CH}-CH_2-\underset{\underset{O}{\Vert}}{C}-OH$	3-methylhexanoic acid
 $CH_3-\underset{\underset{Cl}{\vert}}{CH}-CH=\underset{\underset{Cl}{\vert}}{C}-CH_2-CH_3$	2,4-dichlorohex-3-ene

Names and Formula

NCEA 2015 Structural Formula and Name (Part One)

Achieved Question

Question: 1a: (i) Complete the following table to show the structural formula a IUPAC (systematic) name for each compound.

Structural formula	**IUPAC (systematic) name**
$CH_3CH_2CH_2NH_2$	propan-1-amine
 $CH_3-CH_2-CH(Cl)-C(=O)OH$	2-chlorobutanoic acid
 $CH_3-CH_2-CH_2-CH(CH_3)-CH(OH)-CH_3$	3-methylhexan-2-ol
 $CH_3-CBr(CH_3)-CH_3$	2-bromo-2-methylpropane or 2-bromomethylpropane

Names and Formula

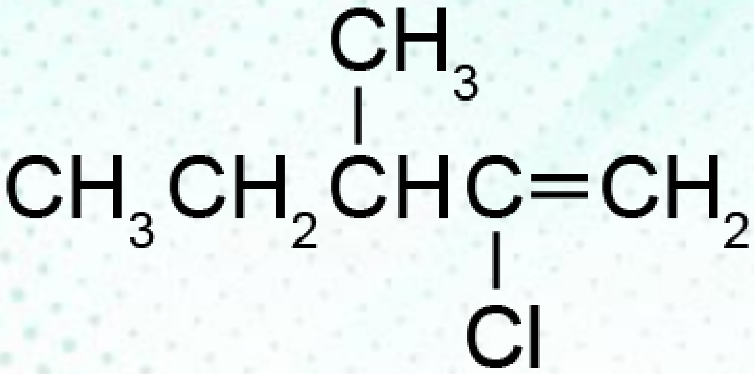
NCEA 2015 Structural Formula and Name (Part Two)

Merit Question

Question: 1a: (ii) The organic compound, 4-chloro-3-methylpent-4-ene has been named incorrectly.

☐ Draw the implied structure and explain why it is named incorrectly.

☐ Give the correct IUPAC name for this structure



$$CH_3CH_2\overset{\displaystyle CH_3}{\overset{|}{C}H}\underset{\underset{\displaystyle Cl}{|}}{C}=CH_2$$

Numbering of the chain starts from the end that carries the main functional group, the double bond. Once counted from this end, the number of the double bond and chlorine change.

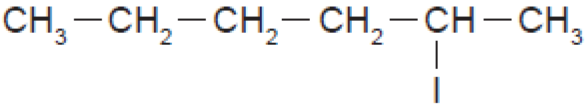
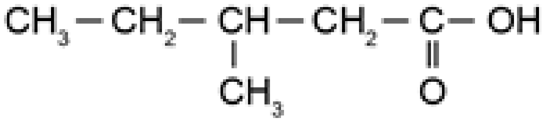
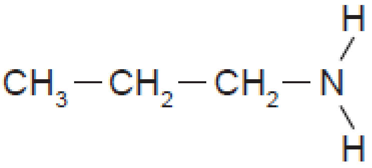
2-chloro-3-methylpent-1-ene.

Names and Formula

NCEA 2016 Structural Formula and Name (Part One)

Achieved Question

Question: 1a: (i) Complete the following table.

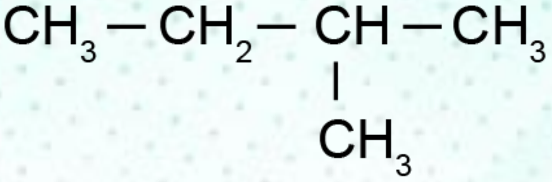
Structural formula	IUPAC (systematic) name
 $CH_3-CH_2-CH_2-CH_2-\underset{\substack{\vert\\ I}}{CH}-CH_3$	2-iodohexane
 $CH_3-CH_2-\underset{\substack{\vert\\ CH_3}}{CH}-CH_2-\underset{\substack{\Vert\\ O}}{C}-OH$	3-methylpentanoic acid
$H-C\equiv C-CH_2-CH_3$	but-1-yne
 $CH_3-CH_2-CH_2-\overset{\substack{H\\ /}}{\underset{\substack{\backslash\\ H}}{N}}$	propan-1-amine (1-propanamine)

NCEA 2016 Structural Formula and Name (Part Two)

Merit Question

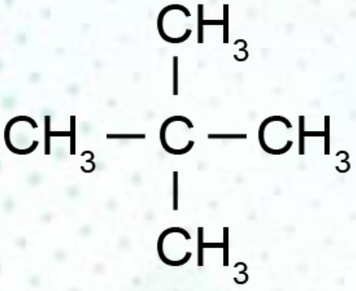
Question: 1a: (ii) Draw and name the THREE constitutional (structural) isomers of the organic compound C_5H_{12}.

$CH_3-CH_2-CH_2-CH_2-CH_3$ pentane



$$CH_3-CH_2-\underset{\underset{CH_3}{|}}{CH}-CH_3$$

methylbutane (or accept 2-methylbutane)



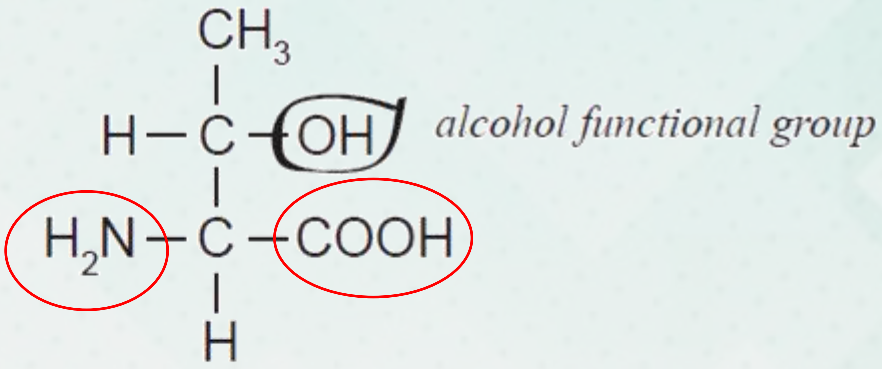
$$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3$$

dimethylpropane (or accept 2,2-dimethylpropane)

NCEA 2017 Structural Formula and Name

Merit Question

Question: 2a: The structure of a molecule of an organic compound, threonine, shown below.



threonine

An alcohol functional group has been identified in the threonine molecule above.

(i) Circle and name **two other** functional groups on the threonine molecule above.

(ii) Classify the alcohol functional group as primary, secondary, or tertiary.

(iii) Explain how you classified the alcohol group.

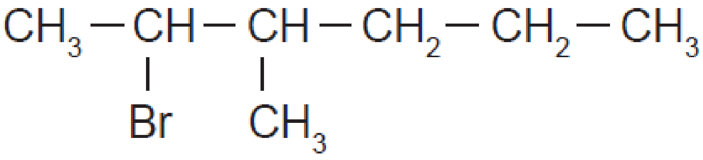
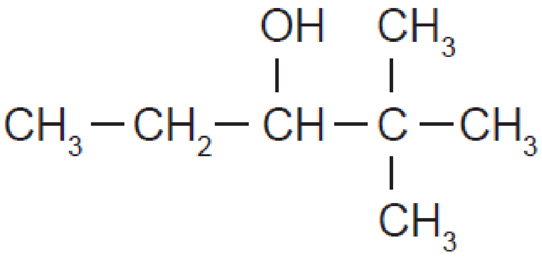
Secondary (or 2°)

This alcohol group is classified as secondary because the carbon atom that is attached to the OH functional group is bonded to either two other carbon atoms or only one hydrogen atom.

NCEA 2017 Structural Formula and Name

Achieved Question

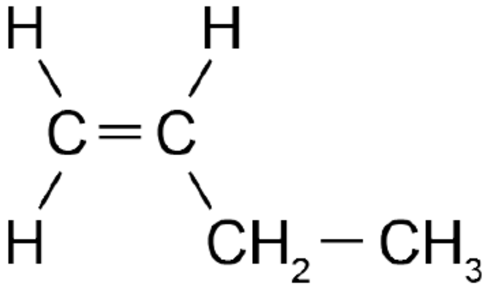
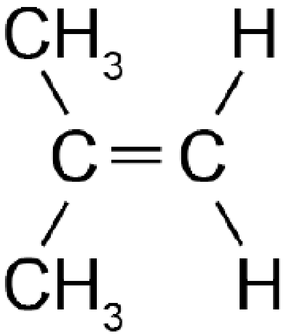
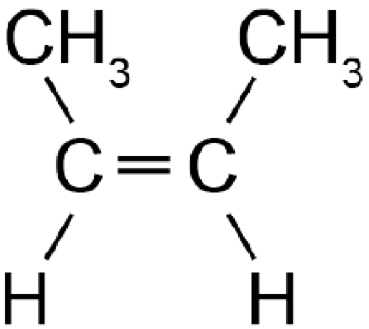
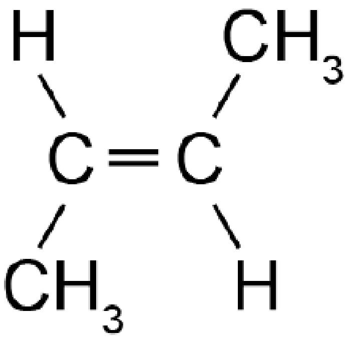
Question: 2b: Name the organic compounds in the table below.

Compound	IUPAC (systematic) name
$CH_3-CH_2-CH_2-C\equiv CH$	Pent-1-yne
 $CH_3-\underset{\substack{\vert\\ Br}}{CH}-\underset{\substack{\vert\\ CH_3}}{CH}-CH_2-CH_2-CH_3$	2-bromo-3-methylhexane
 $CH_3-CH_2-\overset{\substack{OH\\ \vert}}{CH}-\overset{\substack{CH_3\\ \vert}}{\underset{\substack{\vert\\ CH_3}}{C}}-CH_3$	2,2-dimethylpentan-3-ol.

NCEA 2017 Structural Formula and Name (PART ONE)

Achieved Question

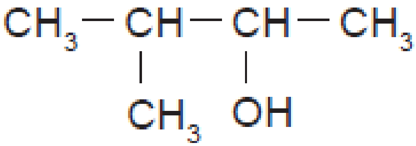
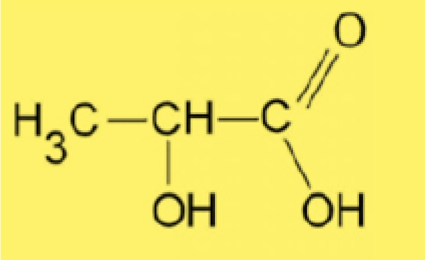
Question: 2c: (i) Draw four alkene isomers for the organic compound C_4H_8 in t
table below..

1. 	**2.** 
3. 	**4.** 

NCEA 2018 Structural Formula and Name

Achieved Question

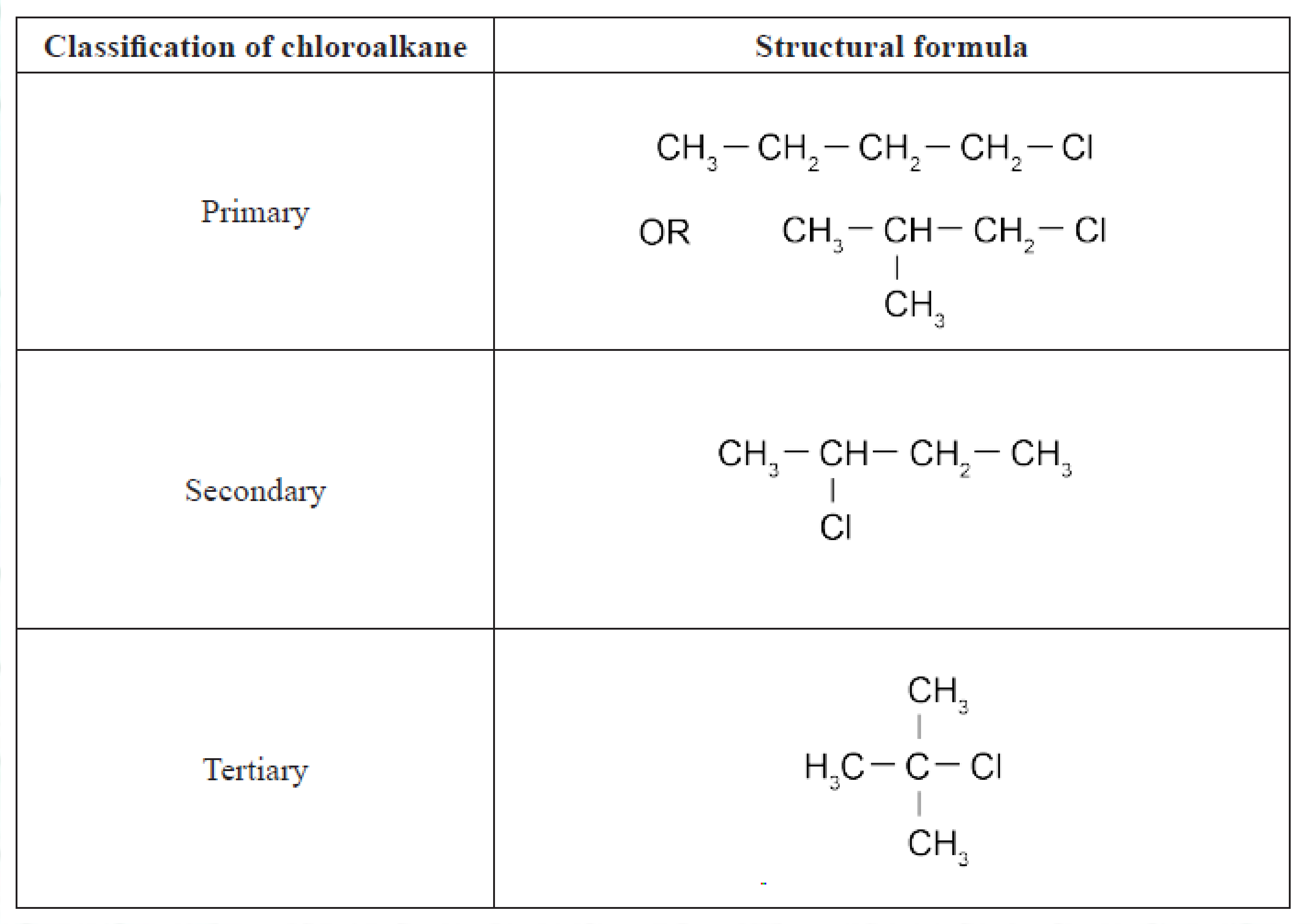
Question: 1a: Complete the following table.

Compound	IUPAC (systematic name)
$CH_2=CH-CH_2-CH_2-CH_3$	pent-1-ene
 $CH_3-\underset{\underset{CH_3}{\vert}}{CH}-\underset{\underset{OH}{\vert}}{CH}-CH_3$	3-methyl butan-2-ol
	2-hydroxypropanoic acid

NCEA 2018 Structural Formula and Name

Achieved Question

Question: 1b: Draw structural formulae for primary, secondary, and tertiary chloroalkane molecules that are constitutional (structural) isomers with the molecular formula C_4H_9Cl.



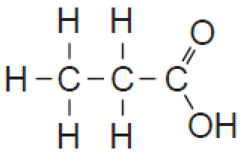
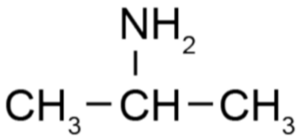
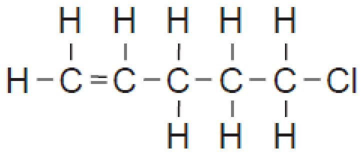
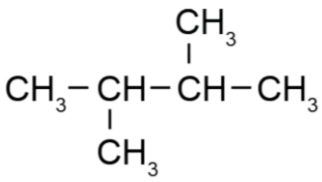
Classification of chloroalkane	Structural formula
Primary	$CH_3-CH_2-CH_2-CH_2-Cl$ OR $CH_3-\underset{\underset{CH_3}{\vert}}{CH}-CH_2-Cl$
Secondary	$CH_3-\underset{\underset{Cl}{\vert}}{CH}-CH_2-CH_3$
Tertiary	$H_3C-\overset{\overset{CH_3}{\vert}}{\underset{\underset{CH_3}{\vert}}{C}}-Cl$

Names and Formula

NCEA 2019 Structural Formula and Name

Achieved Question

Question: 1a: Complete the following table.

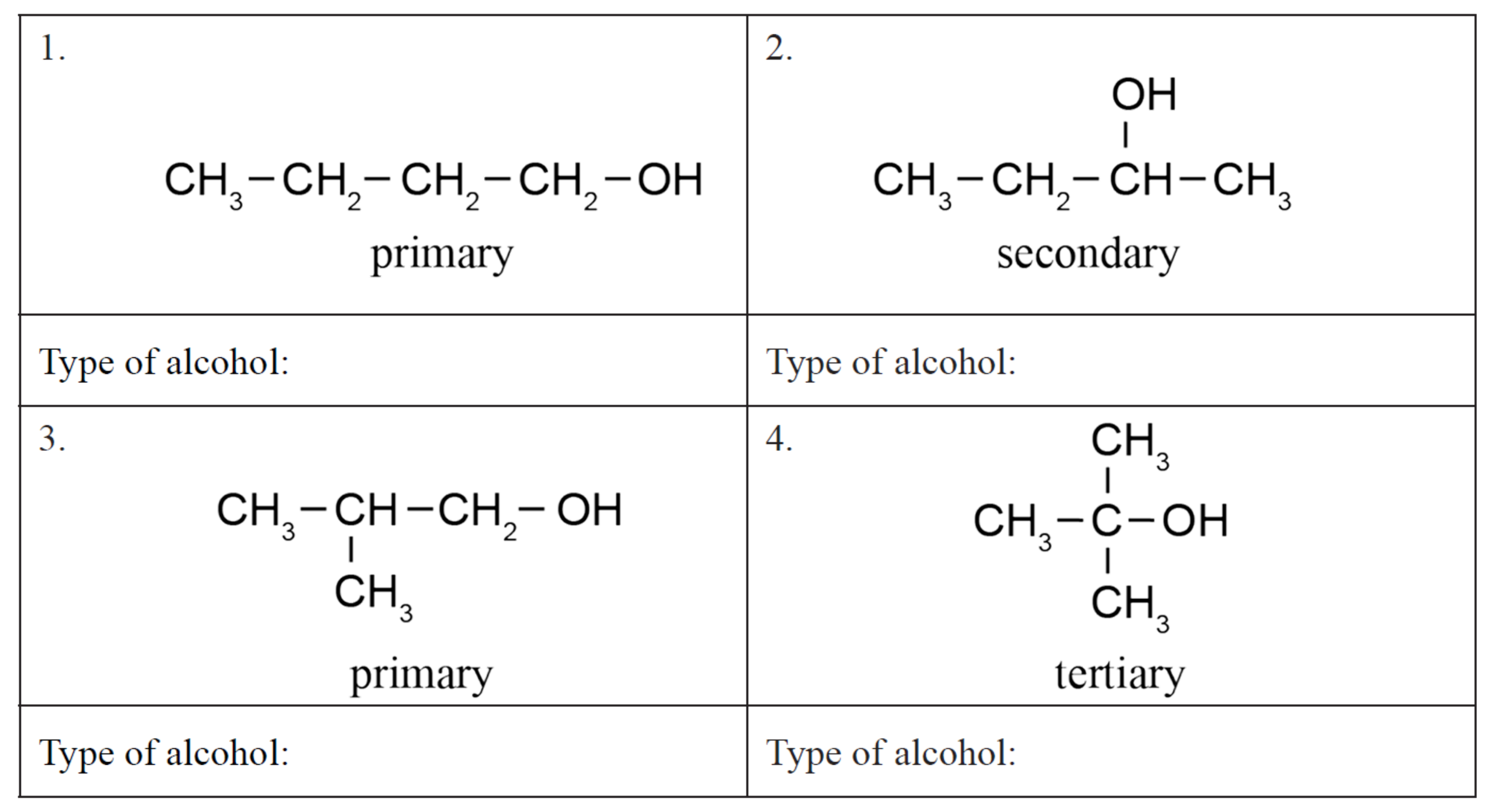
Compound	IUPAC (systematic name)
	Propanoic acid
 $CH_3-CH(NH_2)-CH_3$	propan-2-amine
	5-chloro pent-1-ene
 $CH_3-CH(CH_3)-CH(CH_3)-CH_3$	2,3-dimethylbutane

Names and Formula

NCEA 2019 Structural Formula and Name

Achieved Question

Question: 1b: Draw four structural (constitutional) isomers of $C_4H_{10}O$ that are alcohols. Classify the alcohols as either primary, secondary or tertiary.

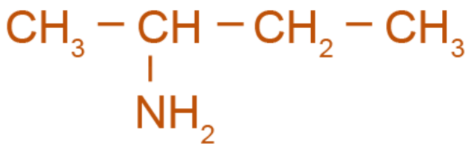
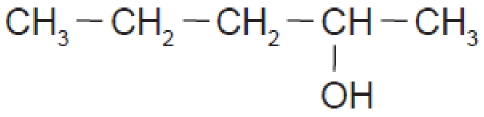
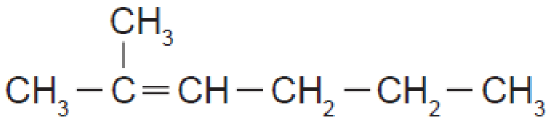
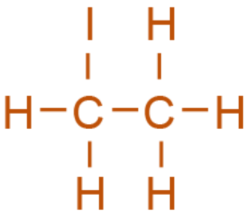


1. $CH_3-CH_2-CH_2-CH_2-OH$ primary	2. $CH_3-CH_2-\overset{OH}{\overset{\vert}{CH}}-CH_3$ secondary
Type of alcohol:	Type of alcohol:
3. $CH_3-\underset{\underset{CH_3}{\vert}}{CH}-CH_2-OH$ primary	4. $CH_3-\overset{CH_3}{\overset{\vert}{\underset{\underset{CH_3}{\vert}}{C}}}-OH$ tertiary
Type of alcohol:	Type of alcohol:

NCEA 2020 Structural Formula and Name

Achieved Question

Question: 1a: Complete the following table

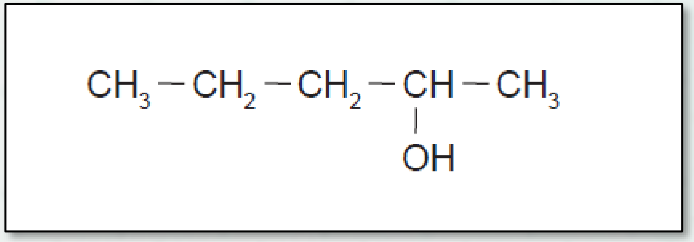
Compound	IUPAC (systematic name)
 $CH_3-\underset{\underset{NH_2}{\vert}}{CH}-CH_2-CH_3$	butan-2-amine
 $CH_3-CH_2-CH_2-\underset{\underset{OH}{\vert}}{CH}-CH_3$	pentan-2-ol
 $CH_3-\overset{\overset{CH_3}{\vert}}{C}=CH-CH_2-CH_2-CH_3$	2-methylhex-2-ene
 $\begin{array}{ccccc} & I & & H & \\ & \vert & & \vert & \\ H- & C & - & C & -H \\ & \vert & & \vert & \\ & H & & H & \end{array}$	iodoethane

Names and Formula

NCEA 2020 Structural Formula and Name

Merit Question

Question: 1b: Classify the alcohol in the table above as primary, secondary, or tertiary, and explain your choice.



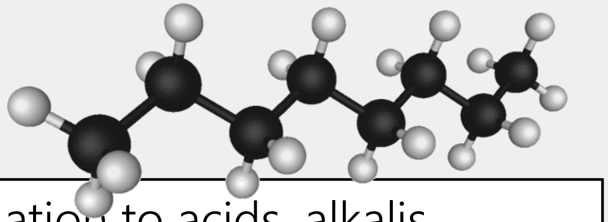
$CH_3-CH_2-CH_2-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

Pentan-2-ol is a secondary alcohol because
the OH is bonded to a carbon
that is bonded to two other carbons.

Background Knowledge

Physical properties of alkanes and alkenes

Alkanes, alkenes and alkynes are known as hydrocarbons due to being comprised of just carbon and hydrogen atoms. These functional groups have common chemical and physical properties

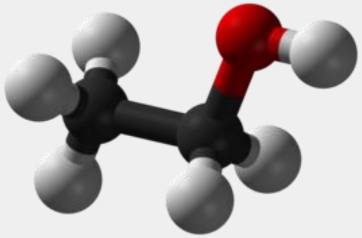


1. **Non reactivity of alkanes and alkenes** (in relation to acids, alkalis, metals, water, because they are non-polar molecules).
2. **Low melting and boiling points** – Organic molecules have weak intermolecular forces holding them together.
3. **Odour** – hydrocarbons are volatile because they have weak intermolecular forces and they have characteristic smells.
4. **Conductivity** - Do not conduct heat or electricity. (as they are molecular)
5. **State** - As the C chain gets longer the hydrocarbons change from gas to liquid to solid.
6. **Combustion** - Alkanes (and alkenes) are very good fuels.
7. **Polarity** - Alkanes and alkenes are non-polar so they are **not soluble** in water

Background Knowledge

Physical properties of alcohols

Small alcohol molecules are polar and the presence of the OH group means their intermolecular bonding is stronger than non-polar alkanes and alkenes. The large difference in electronegativity (ability to "grab" electrons from another atom due to their pull from the combined positive protons in their nucleus) between the O and H atoms means the O-H bond is very polar and the slightly positive charge on this H atom is attracted to the non-bonding electron pairs of the oxygen on another molecule.



Physical properties: This means small alcohol molecules are **highly soluble in water**. However as the length of the non-polar hydrocarbon chain increases this solubility in water decreases.

Chemical properties: Aqueous solutions are neutral. The presence of the OH group in this molecule is NOT the same as the OH- in sodium hydroxide, NaOH (an ionic compound).

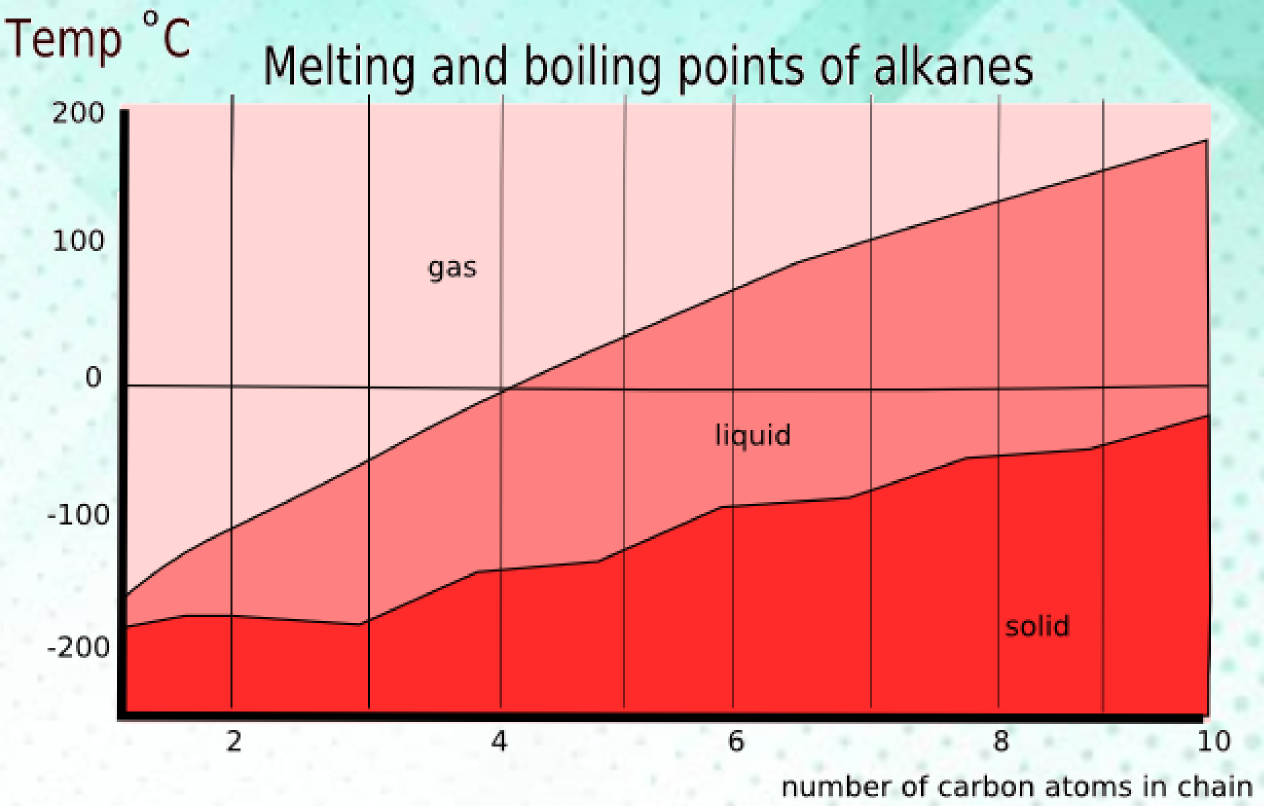
Melting and boiling points of alkanes

Alkanes are **non-polar molecules** and are bonded together by **weak intermolecular** forces.

As the number of carbons increase, so does the Molar Mass of the molecule. The larger the molar mass the more total valence electrons are available. These valance electrons can randomly cluster on one side or the other of the molecule creating an instantaneous polar end – thereby creating a stronger bond to another molecules

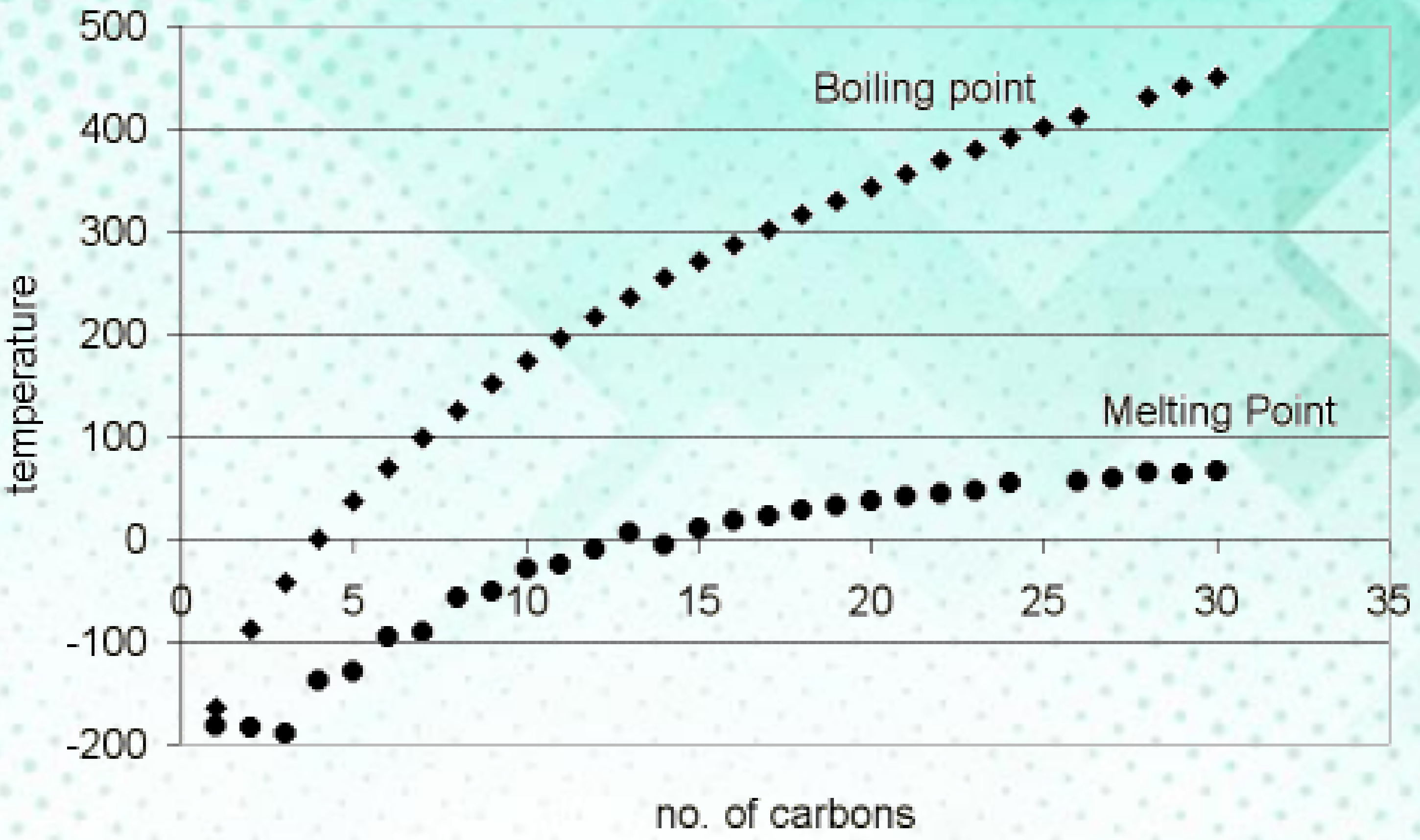
instantaneous polar end

extra info



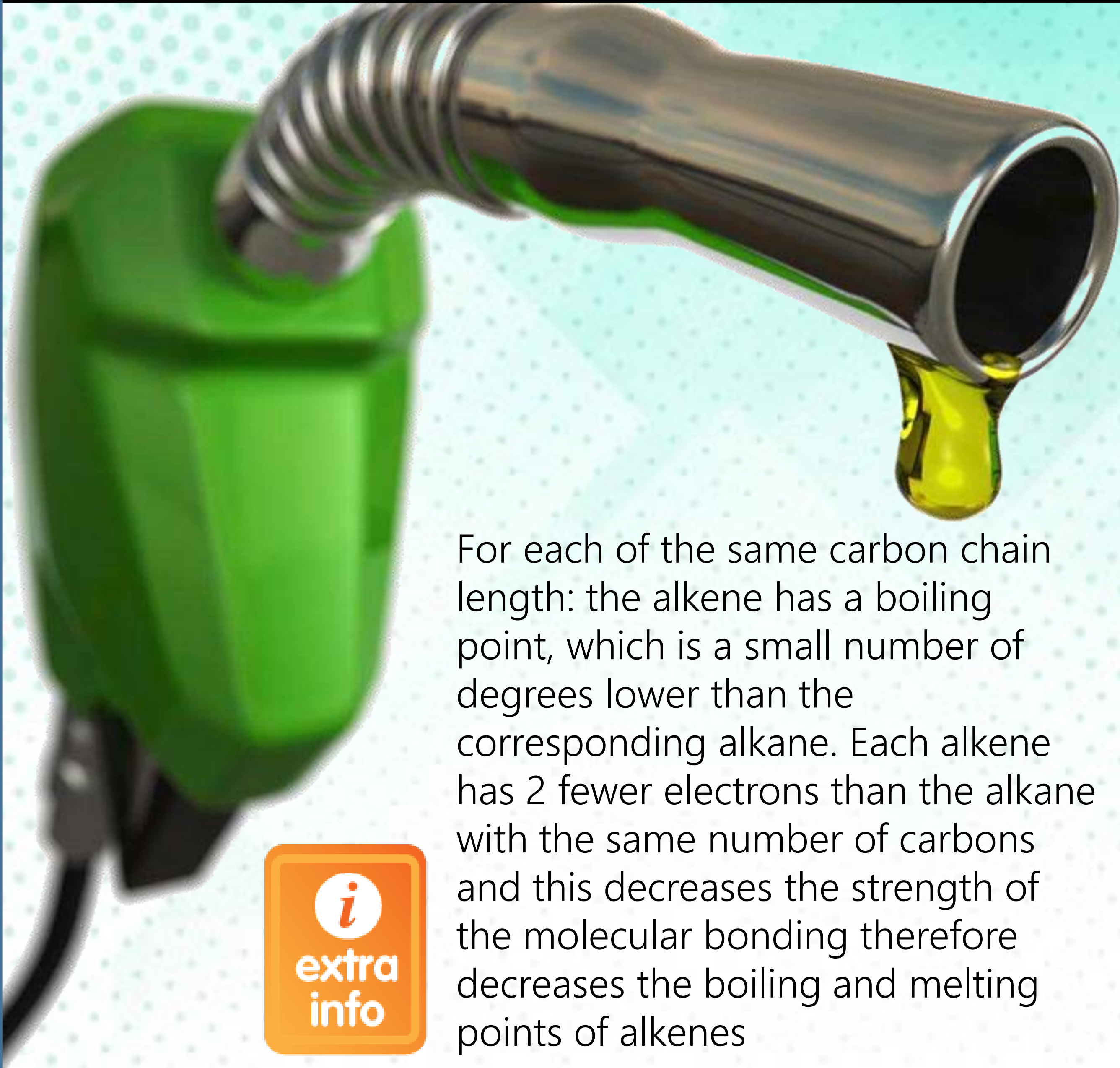
The greater the number of carbons; the stronger the bond between molecules and therefore the higher the melting and boiling point.

Summary of Boiling points for alkenes



The same principle of increasing molar mass (more carbons in the chain) leading to a higher MP/BP applies to alkenes as it did alkanes.
The MP/BP is still very low as these hydrocarbons are non-polar molecular solids with weak intermolecular bonding.

Comparing Melting and boiling points of alkanes and alkenes



The **melting point** and **boiling point** of each **alkene** is very similar to that of the alkane with the same number of carbon atoms. Ethene, propene and butane are gases at room **temperature**. Intermolecular forces of **alkenes** gets stronger with increase in the size of the molecules

For each of the same carbon chain length: the alkene has a boiling point, which is a small number of degrees lower than the corresponding alkane. Each alkene has 2 fewer electrons than the alkane with the same number of carbons and this decreases the strength of the molecular bonding therefore decreases the boiling and melting points of alkenes

Summary of Boiling points

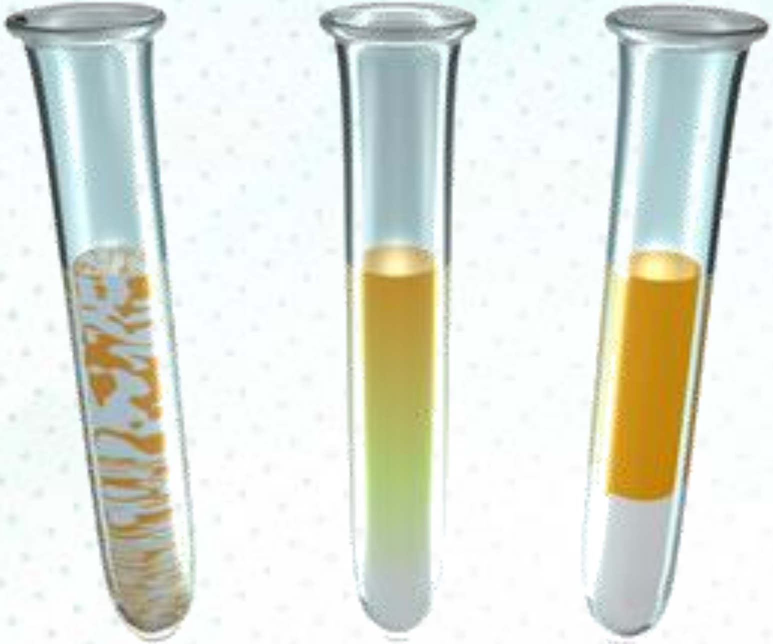
Alkanes: The smaller the alkane molecule the lower the boiling point and the more volatile (easier to combust) the alkane. As the molar mass (Mass number of all the atoms combined) increases, the boiling points also increase as the strength of the intermolecular (between molecules) attractions increases.
The alkanes methane to butane (C1 – C4) are all gases at room temperature
Alkanes with between 5C and 15C atoms are all liquids
Alkanes with over 15 C atoms are soft solids

Alkenes: The boiling point trend is similar to alkanes where the larger the number of C atoms in the chain the higher the boiling point. The equivalent length C chain alkene has a slightly higher point than that of the alkanes.

Alcohols: The boiling point trend is similar to both alkanes and alkenes where the larger the number of C atoms in the chain the higher the boiling point.
The boiling point is higher than both alkanes and alkenes as the intermolecular bonding is stronger due to being a polar molecule– which creates a positive and negative end and hold the individual alcohol molecules together stronger and thus needs more energy to break them (heat energy)
Even small chain alcohols are liquid at room temperature

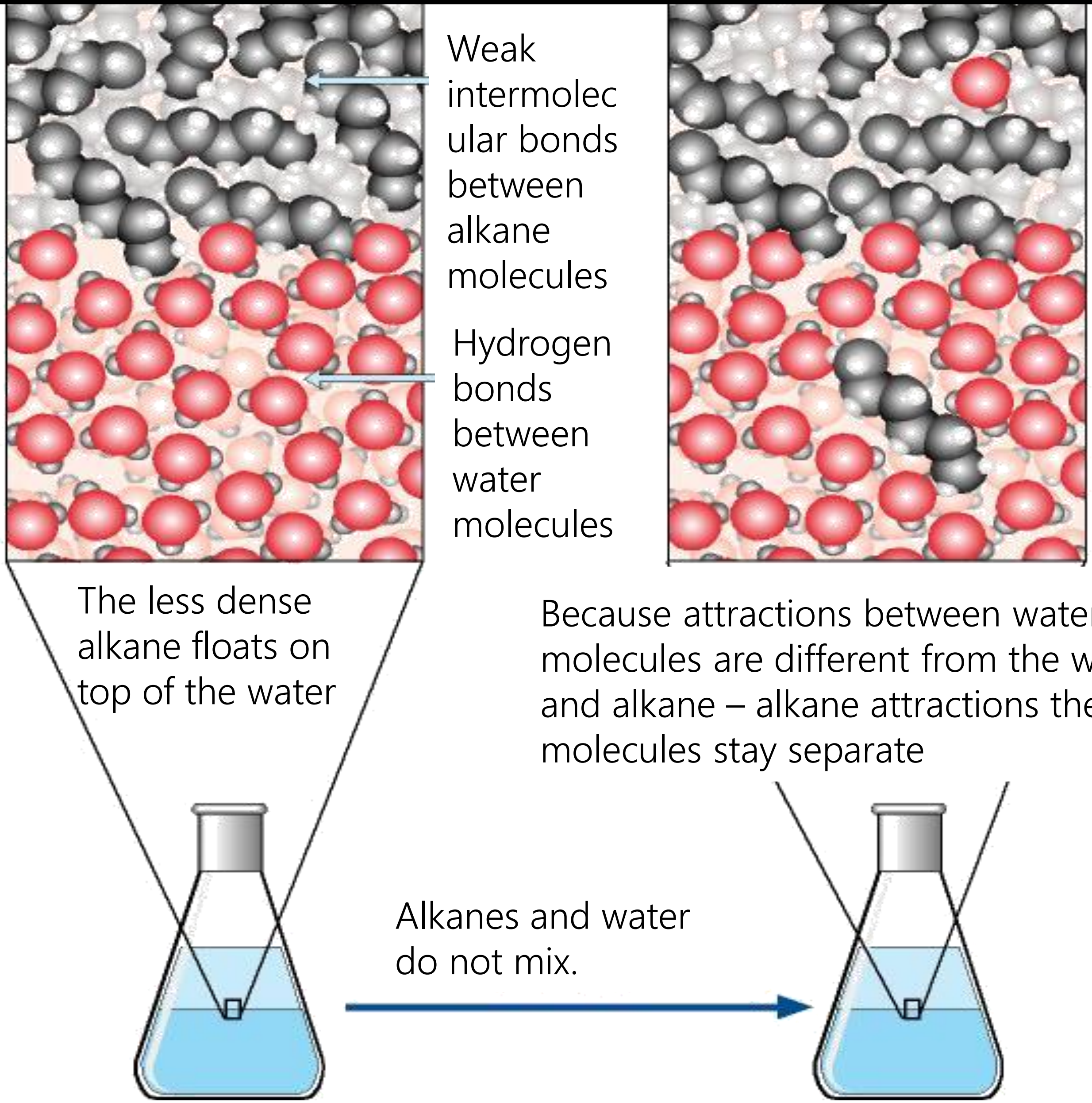
Solubility in water – alkanes and alkenes

Alkanes and Alkenes: **Not soluble in water.** These molecules are non-polar (there is no negative or positive ends to the molecule) compared with water which is polar (having a negative area near the oxygen atom and positive area near the hydrogen atoms) so they are not attracted to each other. Alkanes and alkenes are **immiscible** (two or more liquids that will not mix together to form a single homogeneous substance) and form a distinct layer from the water. Smaller C chained alkanes and alkenes are less dense than water and float on top.



If either an Alkane or Alkene is mixed into water eventually the two liquids will form separate **immiscible** layers

Summary of solubility in Water – Alkanes and Alkenes



Weak intermolecular bonds between alkane molecules

Hydrogen bonds between water molecules

The less dense alkane floats on top of the water

Because attractions between water and alkane molecules are different from the water – water and alkane – alkane attractions the two types of molecules stay separate

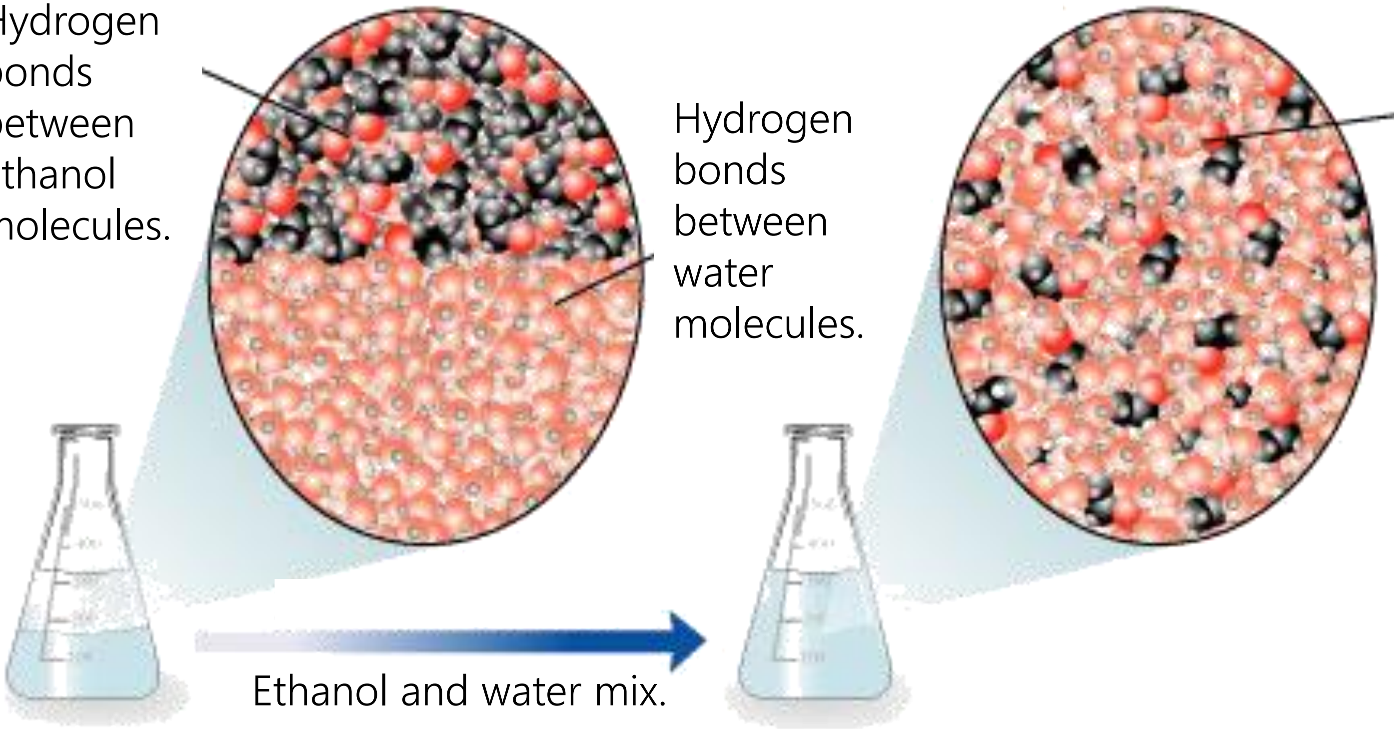
Alkanes and water do not mix.

Summary of solubility in Water - Alcohol

Alcohols: **Soluble in water.** These molecules are polar (due to the –OH end) and water, also being polar, will bond with the alcohol. The alcohol molecules will therefore disperse and mix within the water molecules.

At the instant ethanol and water are mixed the ethanol floats on top of the water

Because the attractions between their molecules are similar, the molecules mix freely, allowing each substance to disperse into the other



Hydrogen bonds between ethanol molecules.

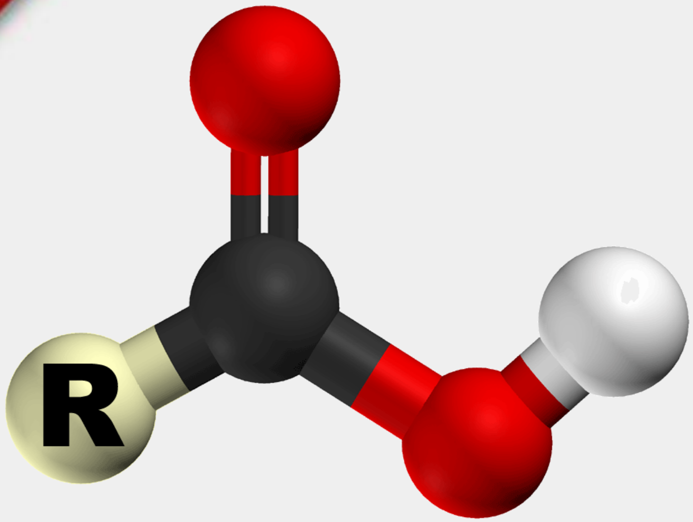
Hydrogen bonds between water molecules.

Hydrogen bonds between ethanol and water molecules.

Ethanol and water mix.

Background Knowledge

Bonding and physical properties Carboxylic Acid



All the simple, straight-chain carboxylic acids up to ten carbons are liquids at room temperature. The liquids have sharp pungent odours and all have high boiling points.

Smaller molecules, less than 10 carbons, are completely miscible in water due to the formation of stronger intermolecular bonding with the water.

The highly polar carboxylic acids dimerise (bond two molecules together) in the liquid phase and in non-aqueous solvents (CCl_4) and form stronger intermolecular bonds between each pair.

This extra degree of stronger intermolecular bonding causes carboxylic acids to have higher boiling points compared to their corresponding alcohols.

Background Knowledge

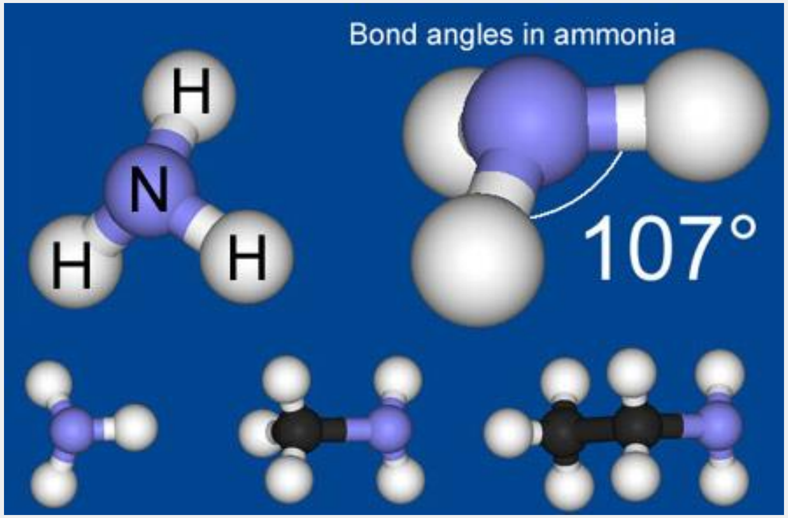
Bonding and physical properties Amines

Intermolecular bonding results from hydrogen bonding between the N-H groups and ID-ID attractions from the hydrocarbon portions.

States

- Aminomethane and aminoethane are **gases**.
- Aminopropane and aminobutane are volatile **liquids** with fishy smells.
- Heavier aminoalkanes are **solids**.

Solubility in water
Lower molecular mass aminoalkanes are soluble in water due to hydrogen bonding. Solubility in water decreases as hydrocarbon portion increases.



GZ Science Resources

NCEA 2014 Physical Properties

Excellence Question

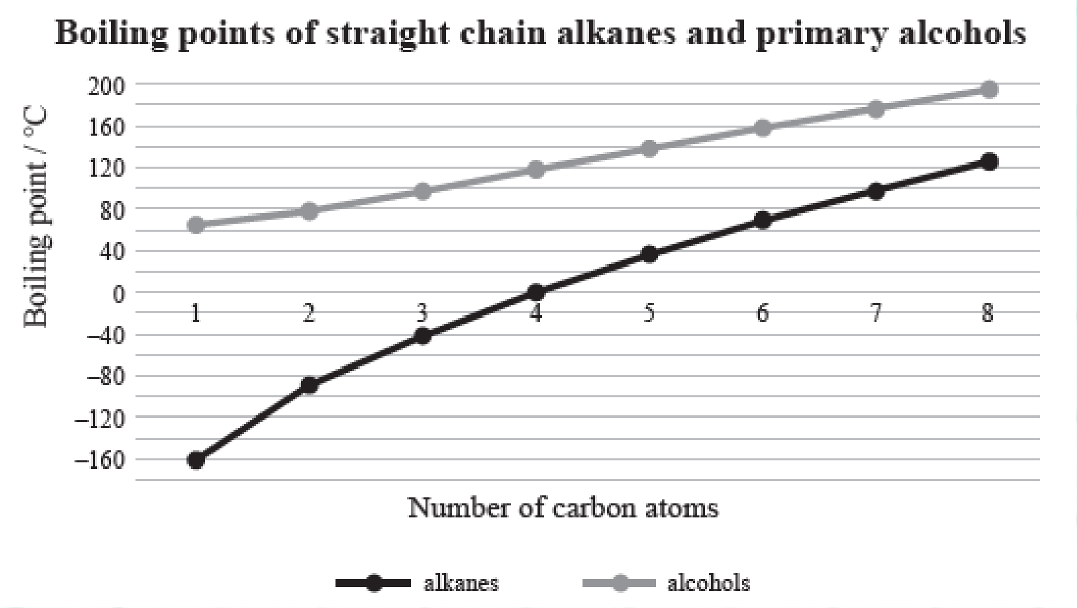
Question 1c: Explain why two layers form in **Reaction One**. Hexane reacts with bromine water

Two layers form in Reaction One as **hexane is non-polar** and the product (bromohexane) is effectively also non-polar. The water from the **bromine water is polar** and therefore the non-polar organic reactant and product will not dissolve in the water; because of this, two layers form as this polar and non-polar layer do not mix.

NCEA 2016 Physical properties

Merit Question

Question 2a (i) : Identify the trends shown on the graph



The boiling points of both alkanes and alcohols increase as the number of C atoms increases. The boiling points of alcohols are always higher than the alkanes (with the same number of C atoms).

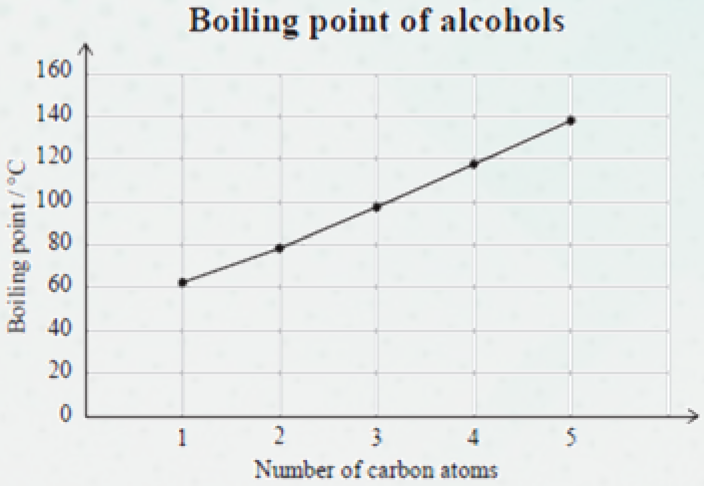
(ii) Identify which alkanes will be gases at room temperature (20°C) according to the graph above.

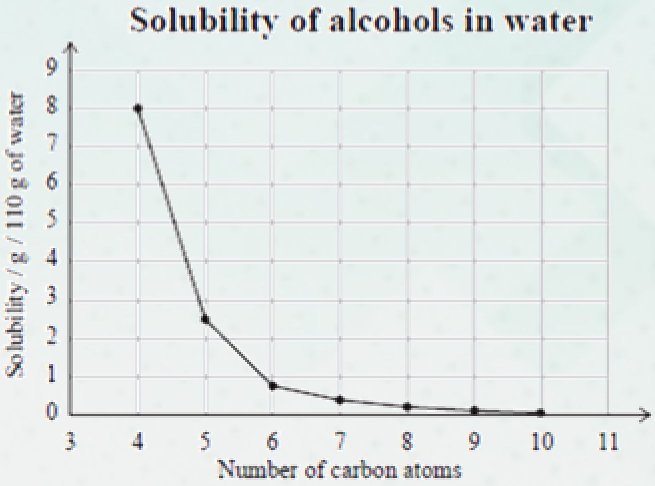
Alkanes with 1, 2, 3, and 4 C atoms (methane, ethane, propane, and butane) will be gases at room temperature.

NCEA 2018 Physical Properties

Achieved Question

Question: 3a: The graphs below show trends in two physical properties of alcohols. Identify the trends shown on the graphs below





As the number of carbons increases, the boiling points for alcohols increase, but the solubilities of the alcohols in water decreases.

Physical Properties

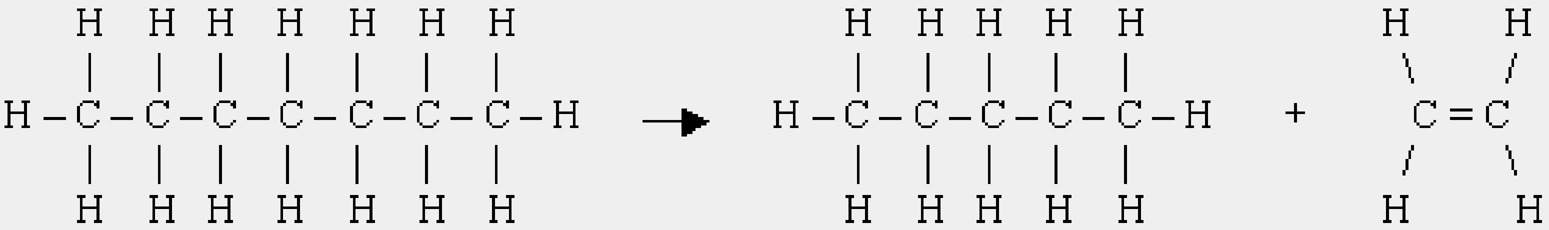
Background Knowledge

Cracking of alkanes to get alkenes

In petroleum there are many more long chain molecules than can be used (at the present time anyhow) and not enough short chain ones for petrol. So the long chain molecules are split up into shorter molecules. This is called **cracking.**

$$C_{10}H_{22} \xrightarrow{\text{Temp, pressure, catalyst}} C_8H_{18} + C_2H_4$$

Long hydrocarbon chain → alkane + alkene



$$\begin{array}{ccccccccccccccccc} & & H & & H & & H & & H & & H & & H & & H & & \\ & & | & & | & & | & & | & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & | & & | & & | & & | & & \\ & & H & & H & & H & & H & & H & & H & & H & & \end{array} \rightarrow \begin{array}{ccccccccccccc} & & H & & H & & H & & H & & H & & \\ & & | & & | & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & | & & | & & \\ & & H & & H & & H & & H & & H & & \end{array} + \begin{array}{ccccc} H & & & & H \\ & \backslash & & / & \\ & C & = & C & \\ & / & & \backslash & \\ H & & & & H \end{array}$$

Combustion of Alkanes

Combustion of hydrocarbons involves the breaking of bonds **between the atoms**, (as opposed to melting) either with plentiful oxygen – complete combustion, or limited oxygen – incomplete combustion. The products formed are water plus CO_2 (or CO/C with limited oxygen).

Background Knowledge

Combustion of Alkanes

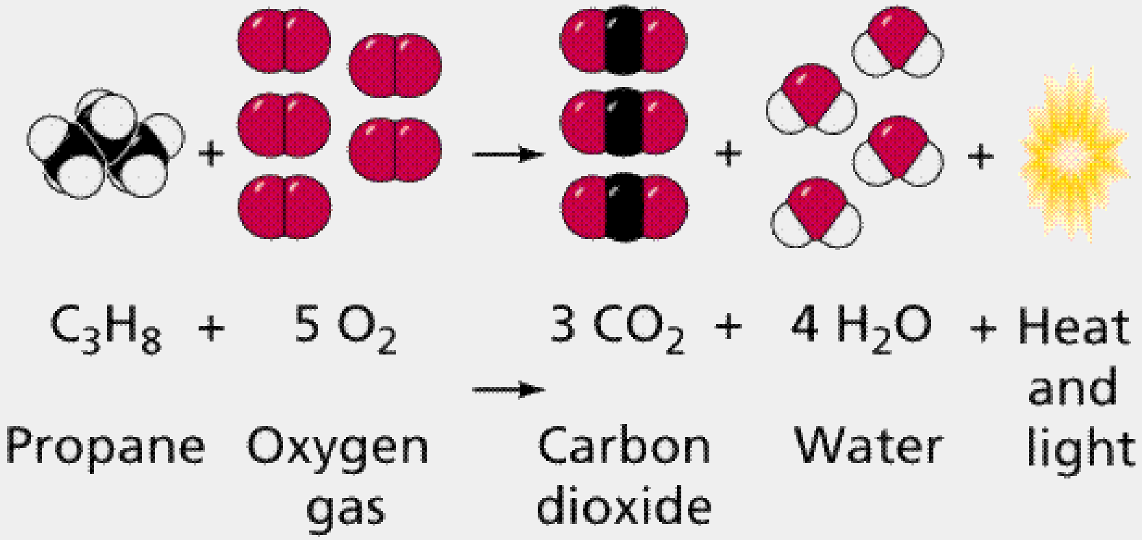
extra info

Complete combustion

Alkane + Oxygen → Carbon Dioxide + water

Incomplete combustion

Alkane + limited oxygen → Carbon Monoxide or Soot + Water



$$C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O + \text{Heat and light}$$

Background Knowledge

GZ Science Resources

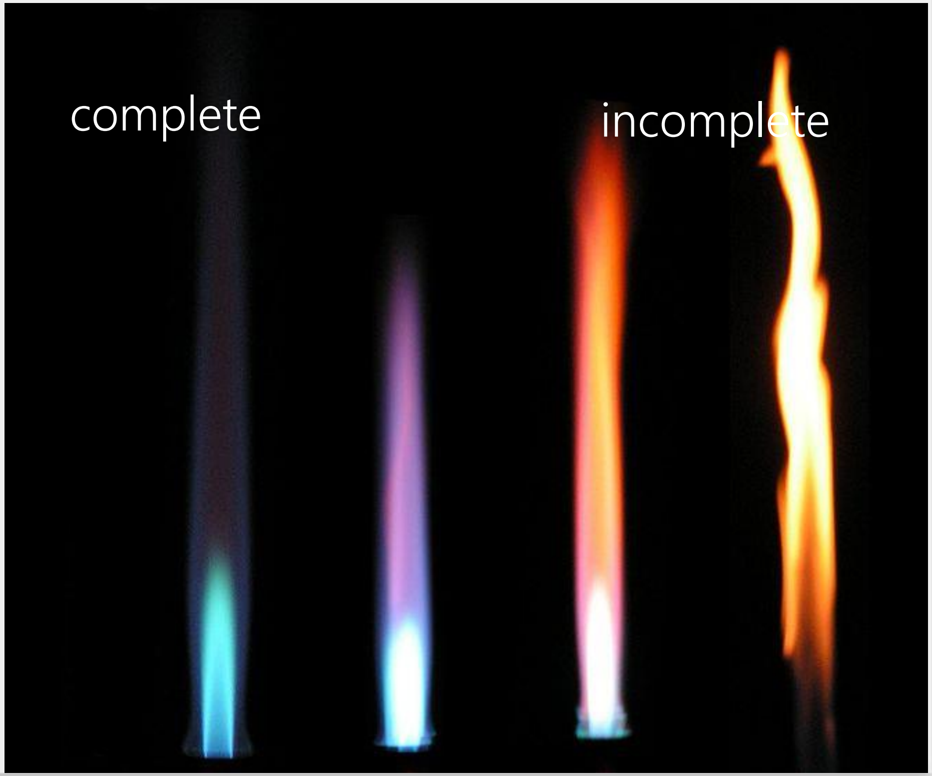
Combustion

extra info

Complete combustion: needs plentiful O_2 / good ventilation. Flame burns clear / blue. The products are CO_2 and H_2O
Energy efficient - maximum amount of energy in hydrocarbon released

Incomplete combustion: occurs in limited O_2 / poor ventilation. Flame burns dirty yellow/orange. The products CO and C (soot) and H_2O. Reduced energy efficiency – less than the maximum amount of energy in hydrocarbon is released

As C chain length increases you get more incomplete combustion occurring as bigger molecules need more O_2 from complete combustion



Background Knowledge

Combustion equations

extra info

Combustion Equations

Step 1. Write down the molecular formula of the alkane plus O_2 on the left hand side

Step 2. Write down CO_2 plus H_2O on the right hand side

Step 3. Add the number of carbon atoms in the Alkane and balance the number of CO_2 (same as number of Cs)

Step 4. Add number of Hydrogen atoms in the Alkane and balance the number of H_2O (will be half number of Os)

Step 5. add the total number of Os on the RHS and balance the LHS of O_2 (if there is an uneven number then you can use ½ Os)

Incomplete combustion

For limited oxygen replace CO_2 with CO and use same steps

For very limited oxygen replace CO_2 with C and use same steps

Background Knowledge

Combustion of Alcohol

extra info

Combustion

Complete	Alcohol + 1 1/2 Oxygen $\longrightarrow$	$CO_2 + 2H_2O$
Incomplete	Alcohol + 1 Oxygen $\longrightarrow$	$CO + 2H_2O$

The longer the chain of carbons in the alcohol the less vigorously the combustion reaction. Methanol and ethanol (drinking alcohol) combust more readily.

Chefs will flambé a dish, setting alight the alcohol – this will reduce the alcohol content in the food or drink.

GZ Science Resources

Background Knowledge

Combustion summary

extra info

Complete combustion – plentiful supply of Oxygen (CO_2 + H_2O)

Alkane $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

Alkene $C_3H_6 + 4\tfrac{1}{2} O_2 \longrightarrow 3CO_2 + 3H_2O$

Alcohol $C_2H_6O + 3 O_2 \longrightarrow 2CO_2 + 3H_2O$

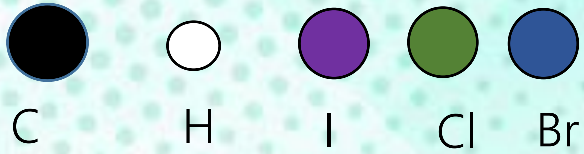
Incomplete combustion – limited supply (CO + H_2O)

Alkane $C_3H_8 + 3\tfrac{1}{2}O_2 \longrightarrow 3CO + 4H_2O$

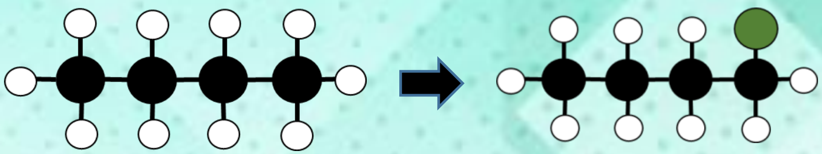
Incomplete combustion – very limited supply (C + H_2O)

Alkane $C_3H_8 + 2O_2 \longrightarrow 3C + 4H_2O$

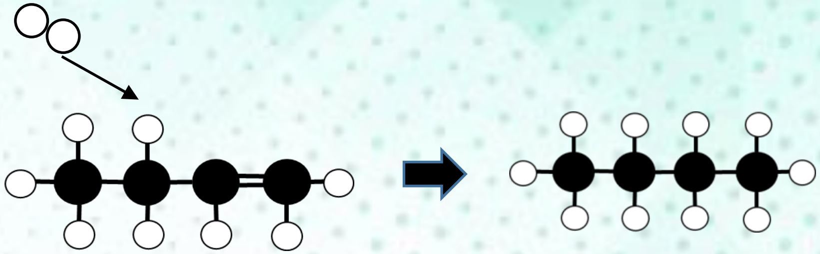
Reaction types (1)



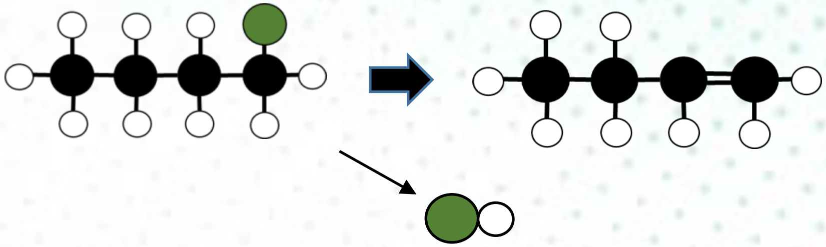
Substitution reactions are characterized by replacement of an atom or group (Y) by another atom or group (Z). Aside from these groups, the number of bonds does not change.



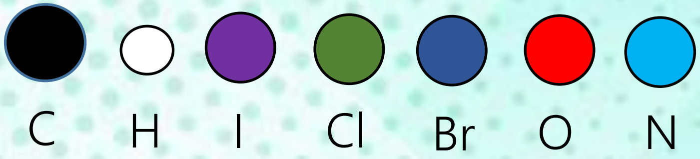
Addition reactions increase the number of bonds to the Carbon chain by bonding additional atoms, usually at the expense of one or more double bonds.



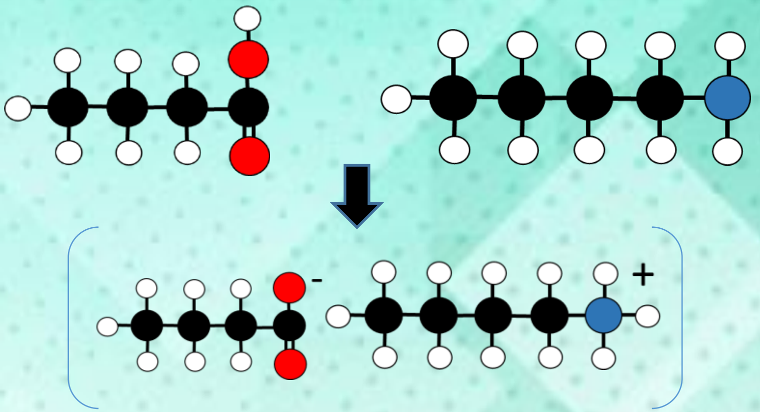
Elimination reactions decrease the number of single bonds by removing atoms and new double bonds are often formed.



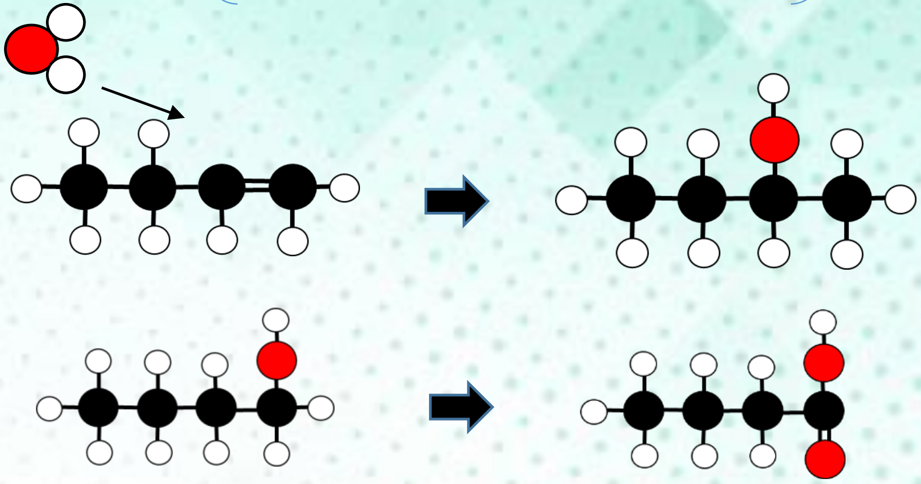
Reaction types (2)



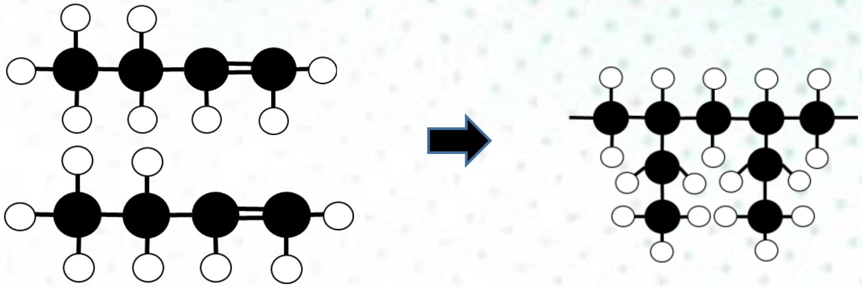
Acid Base Reactions involve the transfer of a proton from the acid to the base which produces a salt



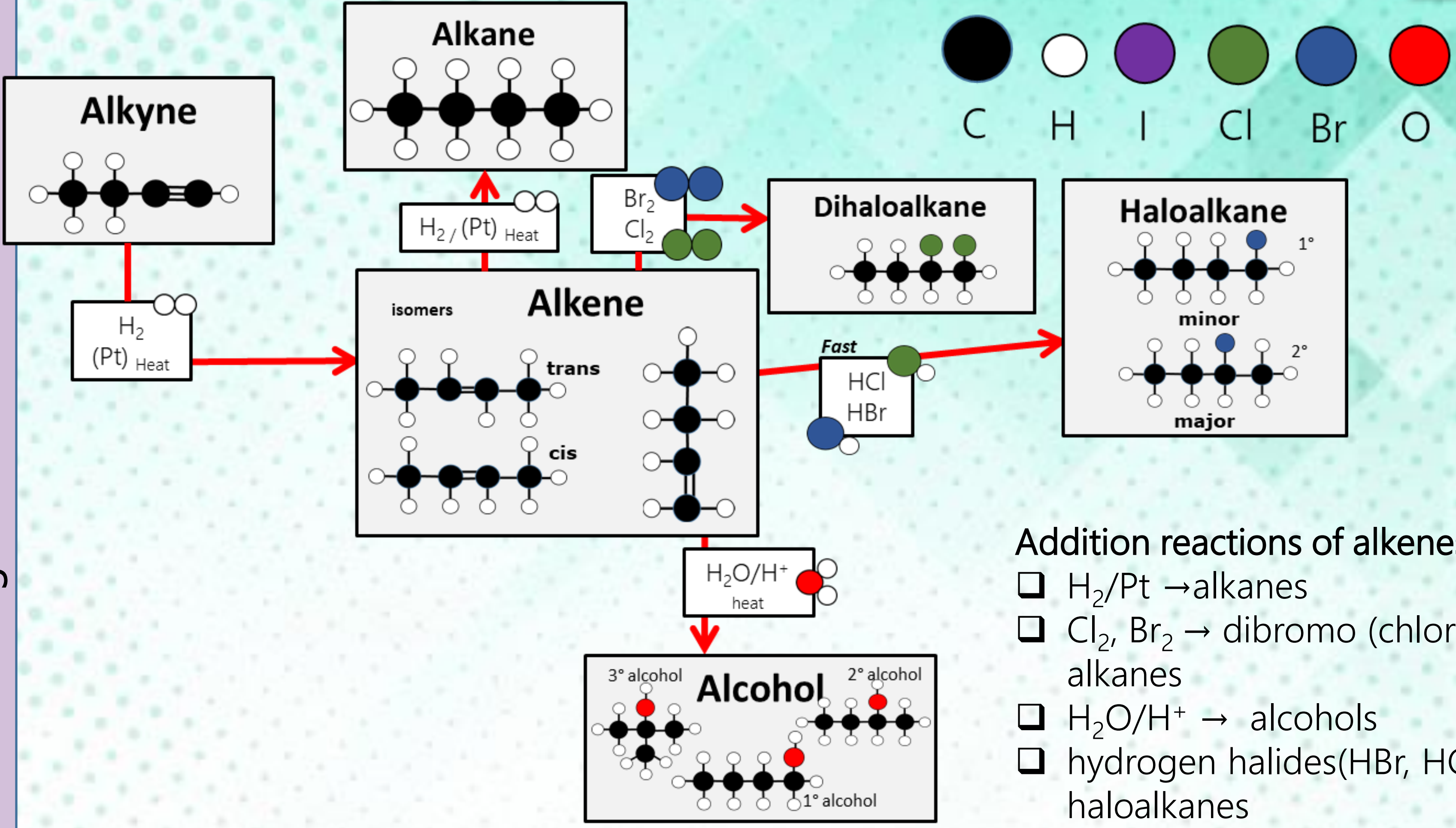
Oxidation reactions involve a lost of electrons from the organic molecule or a gain of oxygen.



Polymerisation reactions join monomers together to form a polymer. **Addition polymerisation** breaks double bonds of alkenes and joins monomers



Addition Reactions



Addition reactions of alkenes with:

- ☐ H_2/Pt →alkanes
- ☐ Cl_2, Br_2 → dibromo (chloro) alkanes
- ☐ H_2O/H^+ → alcohols
- ☐ hydrogen halides(HBr, HCl) → haloalkanes

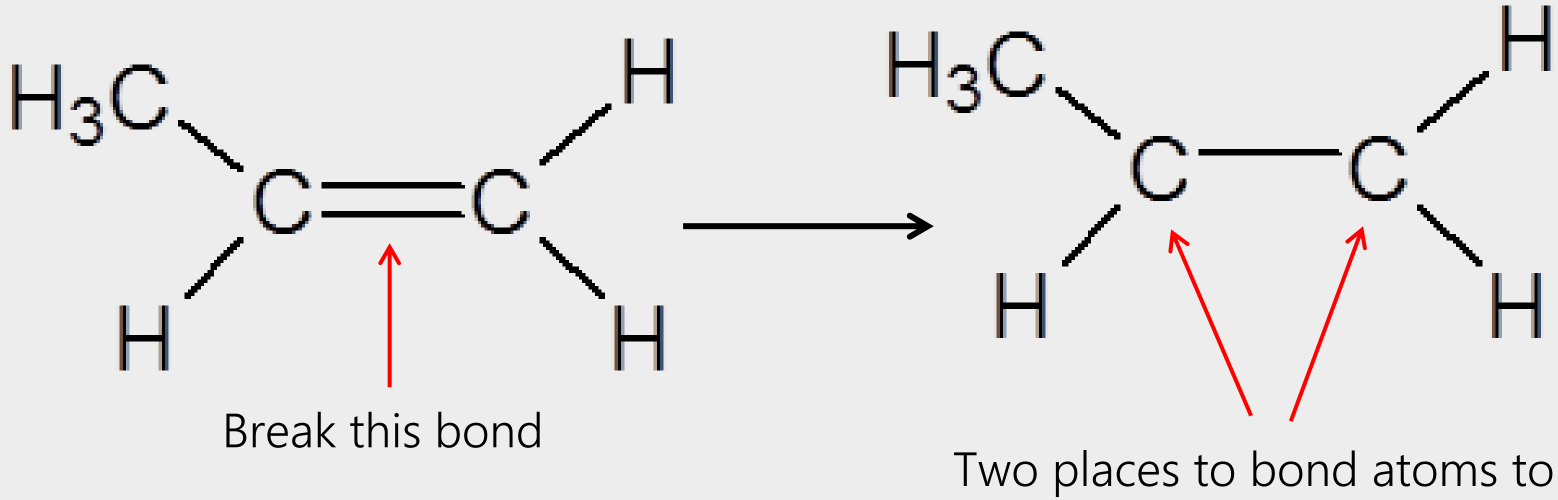
including identification of major and minor products on addition to asymmetric alkenes

Addition reactions increase the number of bonds to the Carbon chain by bonding additional atoms, usually at the expense of one or more double bonds.

Alkene Reactions - Addition

Alkenes are **unsaturated** molecules because not every carbon atom has the maximum amount of atoms bonded to it due to one or more double bonds. The double bond can be broken down to a single bond and the two available sites can be occupied by two atoms or groups.

This reaction is known as an **addition** reaction. This reaction has a lower activation energy requirement than substitution, requiring less energy to break a double bond than to break a single C-H bond, therefore it can proceed quicker than a substitution reaction.



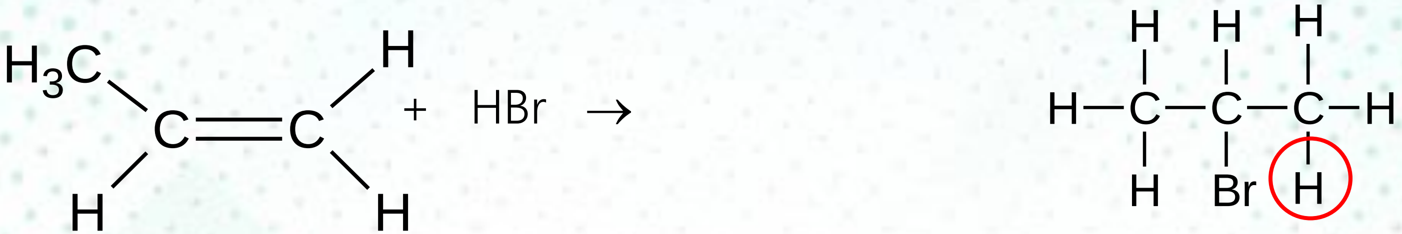
Markovnikov's Rule in Addition reactions

Markovnikov's rule - sometimes called the "rich get richer" rule.
When asymmetric molecules such as HBr, HCl and H_2O are added to asymmetrical alkenes, this results in the formation of two possible products: a major and minor product. The major product, is made in higher proportions than the other, the minor product.

The **major** product is the one in which the H atom of an unsymmetrical molecule such as HBr attaches to the C atom with the **most H atoms** already

Minor

1-bromopropane



Major

2-bromopropane

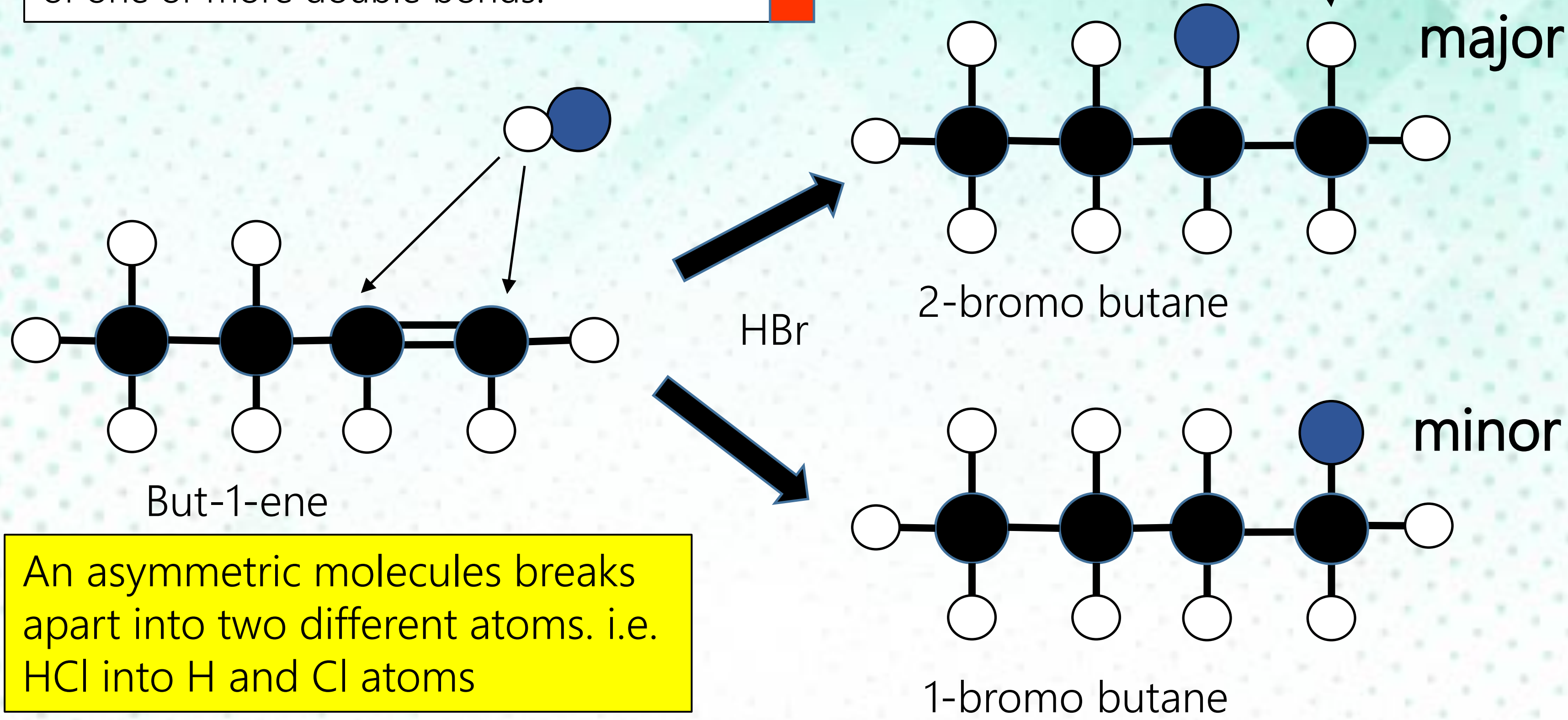
Addition Reaction - HCl or HBr to unsymmetrical Alkenes to produce a haloalkane

● C ○ H ● I ● Cl ● Br

Addition reactions increase the number of bonds to the Carbon chain by bonding additional atoms, usually at the expense of one or more double bonds.

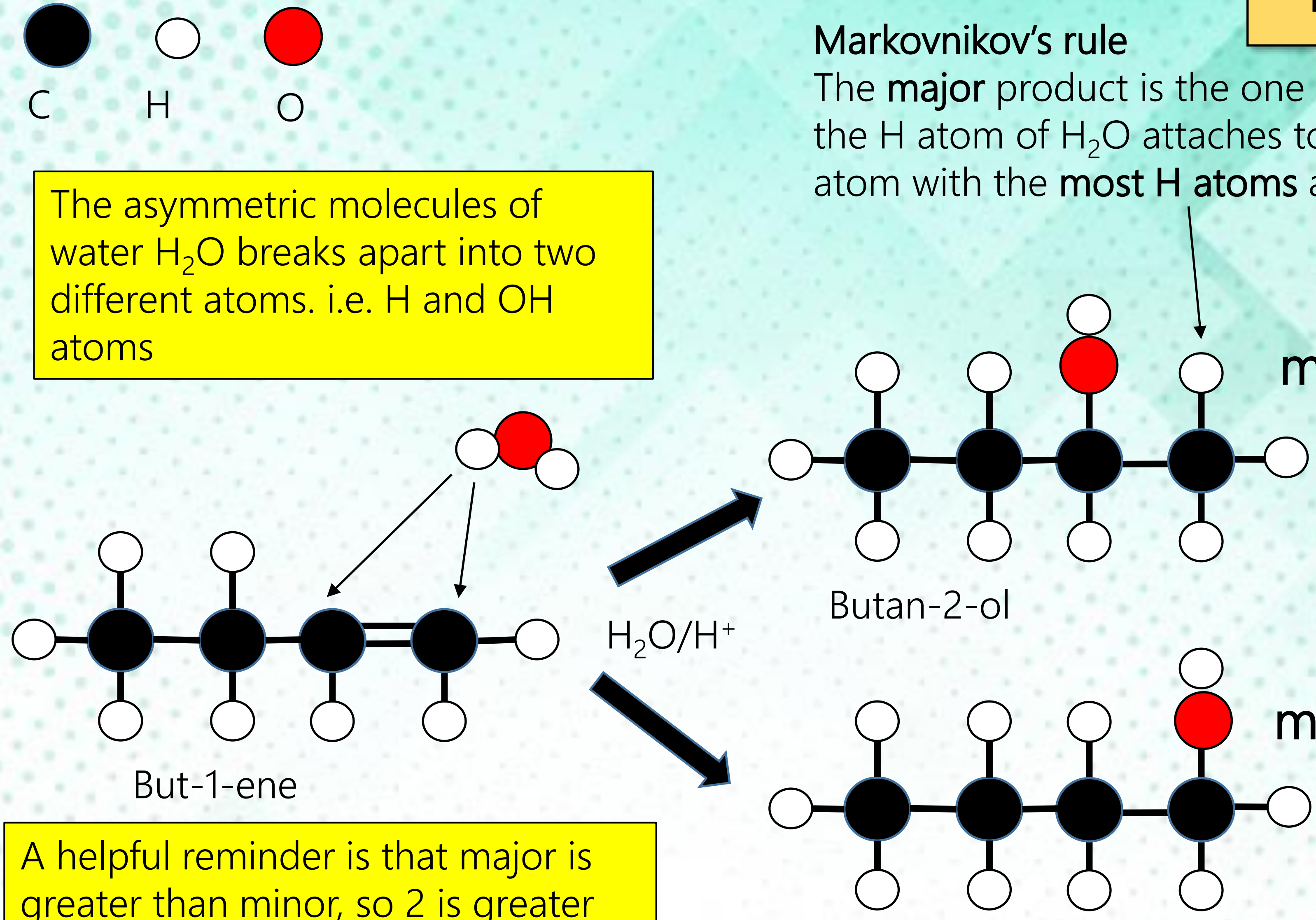
Markovnikov's rule

The **major** product is the one in which the H atom of HBr attaches to the C atom with the **most H atoms** already.



An asymmetric molecules breaks apart into two different atoms. i.e. HCl into H and Cl atoms

Addition Reaction - H_2O (acidified) to unsymmetrical Alkenes to produce an alcohol



The asymmetric molecules of water H_2O breaks apart into two different atoms. i.e. H and OH atoms

Markovnikov's rule

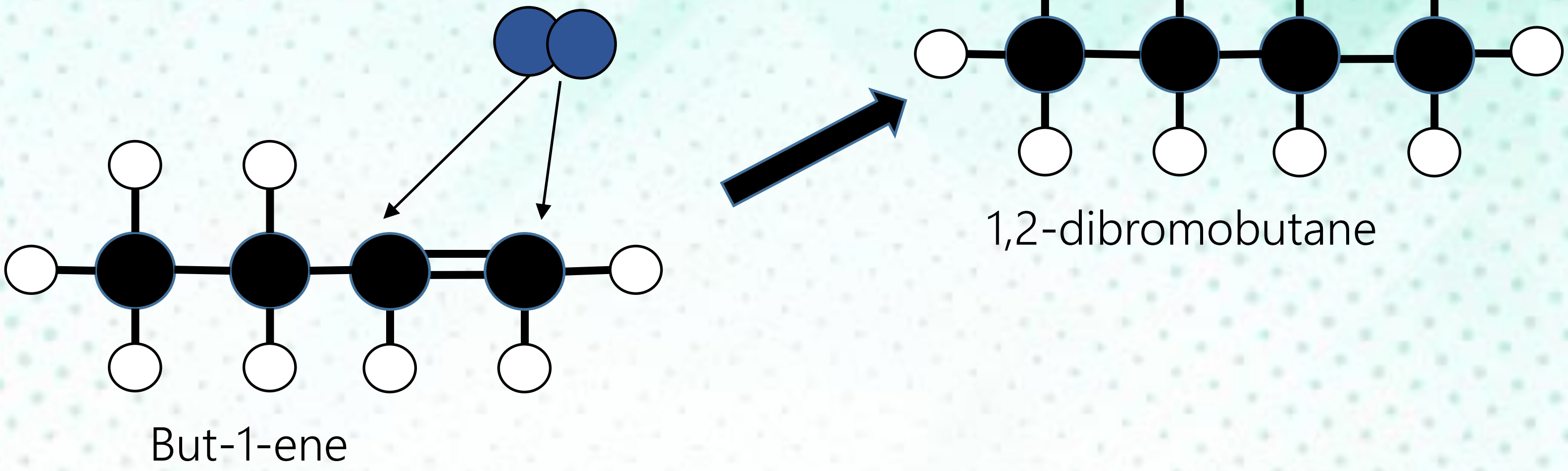
The **major** product is the one in which the H atom of H_2O attaches to the C atom with the **most H atoms** already.

A helpful reminder is that major is greater than minor, so 2 is greater than 1 (propan-2-ol vs propan-1-ol)

Addition Reaction - Cl_2, Br_2 to form a dihaloalkane

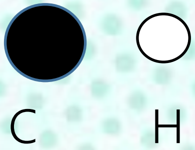
● C ○ H ● Cl ● Br

The Cl_2 or Br_2 is not asymmetrical so both atoms added are the same

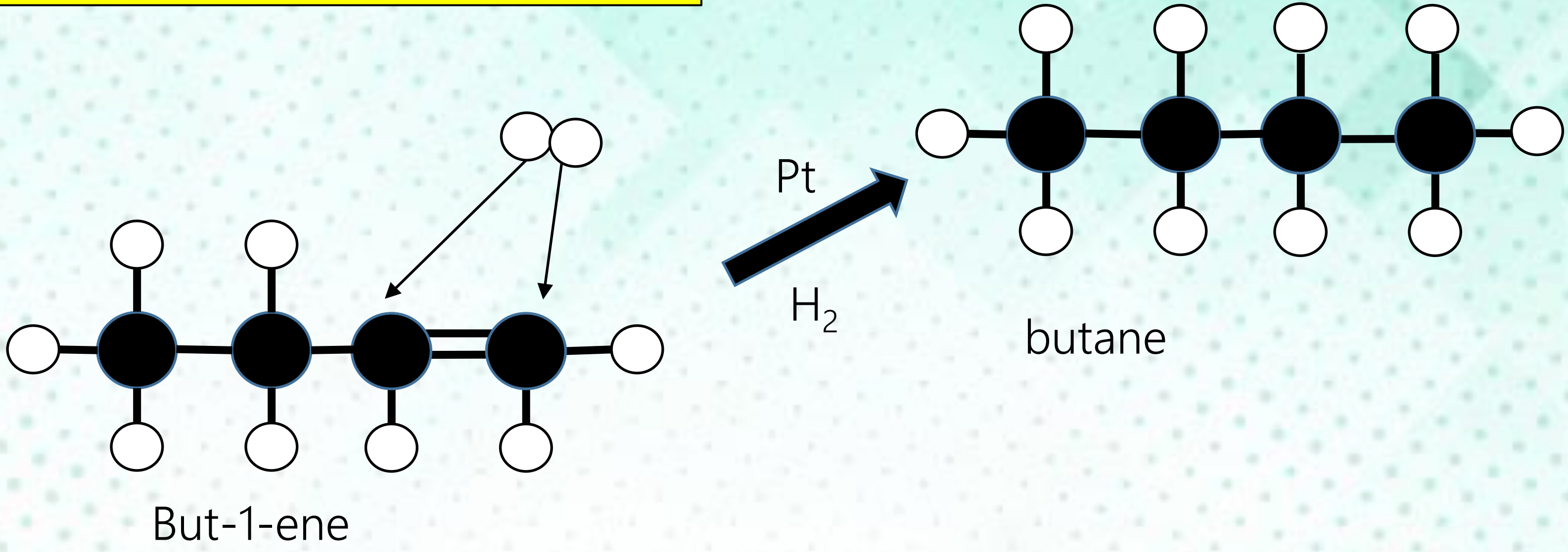


No major or minor isomers are formed

Addition Reaction - H_2 (Pt) to form a alkane



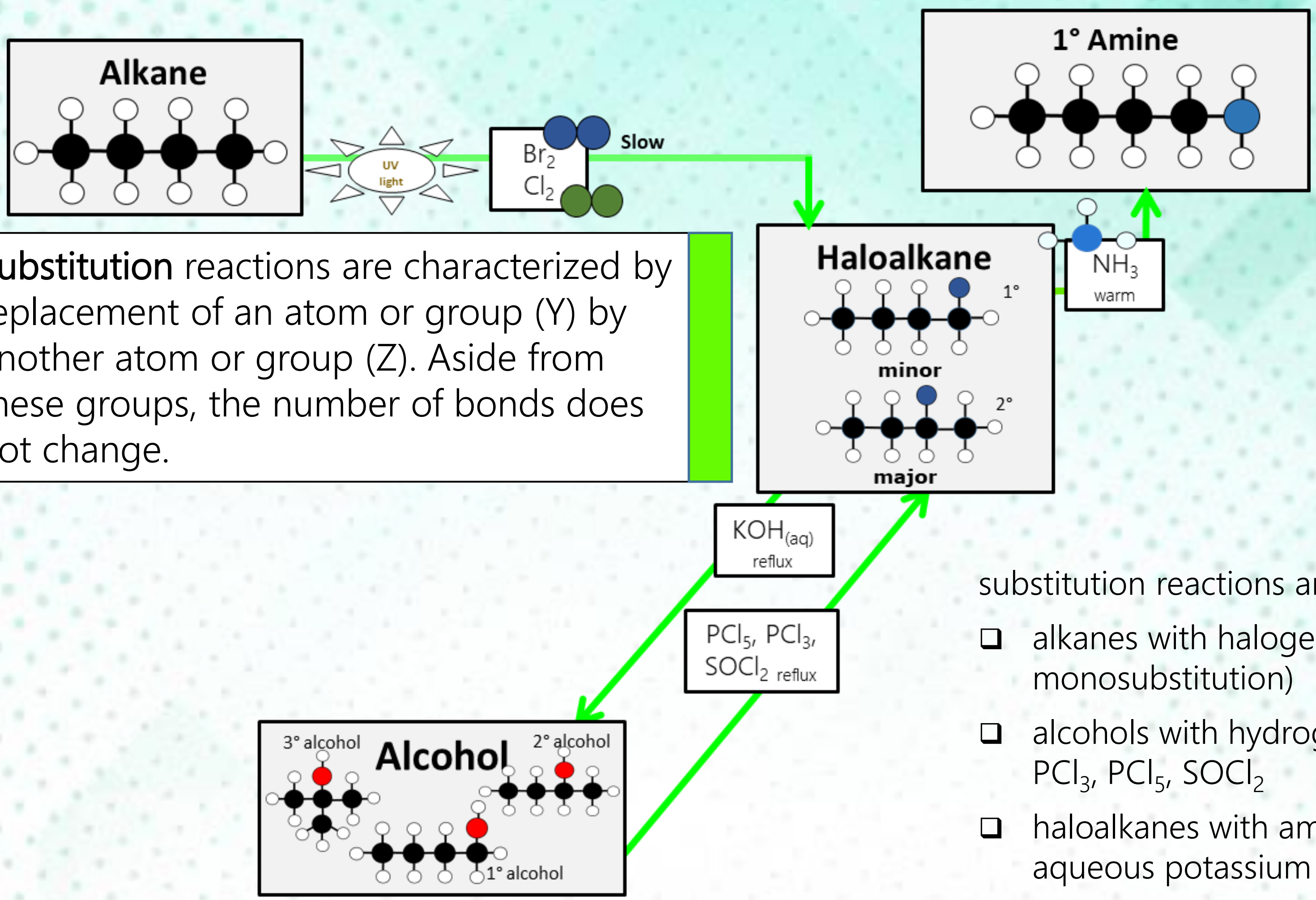
The H_2 is not asymmetrical so both atoms added are the same



No major or minor isomers are formed

Substitution Reactions

● C ○ H ● I ● Cl ● Br ● O ● N



Substitution reactions are characterized by replacement of an atom or group (Y) by another atom or group (Z). Aside from these groups, the number of bonds does not change.

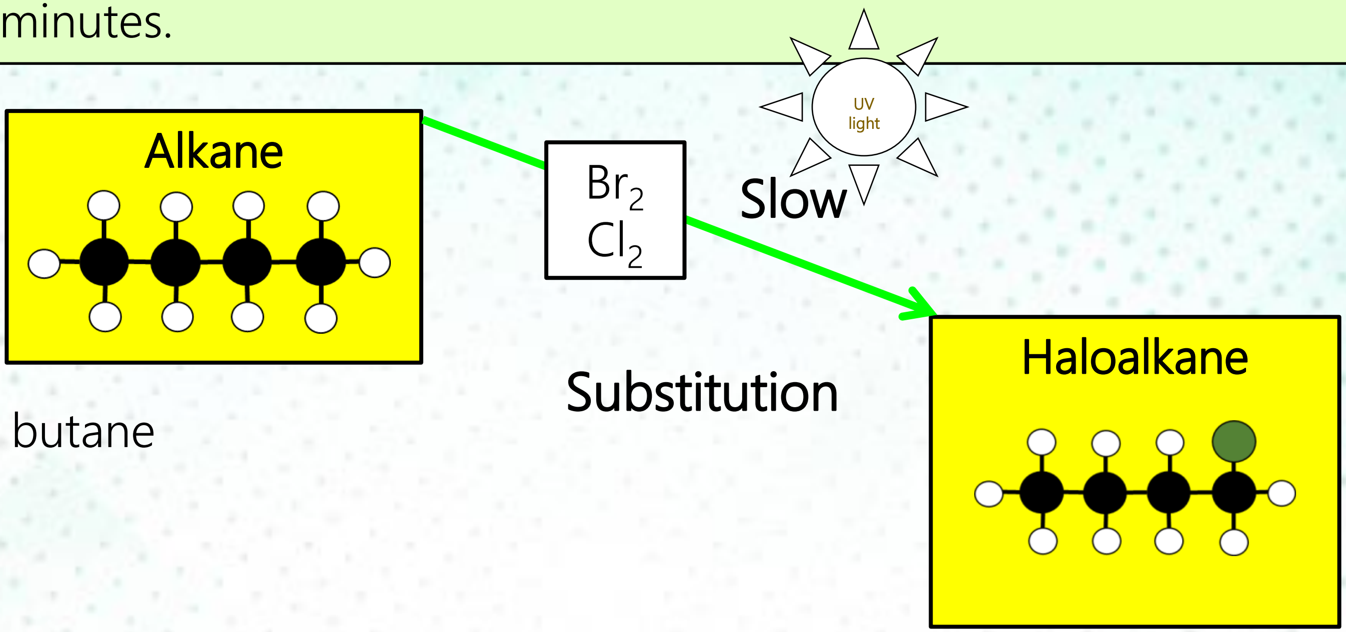
substitution reactions are limited to:

- ❑ alkanes with halogens (limited to monosubstitution)
- ❑ alcohols with hydrogen halides, PCl_3, PCl_5, $SOCl_2$
- ❑ haloalkanes with ammonia and aqueous potassium hydroxide

Substitution Reactions - Alkanes with halogen

Alkanes are **saturated** molecules, because every carbon atom has the maximum amount of hydrogen atoms bonded to it. If any other atoms are to be added to an alkane one atom must be removed first.

This reaction is known as a **substitution** reaction. For this reaction to proceed enough energy must be available to overcome the activation energy required to break the strong C-H bond. The available site can then be occupied by the provided atom. This energy may be provided by heat or **UV light** to provide the activation energy for the reaction to proceed. This is a **slow reaction** that can take several minutes.



Alkane

Br_2
Cl_2

Slow

Substitution

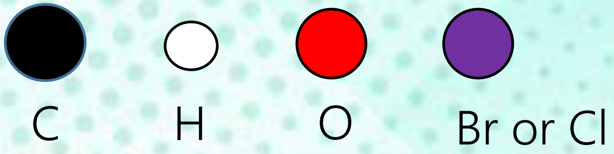
Haloalkane

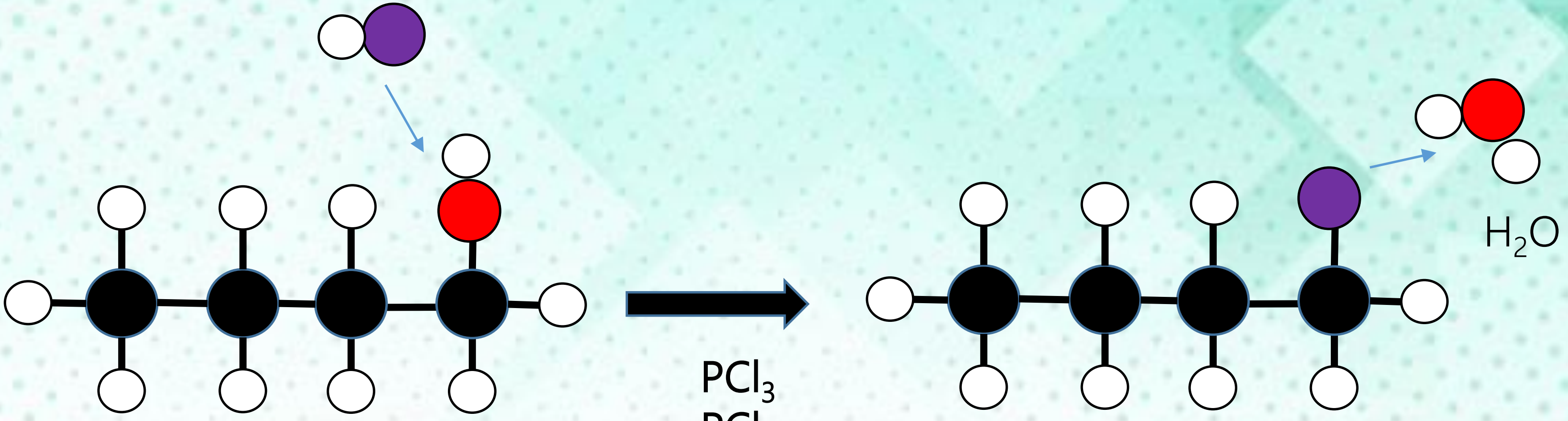
butane

1-bromobutane

Substitution Reactions of alcohol

Substitution reactions are characterized by replacement of an atom or group (Y) by another atom or group (Z). Aside from these groups, the number of bonds does not change.





PCl_3
PCl_5
$SOCl_2$

butan-1-ol

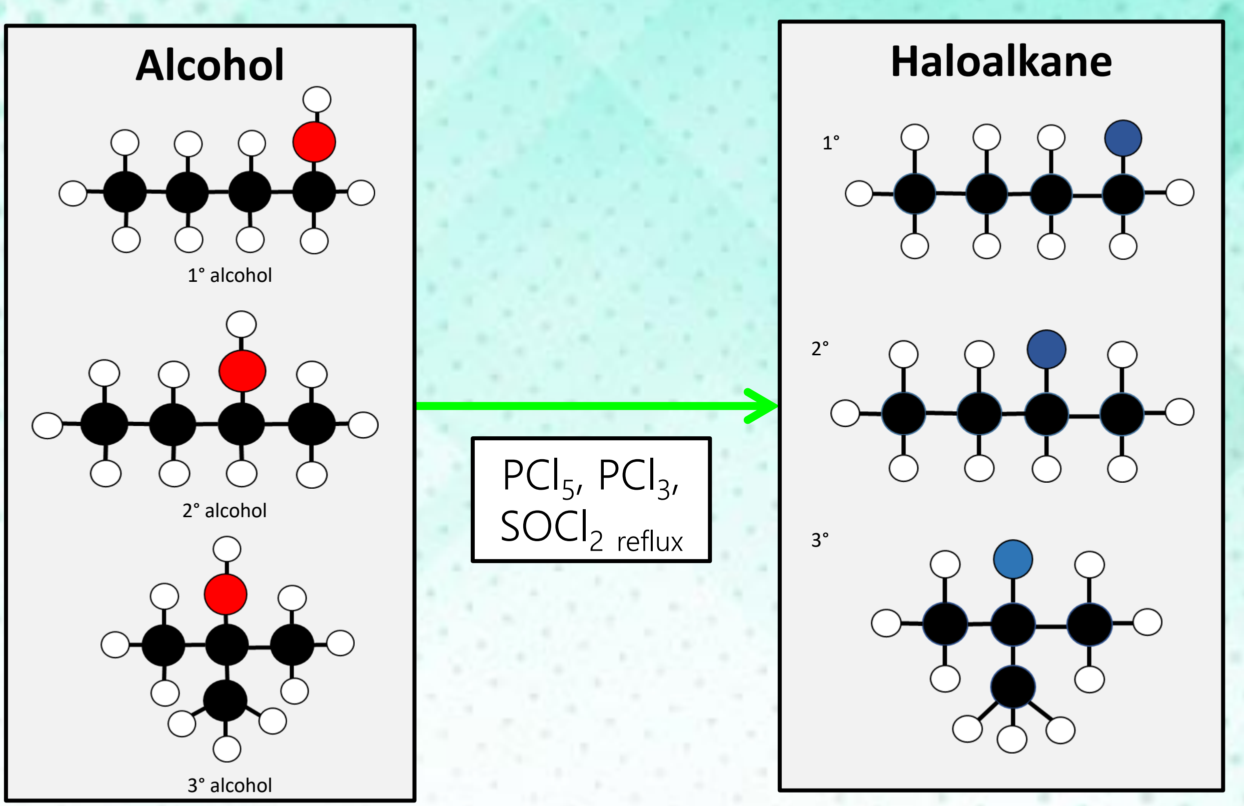
1-chloro butane

Substitution - of the OH^- by a Cl^- to form a chloroalkane.
This substitution removes the hydroxyl group (plus one hydrogen to form water) and replaces the two bonding sites on the carbons with a H and Cl (from HCl).The haloalkane formed is nonpolar and insoluble in the aqueous solution so forms a cloudy emulsion that separates out as two layers.

Organic Reactions

Substitution Reactions – alcohols with hydrogen halides, PCl_3, PCl_5, $SOCl_2$

GZ Science Resources



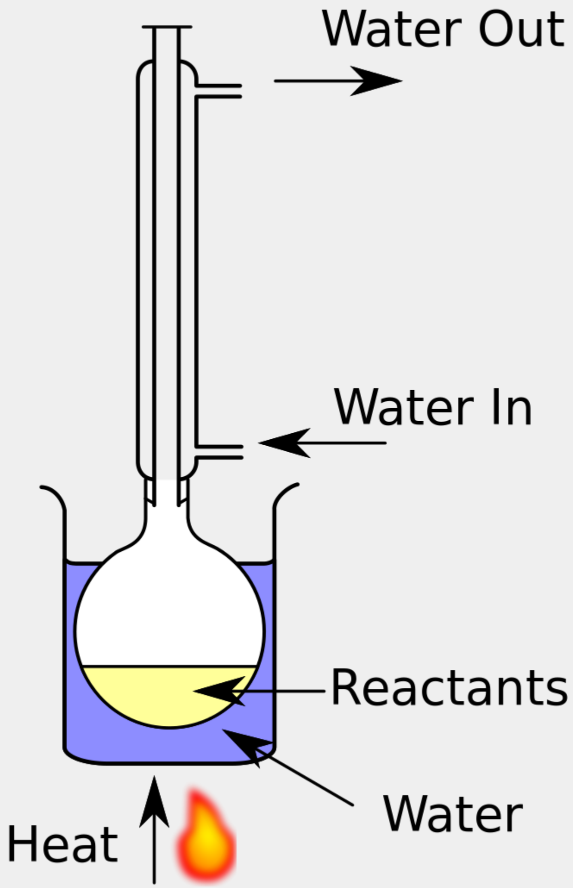
The substituted halogen (Br or Cl) will take the same place that the hydroxyl (OH) is removed from.

If the alcohol was a primary isomer (OH bonded to a C that is bonded to 1 other), then the haloalkane will also be a primary isomer. The same applies for secondary and tertiary.

Background Knowledge

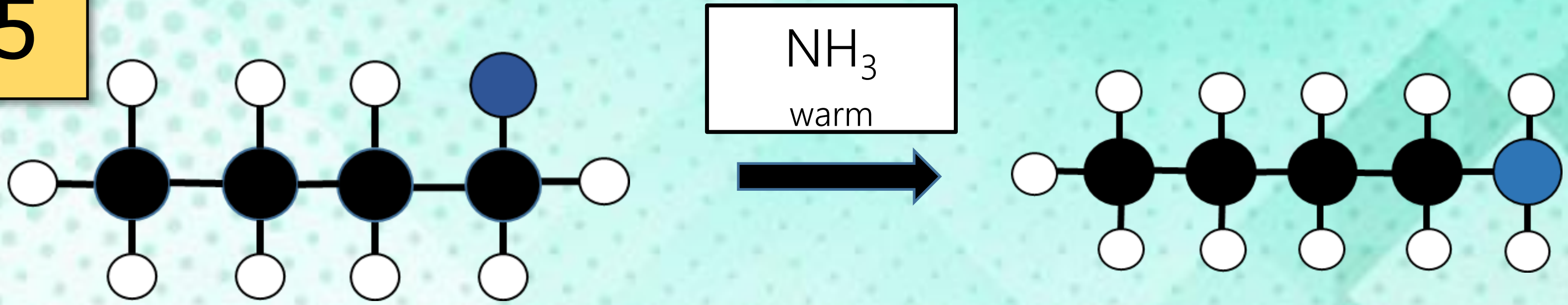
Reflux

The reaction is increased by heating the reaction mixture under **reflux.** Reflux is a system of heating the solution with a condenser attached to the reaction vessel so that any organic substance, which evaporates will be condensed and returned to the container. This way the reaction can be heated for a period of time without the organic substance (reactant, product or solvent) evaporating away.



Substitution Reactions – haloalkanes with ammonia and aqueous potassium hydroxide

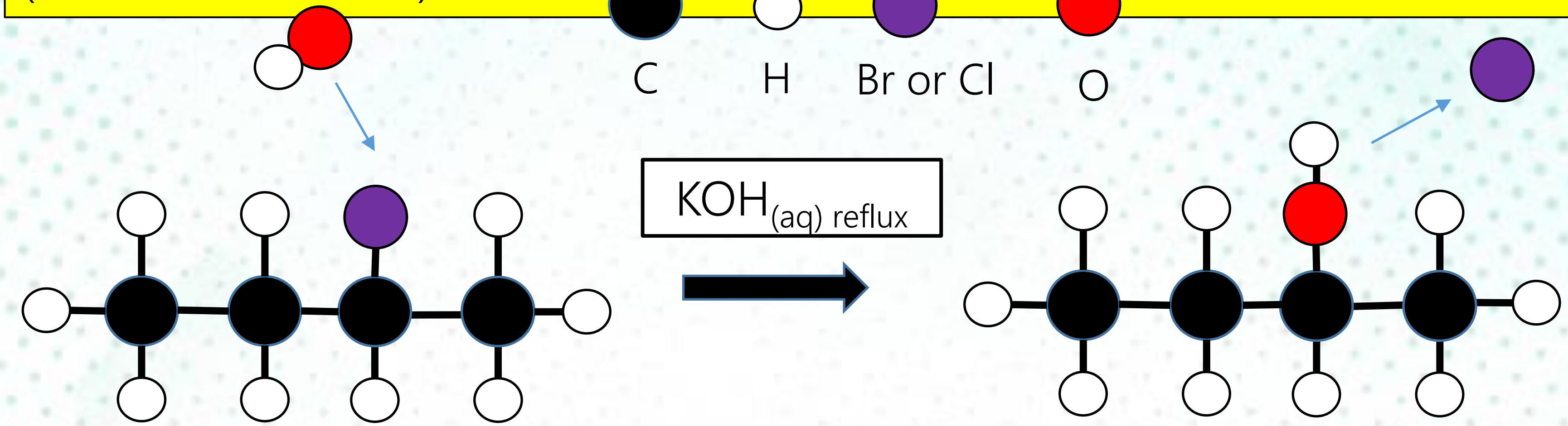
5



1-bromobutane

1-aminobutane

The substituted group(OH or NH_2) will take the same place that the halogen (Br or Cl) is removed from. Substitution reactions do not change the number of single bonds. The Halogen atom is removed and a hydroxyl (OH) group is substituted. Substitution of Haloalkanes is favoured when the solvent used is polar e.g. **aqueous** (rather than alcoholic) **KOH.**



2-bromobutane

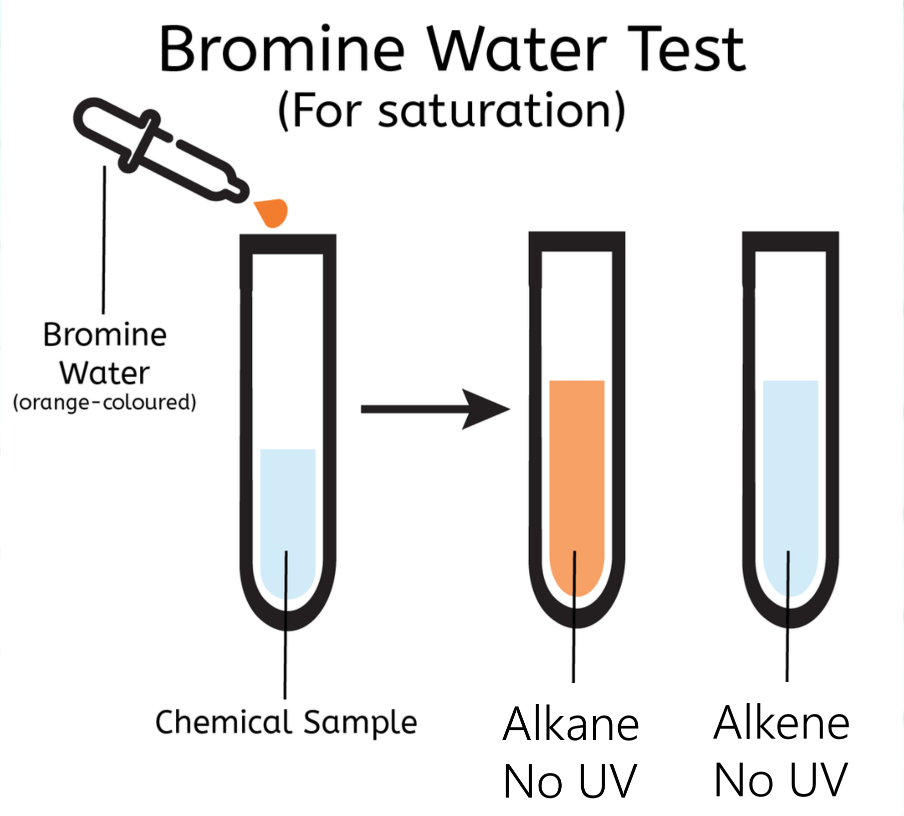
Butan-2-ol

Testing for Addition and Substitution reactions

Alkenes undergo **addition** reactions - this means they can undergo addition of a halogen atom (chlorine, bromine, iodine) across the double bond to form a haloalkane.

The common test for an unsaturated hydrocarbon (alkene) to distinguish it from a saturated hydrocarbon (alkane) is the **rapid** decolourisation of an orange solution of bromine in the **addition reaction of an alkene**.

This occurs much **slower** in the **substitution reaction of an alkane** and requires the presence of **UV light** (sunlight) to provide the activation energy to break the bond of the C-H

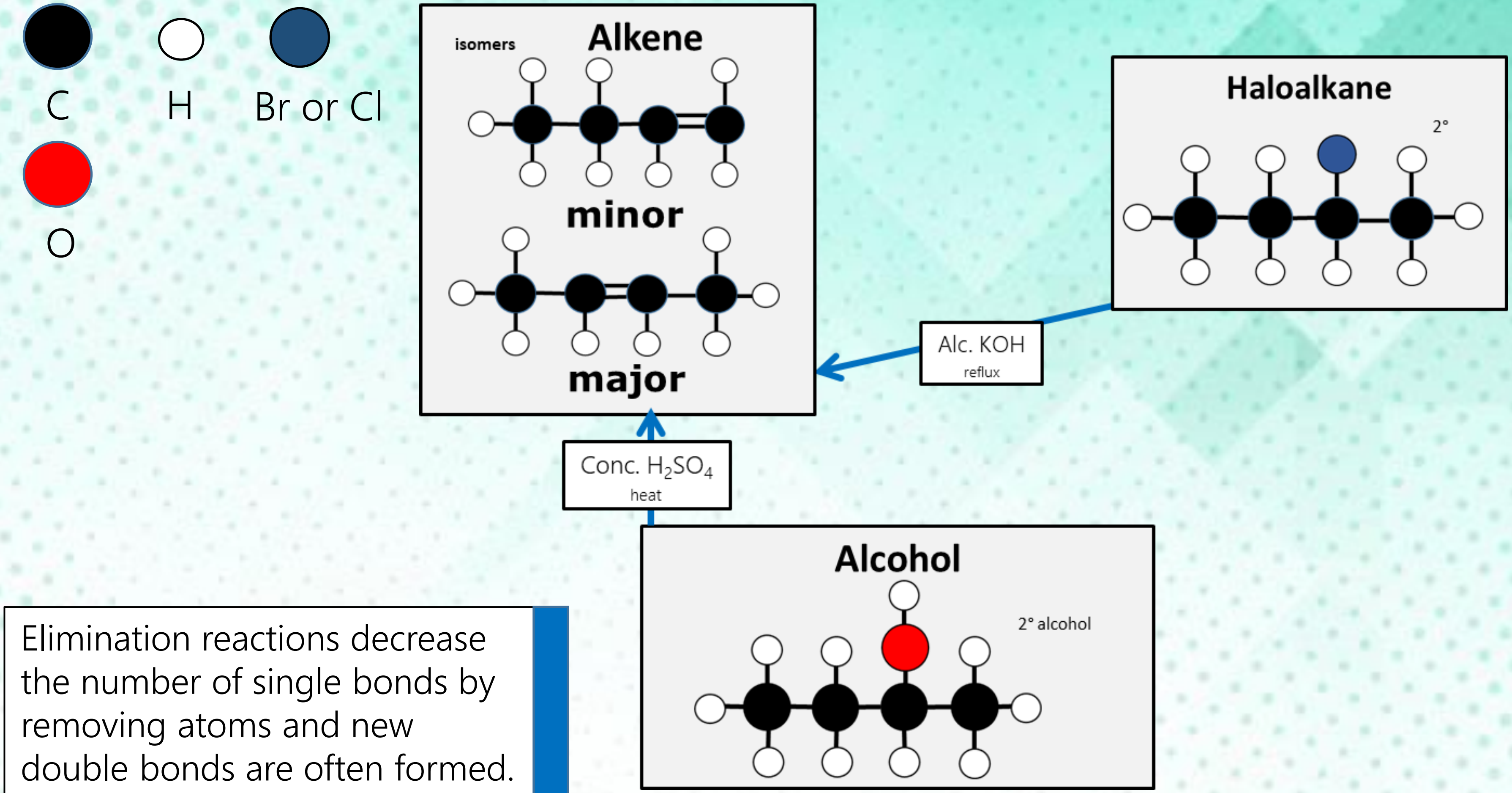


Tests to distinguish between Alkanes and Alkenes

We can use these to identify whether the molecule is an alkene or alkane

Alkane – single bonds, saturated hydrocarbon	Alkenes – at least one double bond, unsaturated hydrocarbon
Substitution – one (or more) hydrogen replaced by another atom	Addition reaction – double bond breaks and atoms added
Halogenation (Bromine) Orange colour fades slowly in UV light	**Halogenation (Bromine)** Orange colour disappears immediately changes to haloalkane
Acidified Potassium Permanganate Doesn't react – solution remains purple	**Acidified Potassium Permanganate** Purple to colourless – oxidation changes to alcohol

Elimination Reactions

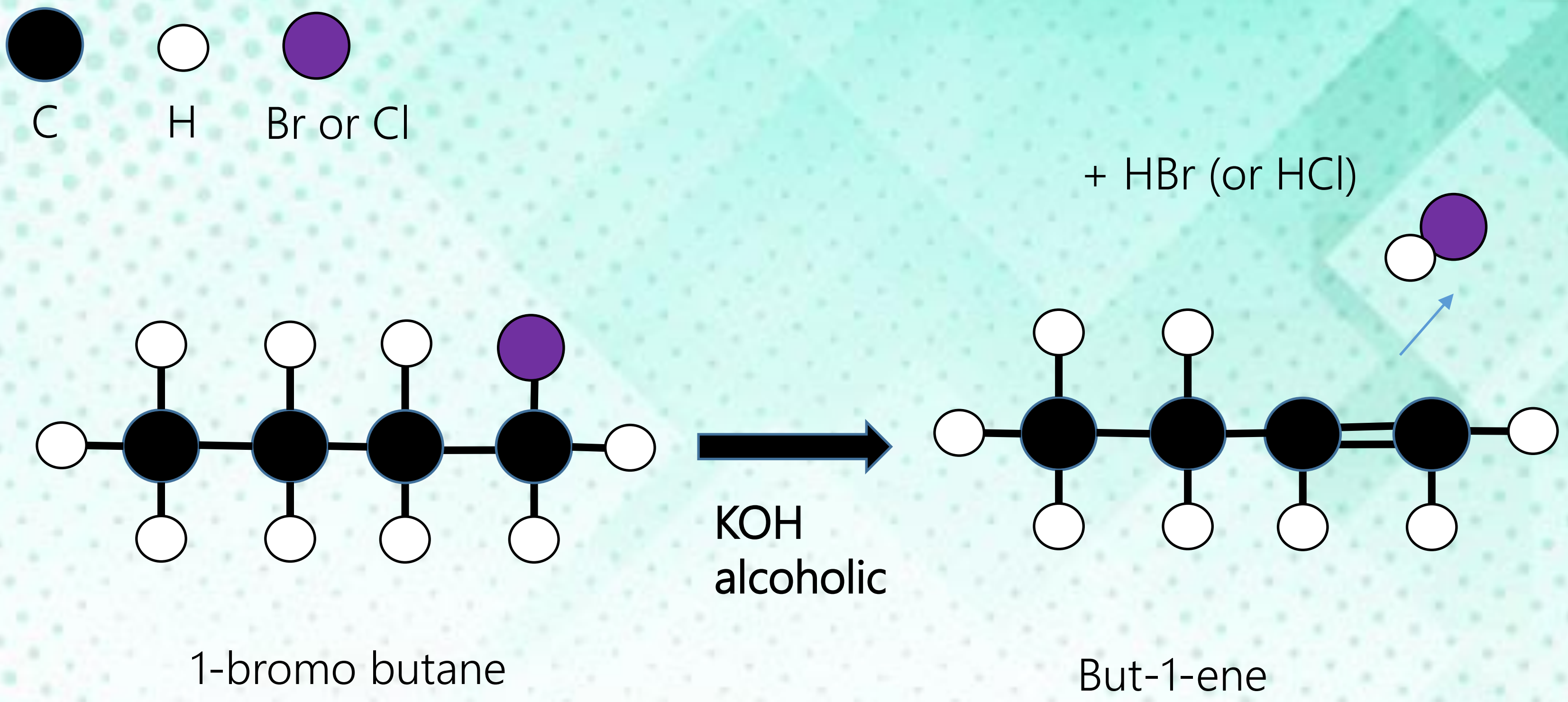


Elimination reactions decrease the number of single bonds by removing atoms and new double bonds are often formed. The Halogen atom is removed and a double bond forms between the two carbon atoms.

elimination of (including identification of major and minor products for asymmetric reactants):

- water from alcohols
- hydrogen halides from haloalkanes

Elimination Reactions of primary haloalkanes



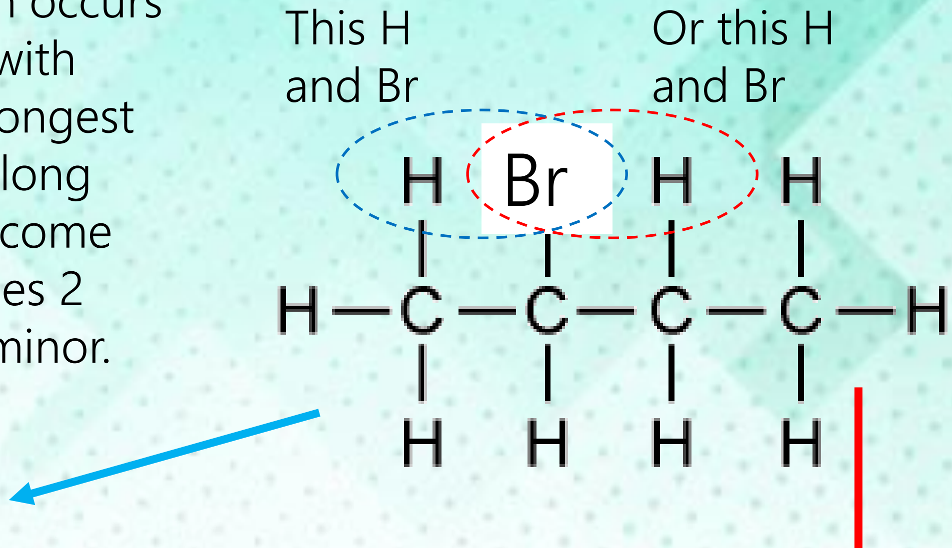
1-bromo butane

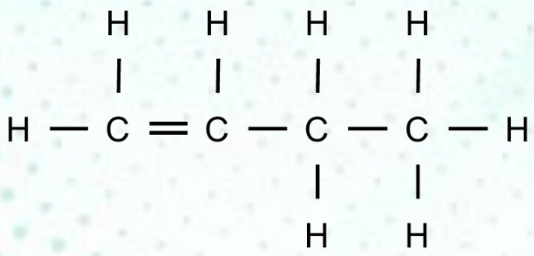
But-1-ene

If the haloalkane is a primary isomer then only one organic product (alkene) will be formed. The hydrogen atom must be removed from the adjacent (beside) carbon atom from the halogen, NOT the same carbon atom. The second product will be a hydrogen halide (HCl if started with chloroalkane and HBr if started with bromoalkene)

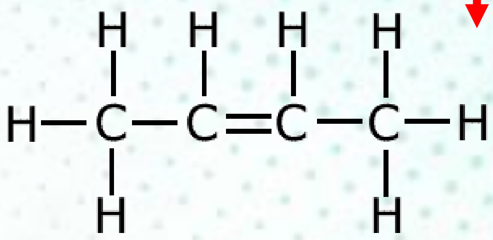
Elimination – major and minor products
Saytzeff's rule (poor get poorer)

When an elimination reaction occurs on a **secondary haloalkane** (with more than 3 carbons in the longest chain) then the H removed along with the halogen (Cl/Br) can come from either side. This produces 2 types of products; major or minor.





But-1-ene



But-2-ene

Minor product as the H is taken from the Carbon with the most hydrogen atoms.

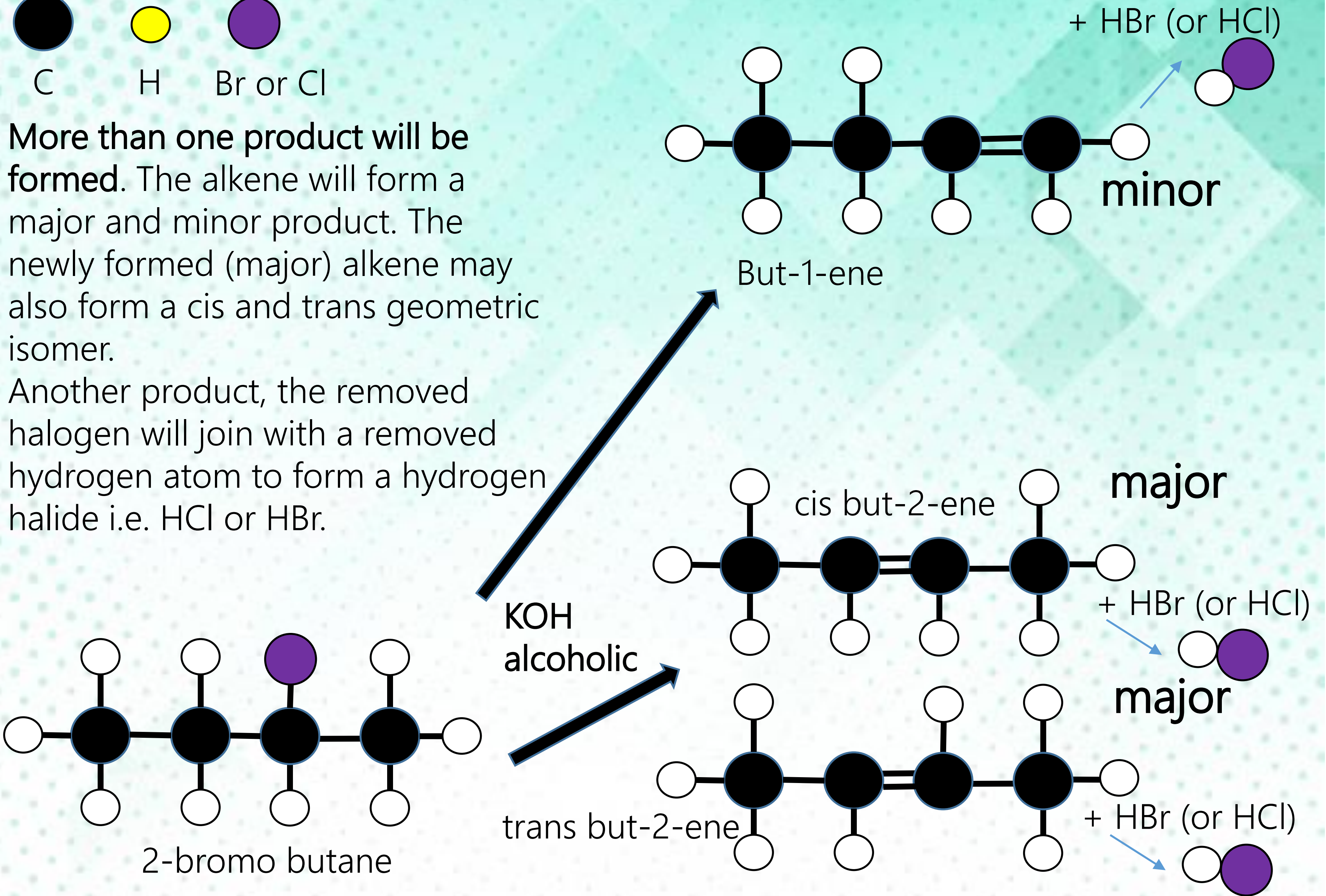
Major product as the H is taken from the Carbon with the least hydrogens atoms (can be cis or trans)

Elimination Reactions of secondary Haloalkanes

⚫ C 🟡 H 🟣 Br or Cl

More than one product will be formed. The alkene will form a major and minor product. The newly formed (major) alkene may also form a cis and trans geometric isomer.

Another product, the removed halogen will join with a removed hydrogen atom to form a hydrogen halide i.e. HCl or HBr.



2-bromo butane

KOH alcoholic

But-1-ene

+ HBr (or HCl)

minor

cis but-2-ene

major

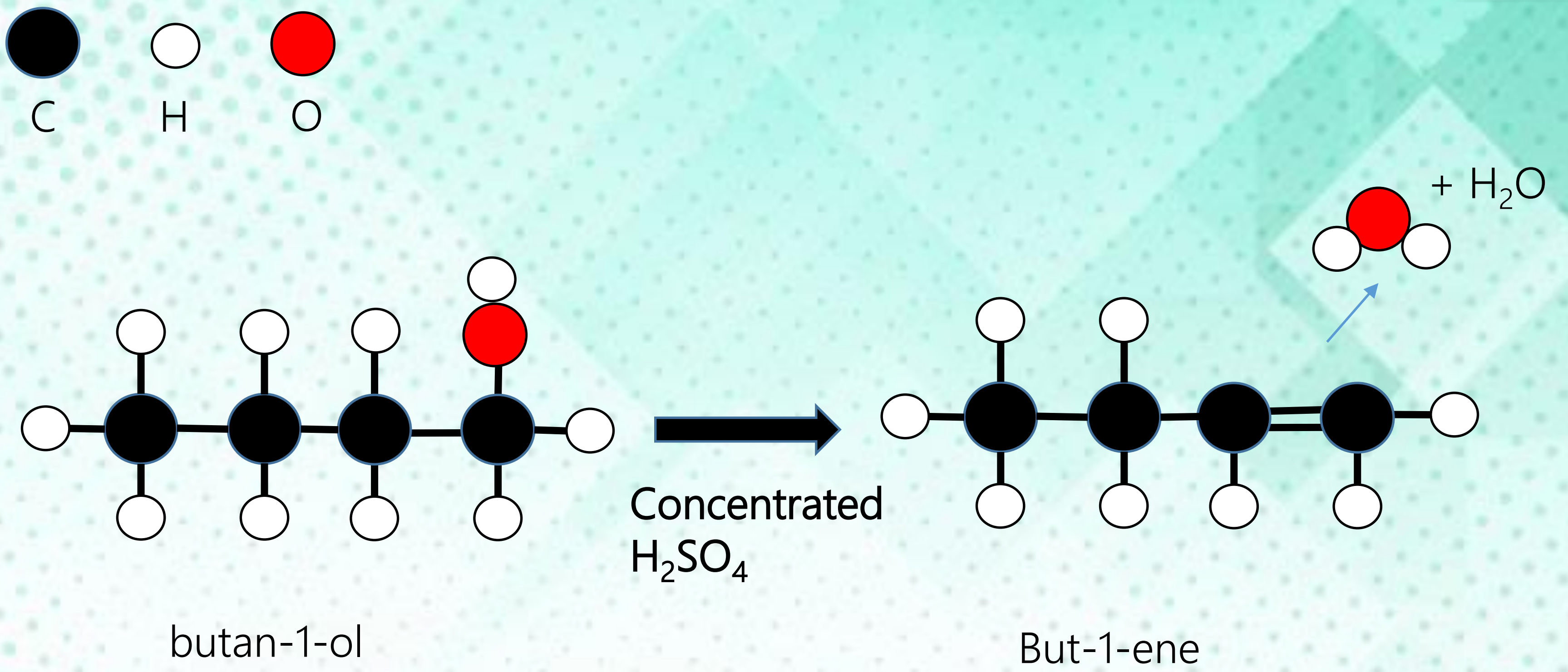
+ HBr (or HCl)

trans but-2-ene

major

+ HBr (or HCl)

Elimination Reactions of primary alcohol



+ H_2O

Concentrated H_2SO_4

butan-1-ol

But-1-ene

Elimination reactions occur when the hydroxyl group (OH) plus a hydrogen from an adjacent (beside) carbon atom is removed. The OH and the H removed form a water molecule. The two carbons with the OH and H taken off join to form a double one. Concentrated sulfuric acid is used as the reagent. This type of elimination reaction is also known as a dehydration reaction because water is removed.

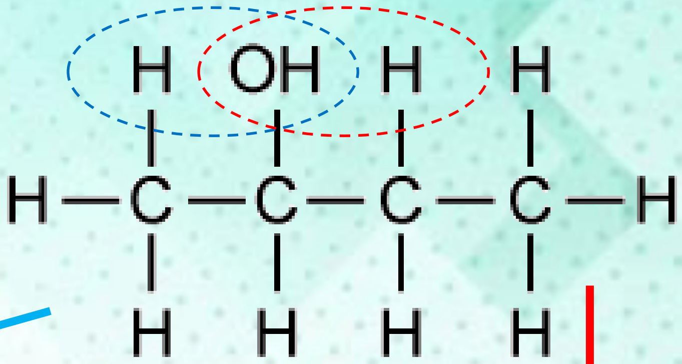
Elimination – major and minor products

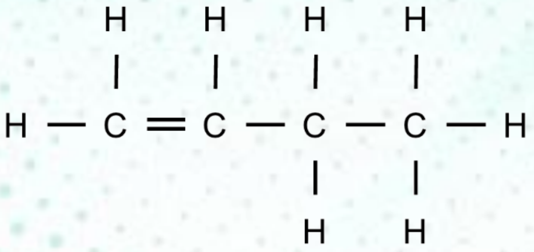
(poor get poorer)

When an elimination reaction occurs on an **asymmetrical secondary** alcohol (with more than 3 carbons in the longest chain) then the H removed along with the OH can come from either side. This produces 2 types of products: major or minor.

This H and OH

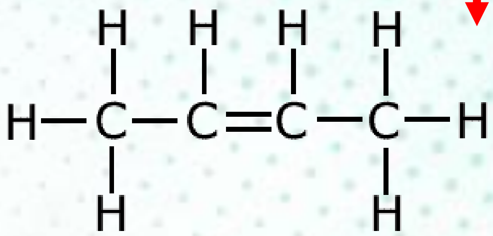
Or this H and OH





But-1-ene

Minor product as the H is taken from the Carbon with the most hydrogen atoms.

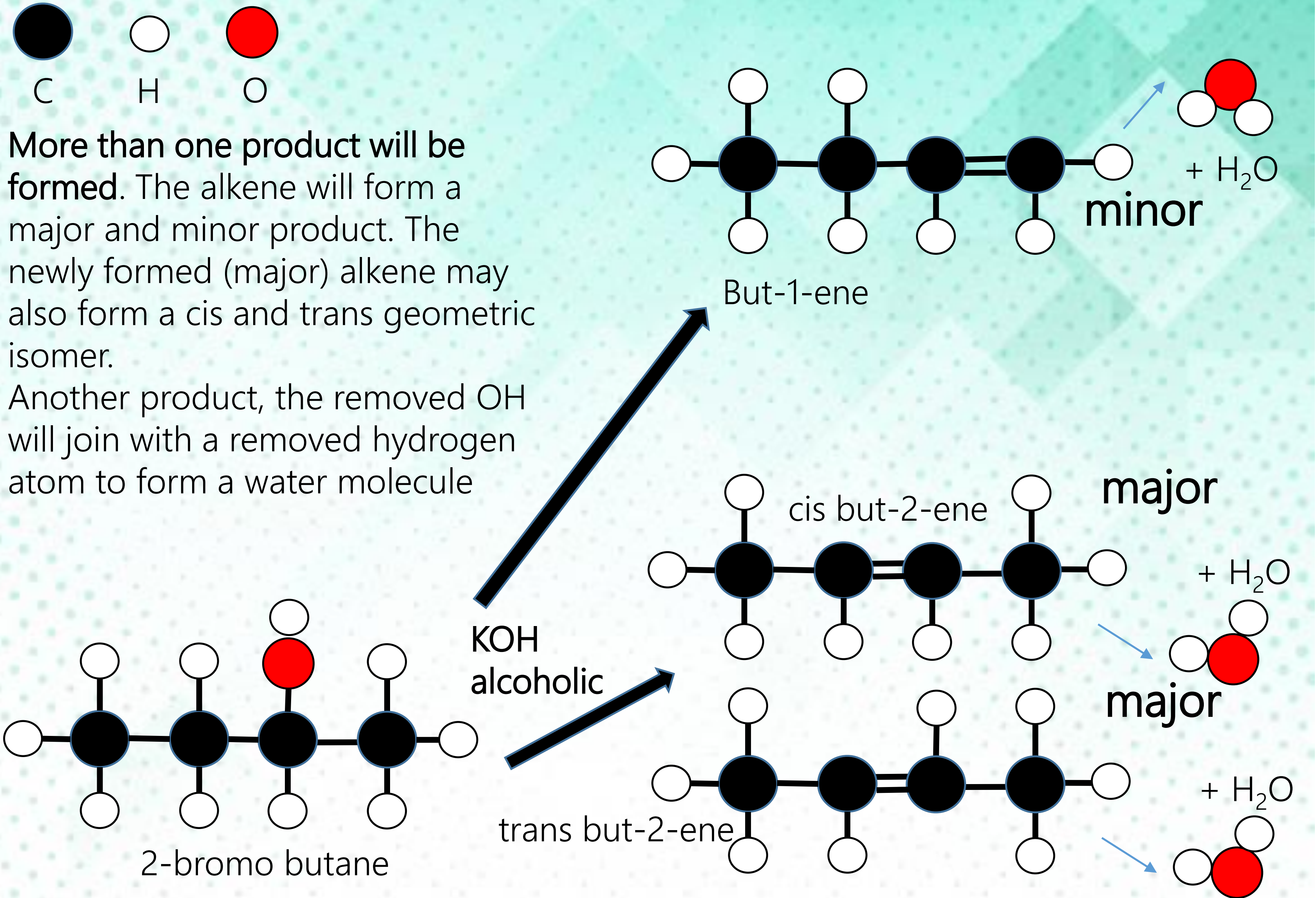


But-2-ene

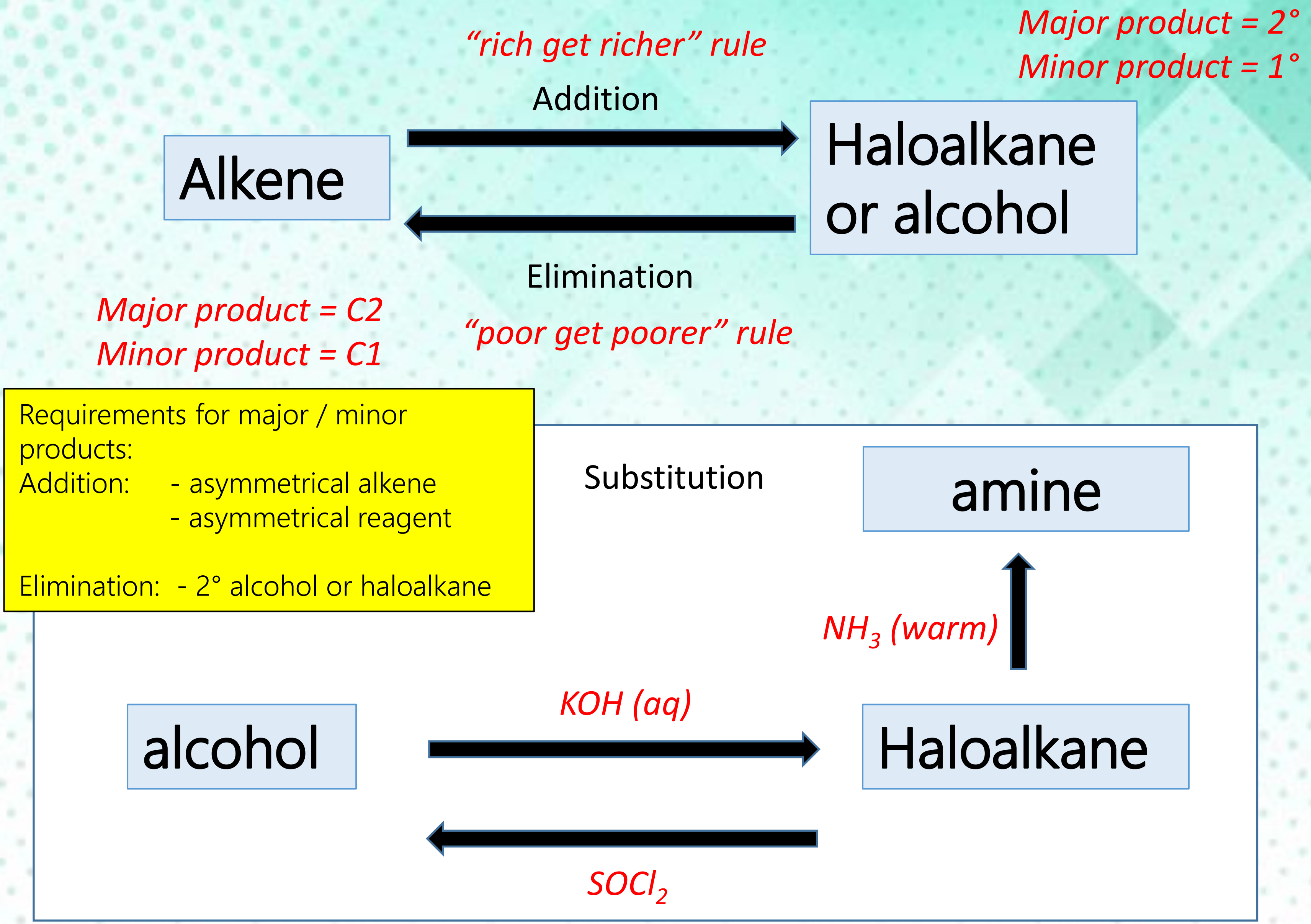
Major product as the H is taken from the Carbon with the least hydrogens atoms (can be cis or trans)

Elimination Reactions of secondary alcohols

More than one product will be formed. The alkene will form a major and minor product. The newly formed (major) alkene may also form a cis and trans geometric isomer.
Another product, the removed OH will join with a removed hydrogen atom to form a water molecule



Summary of Addition, Elimination and Substitution



"rich get richer" rule

Addition

Alkene

Haloalkane or alcohol

Major product = 2°

Minor product = 1°

Elimination

"poor get poorer" rule

Major product = C2

Minor product = C1

Requirements for major / minor products:

Addition: - asymmetrical alkene

- asymmetrical reagent

Elimination: - 2° alcohol or haloalkane

Substitution

amine

NH_3 (warm)

alcohol

KOH (aq)

Haloalkane

$SOCl_2$

NCEA 2012 Reactions (substitution + elimination)

Excellence Question

Question 2d: Chloroethane, CH_3CH_2Cl, reacts with aqueous KOH, alcoholic KOH, and with NH_3.

Compare and contrast the reactions of chloroethane with the three reagents.

In your answer you should include:

- the type of reaction occurring and the reason why it is classified as that type
- the type of functional group formed
- equations showing structural formulae for reactions occurring.

Chloroethane reacts with **$KOH_{(aq)}$** to form an alcohol in a **substitution** reaction; Cl is replaced by OH.

$CH_3CH_2Cl \rightarrow CH_3CH_2OH$

Chloroethane reacts with **$KOH_{(alc)}$** to form an alkene in an **elimination** reaction; H and Cl removed / HCl formed.

$CH_3CH_2Cl \rightarrow CH_2 = CH_2$

Chloroethane reacts with **$NH_{3(alc)}$** to form an amine in a **substitution** reaction; Cl is replaced by NH_2

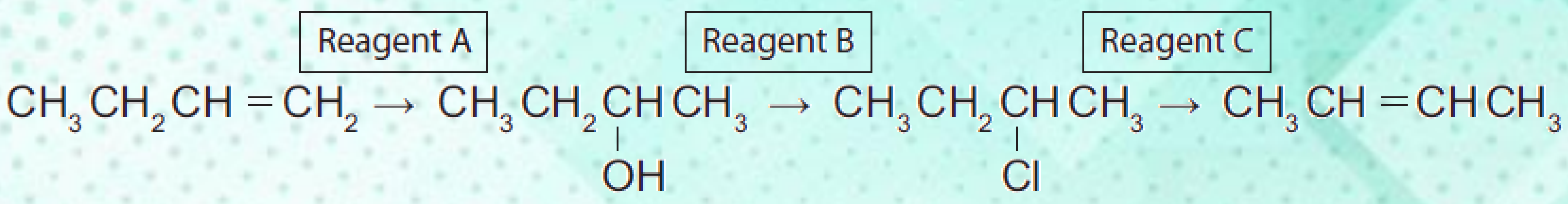
$CH_3CH_2Cl \rightarrow CH_3CH_2NH_2$

Organic Reactions

NCEA 2013 Reactions (scheme)

Excellence Question

Question 3a: The flow diagram below shows a reaction scheme for the conversion of but-1-ene into but-2-ene.



$$CH_3CH_2CH=CH_2 \xrightarrow{\text{Reagent A}} CH_3CH_2\underset{\underset{\displaystyle OH}{|}}{CH}CH_3 \xrightarrow{\text{Reagent B}} CH_3CH_2\underset{\underset{\displaystyle Cl}{|}}{CH}CH_3 \xrightarrow{\text{Reagent C}} CH_3CH=CHCH_3$$

Use the reaction scheme above to complete the following table to show:

- the formula of each reagent, including any necessary conditions
- the type of reaction occurring.

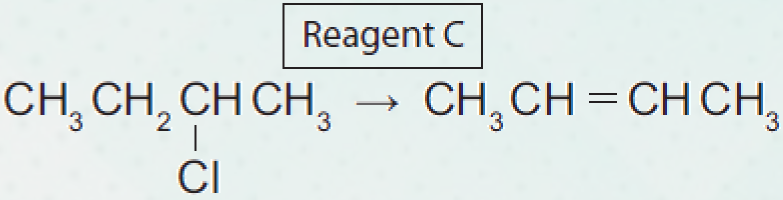
Reagent	Formula of reagent / conditions	Type of reaction
A	H_2O/H^+	addition
B	PCl_5 / PCl_3 / $SOCl_2$	substitution
C	KOH (alc)	elimination

Organic Reactions

NCEA 2013 Reactions (elimination)

Excellence Question

Question 3a: For the following reaction:

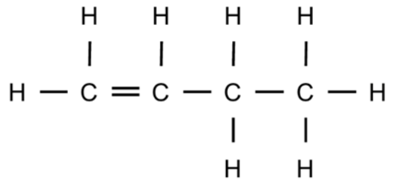


$$CH_3CH_2\underset{\displaystyle Cl}{\underset{|}{CH}}CH_3 \xrightarrow{\boxed{\text{Reagent C}}} CH_3CH=CHCH_3$$

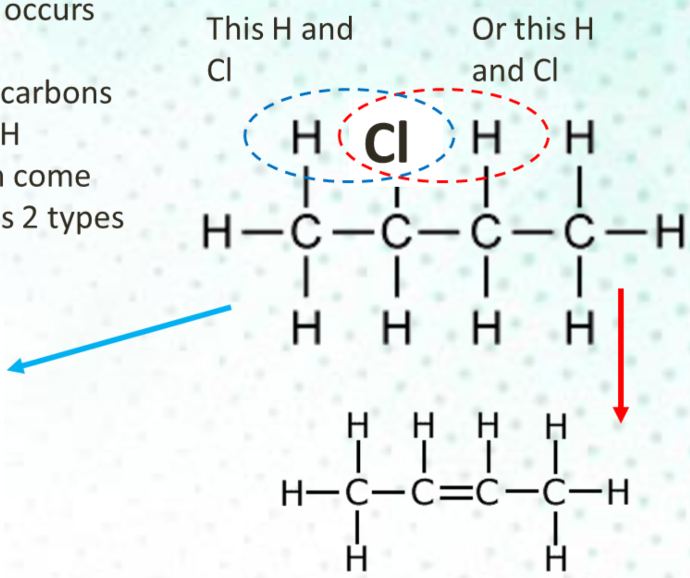
Circle the words below that describe if the product formed is major or minor. Explain your answer.

Major product – the carbon with the least hydrogen atoms attached loses another hydrogen atom (to form the double bond).

When an elimination reaction occurs on a **asymmetrical secondary** haloalkane (with more than 3 carbons in the longest chain) then the H removed along with the Cl can come from either side. This produces 2 types of products; major or minor.



But-1-ene



But-2-ene

Organic Reactions

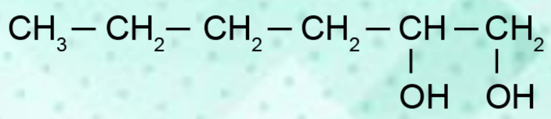
NCEA 2014 Reactions (addition)

Achieved Question

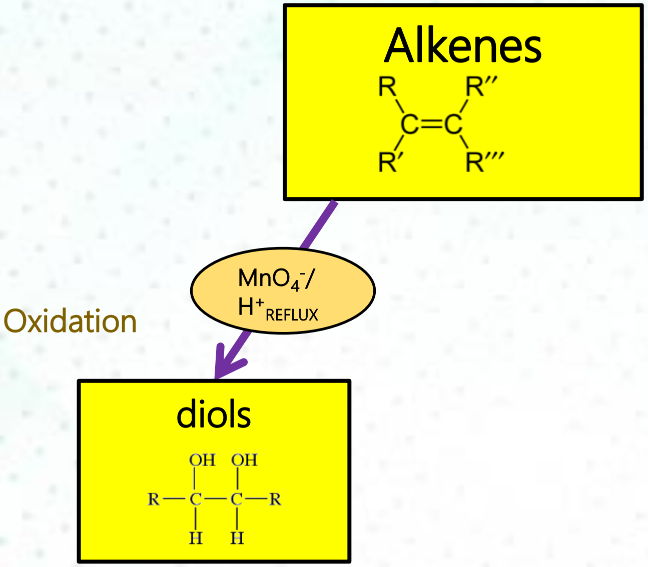
Question: 1b: (ii) Permanganate ion, MnO_4^-, can be used to oxidise alkenes.

☐ Draw the product of the following reaction

$CH_3-CH_2-CH_2-CH_2-CH=CH_2 \xrightarrow{MnO_4^-}$



$$CH_3-CH_2-CH_2-CH_2-\underset{OH}{\underset{|}{CH}}-\underset{OH}{\underset{|}{CH_2}}$$



Alkenes

Oxidation

MnO_4^-/H^+ REFLUX

diols

NCEA 2014 Reactions (substitution)

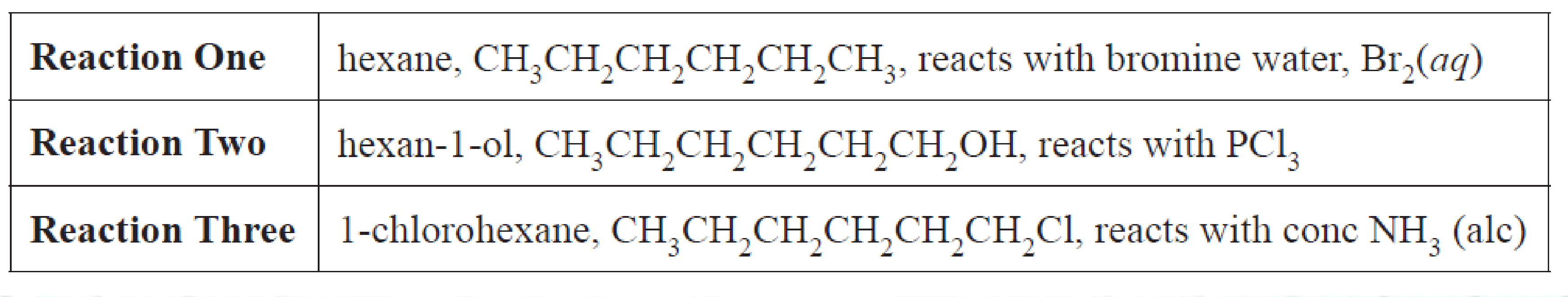
Excellence Question

Question: 1c:

The reactions shown below are all classified as being the same type of reaction. Compare and contrast these reactions.

In your answer you should:

- state whether any conditions are required
- describe the type of reaction occurring and explain why all three reactions are classified as this type of reaction
- explain why two layers form in **Reaction One**.

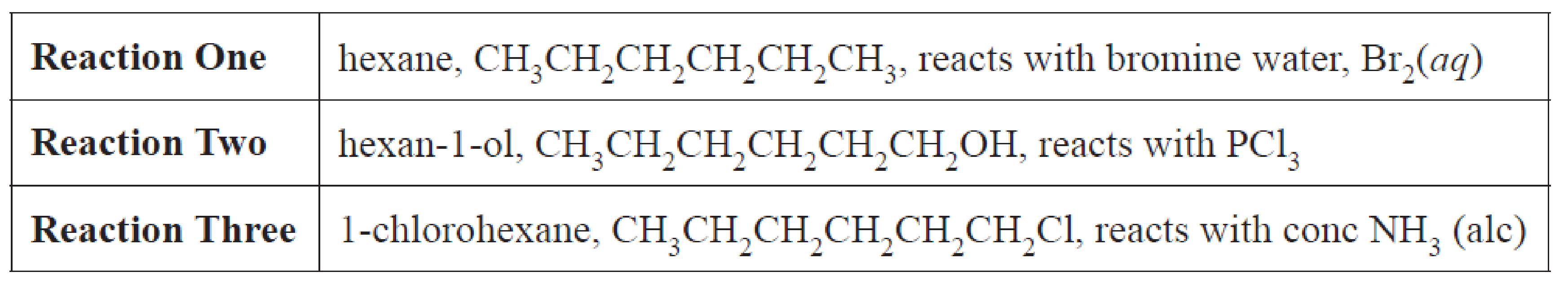


Reaction One	hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$, reacts with bromine water, $Br_2(aq)$
Reaction Two	hexan-1-ol, $CH_3CH_2CH_2CH_2CH_2CH_2OH$, reacts with PCl_3
Reaction Three	1-chlorohexane, $CH_3CH_2CH_2CH_2CH_2CH_2Cl$, reacts with conc NH_3 (alc)

NCEA 2014 Reactions (substitution)

Excellence Question

Answer: 1c:



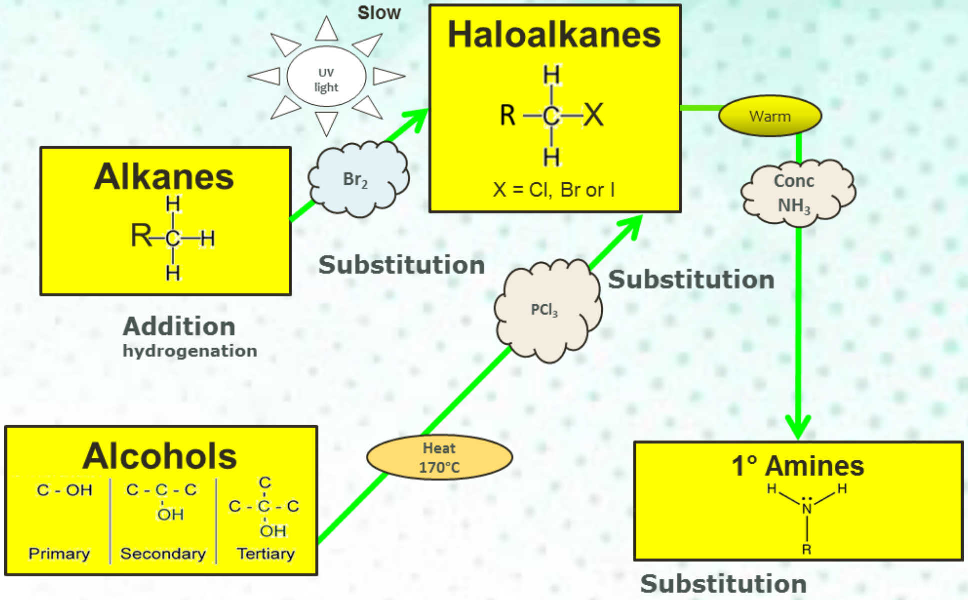
Reaction One	hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$, reacts with bromine water, $Br_2(aq)$
Reaction Two	hexan-1-ol, $CH_3CH_2CH_2CH_2CH_2CH_2OH$, reacts with PCl_3
Reaction Three	1-chlorohexane, $CH_3CH_2CH_2CH_2CH_2CH_2Cl$, reacts with conc NH_3 (alc)

All three reactions are **substitution** reactions. In all three reactions an atom or group of atoms is being replaced with another atom or group of atoms.

In **Reaction One;** a Br atom replaces an H atom. UV light is necessary.

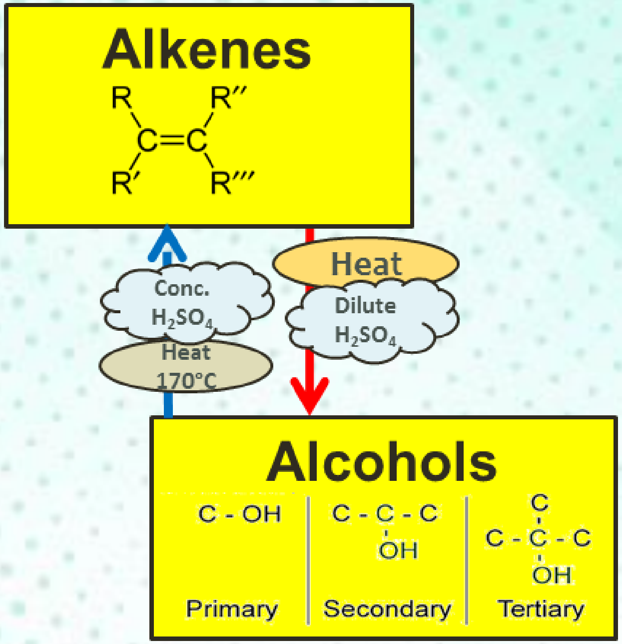
In **Reaction Two;** a Cl atom replaces the OH group. No conditions are required.

In **Reaction Three;** the Cl atom is replaced by NH_2. No conditions are required.



NCEA 2015 reactions (elimination + addition)

Excellence Question

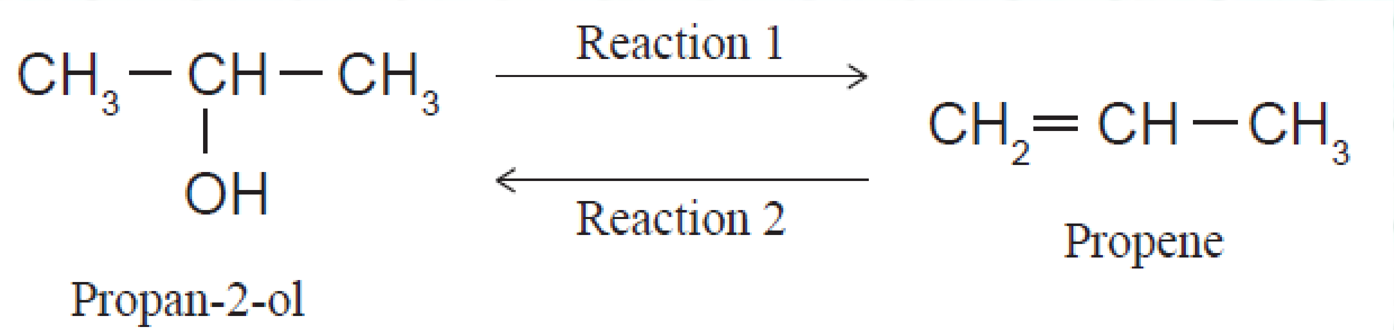


Question: 2b: In Reaction 1, propan-2-ol can be converted to propene.

In Reaction 2, propene can be converted back to propan-2-ol.

Analyse BOTH of these reactions by:

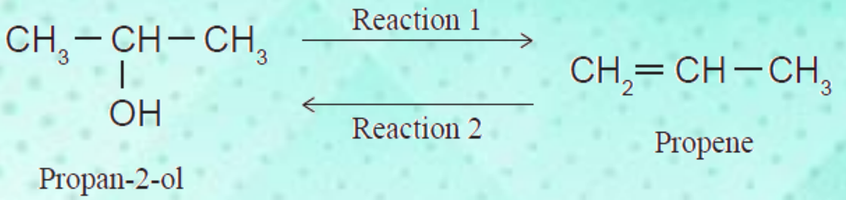
- ☐ describing the reagents and conditions needed for each reaction to occur
- ☐ identifying each type of reaction and explaining your choice
- ☐ explaining why Reaction 1 forms only a single organic product, but Reaction 2 forms a mixture of organic products.



NCEA 2015 reactions (elimination)

Excellence Question

Question: 2b:



To convert propan-2-ol to propene, add **concentrated sulfuric acid** (which is a dehydrating agent). It is an **elimination** reaction because OH and H are removed from adjacent carbon atoms and a double bond is created to form an alkene.

To convert propene to propan-2-ol, add **dilute (sulfuric) acid**. This is an **addition** reaction because the double bond is broken forming a C-C (single) bond, allowing H and OH from water to bond to the C atoms that were double bonded together.

Reaction 1 forms only one product because the carbon atom from which the H is removed (C1 or C3) does not affect the structure of the product as propan-2-ol is symmetrical.

Reaction 2 produces two products because an asymmetric reagent (H-OH) adds onto an asymmetric alkene ($CH_3CH=CH_2$). There are two carbons that the H or OH can bond with (C1 and C2), so there are two possible combinations. We can predict which will be the major product by using **Markovnikov's rule**, which states that the carbon with the most hydrogens gains more hydrogens. This means that most of the time, C1 will get another hydrogen while C2 will get the OH in this reaction. **Propan-2-ol will be the major product** and **propan-1-ol the minor product**.

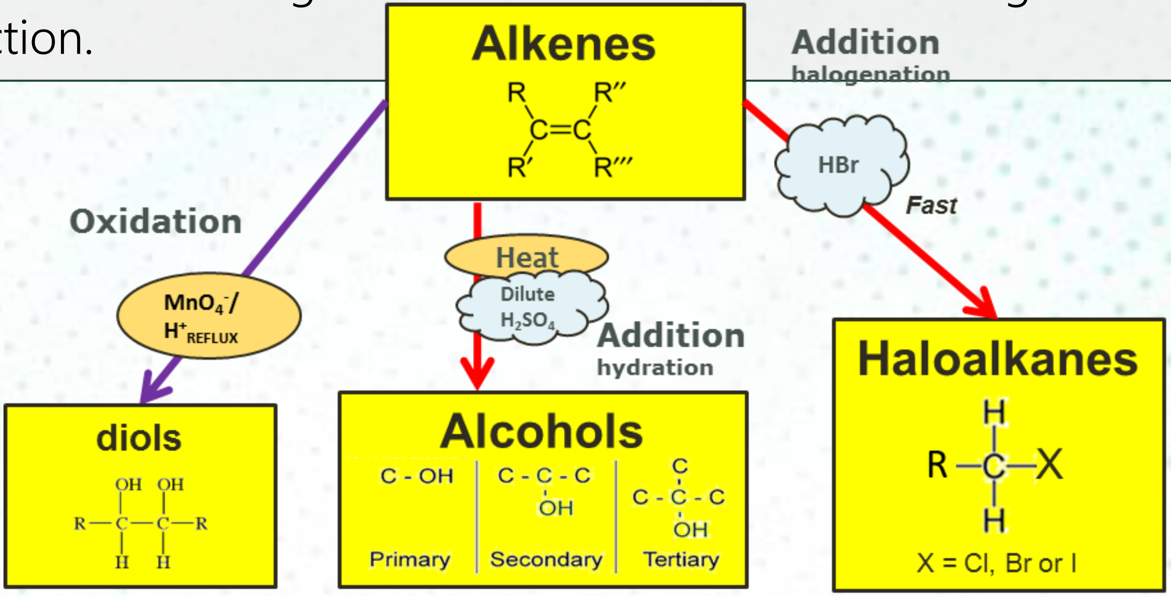
Organic Reactions

NCEA 2015 Reactions (addition)

Excellence Question

Question: 3b: Ethene, $C_2H_{4(g)}$, reacts with aqueous potassium permanganate solution, **$KMnO_{4(aq)}$**, dilute acid, **H_2O / H^+**, and hydrogen bromide, **HBr.**
Compare and contrast the reactions of ethene gas with each of these three reagents.
In your answer, you should:

- describe any observations that can be made
- identify, with reasons, the type of reaction ethene undergoes with each reagent
- describe the functional group of the products formed
- include equations showing the structural formulae for the organic compounds for each reaction.

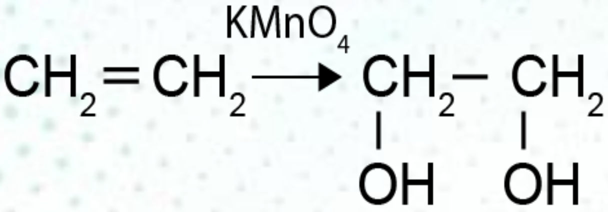


NCEA 2015 Reactions (Alkenes)

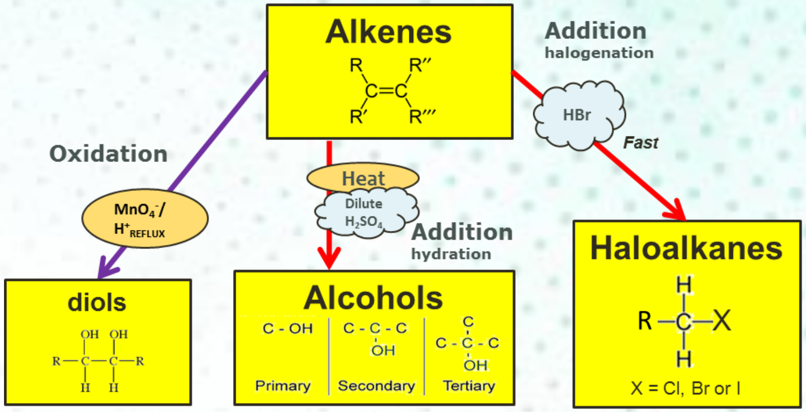
Excellence Question

Answer: 3b: Ethene, $C_2H_{4(g)}$, reacts with aqueous potassium permanganate solution, **$KMnO_{4(aq)}$**, dilute acid, **H_2O / H^+**, and hydrogen bromide, **HBr.**

Ethene reacts with aqueous $KMnO_4$ to form a diol, **ethan-1,2-diol**. This is an **oxidation** or addition reaction in which the double bond is broken and two –OH groups attach to each C atom of the double bond. The purple $KMnO_4$ turns brown (or colourless)



$$CH_2{=}CH_2 \xrightarrow{KMnO_4} \underset{\underset{OH}{|}}{CH_2}-\underset{\underset{OH}{|}}{CH_2}$$



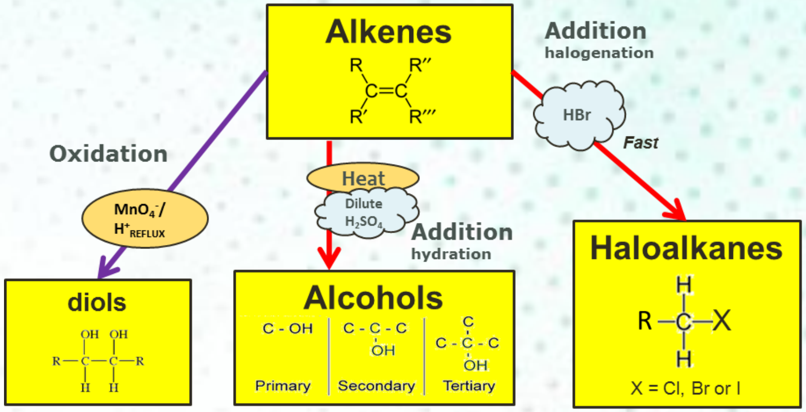
NCEA 2015 Reactions (addition)

Excellence Question

Answer: 3b: Ethene, $C_2H_{4(g)}$, reacts with aqueous potassium permanganate solution, **$KMnO_{4(aq)}$**, dilute acid, **H_2O / H^+**, and hydrogen bromide, **HBr.**

Ethene reacts with dilute acid, H_2O / H^+, to form **ethanol**.
This is an **addition** reaction as once again the double bond is broken. However, in this reaction one –OH group and one –H atom attach to each C atom of the double bond. No colour changes are observed in this reaction.

$$CH_2=CH_2 \xrightarrow{H_2O/H^+} CH_3-CH_2-OH$$



Organic Reactions

NCEA 2015 Reactions (addition)

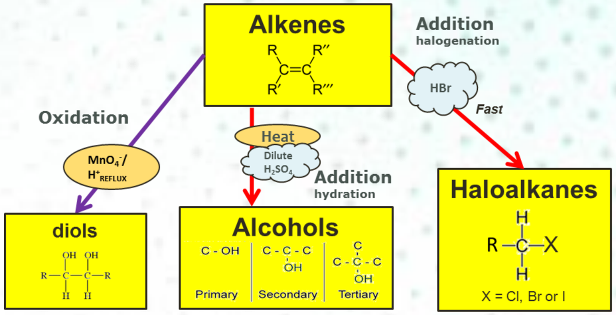
Excellence Question

Answer: 3b: Ethene, $C_2H_{4(g)}$, reacts with aqueous potassium permanganate solution, **$KMnO_{4(aq)}$**, dilute acid, **H_2O / H^+**, and hydrogen bromide, **HBr**.

When ethene reacts with hydrogen bromide, **bromoethane** is formed. Again there is no colour change observed.
This reaction is an **addition** reaction, as the double bond is broken and two atoms are added to each C atom of the double bond. In this reaction one H and one Br atom are added.

All three reactions involve the breaking of the double bond.
All three reactions involve addition.
Two of these reactions are addition reactions and one is an oxidation reaction.
Only one of the reactions gives a colour change that is easily observed.

$$CH_2{=}CH_2 \xrightarrow{HBr} CH_3{-}CH_2{-}Br$$



NCEA 2016 Reactions (substitution vs addition)

Merit Question

Question 2c: Ethane gas, $C_2H_{6(g)}$, and ethene gas, $C_2H_{4(g)}$, will both react with bromine water, $Br_{2(aq)}$. Compare and contrast these two reactions.
In your answer you should refer to:

- any conditions required
- the observations made
- the types of reactions occurring
- structural formulae of the organic products formed.

Ethane is an alkane which will react slowly with bromine water, $Br_2(aq)$, if (UV) light (or heat) is present, whereas the reaction between ethene and bromine water is immediate, and requires no special conditions.

When they react, both ethane and ethene cause orange / yellow bromine water to decolourise.

Since ethane is already a saturated molecule / hydrocarbon, it undergoes substitution with bromine water, resulting in the formation of bromoethane, CH_3CH_2Br. Ethene, however, is an unsaturated molecule / hydrocarbon, because it has a double C=C bond, which breaks, allowing two extra atoms to bond to the structure, resulting in the formation of 1,2-dibromoethane, CH_2BrCH_2Br. This is an addition reaction.

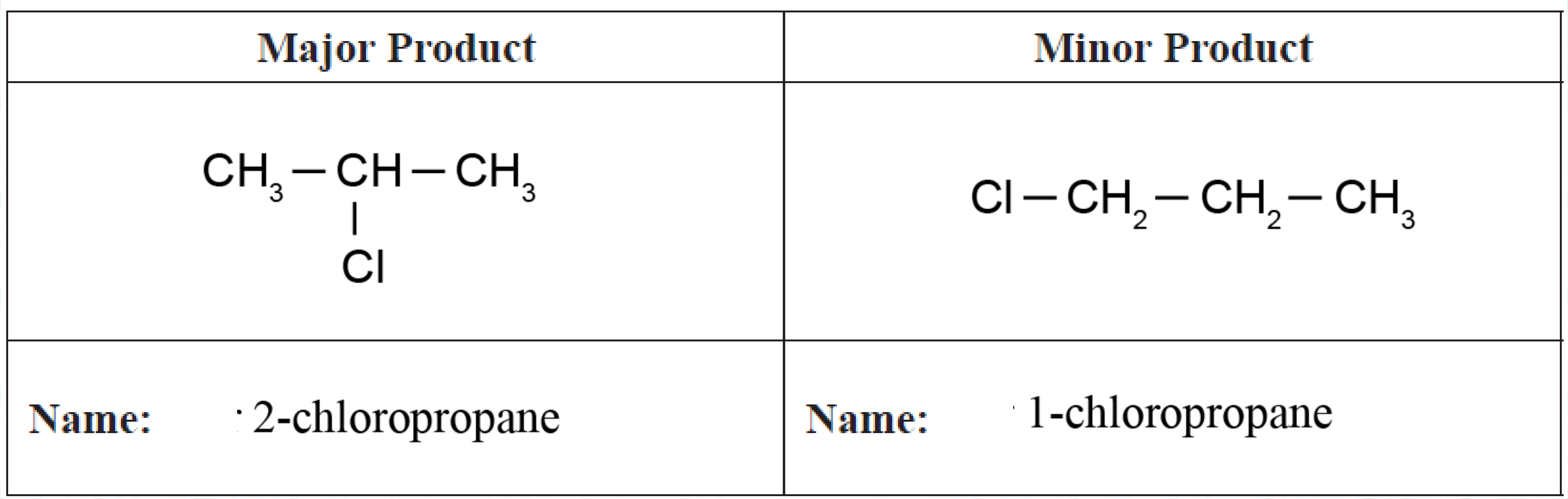
NCEA 2016 Reactions (addition)

Achieved Question

Question 3c: The reaction between propene, $C_3H_{6(g)}$, and hydrogen chloride, $HCl_{(g)}$, produces a mixture of products.

One of these products, the major product, is made in higher proportions than the other, the minor product. $CH_2CHCH_3 + HCl \rightarrow$

(i) Draw and name the major and minor products for this reaction.



Major Product	Minor Product
$\underset{\displaystyle Cl}{CH_3-\overset{}{CH}-CH_3}$	$Cl-CH_2-CH_2-CH_3$
Name: 2-chloropropane	**Name:** 1-chloropropane

NCEA 2016 Reactions (addition)

Excellence Question

Question 3c: The reaction between propene, $C_3H_{6(g)}$, and hydrogen chloride, $HCl_{(g)}$, produces a mixture of products.
(ii) Elaborate on the reaction that occurs between propene and hydrogen chloride.

Two products are formed in this reaction because propene is an asymmetric alkene. When another asymmetric molecule such as hydrogen chloride, HCl, is added to it, there are two possible products. One product is produced in greater quantities (the major product) than the other (minor product).

The rule for determining which is the major product (called the Markovnikov's rule) states that the C in the double bond with the most H atoms directly attached to it is most likely to gain another H atom ('rich get richer' concept).

The most common product, the major product, is therefore 2-chloropropane, and 1-chloropropane is the minor product.

NCEA 2017 Reactions (elimination) Part ONE

Excellence Question

Question 1b: (iii) 2-bromo-3-methylbutane also reacts with conc. KOH(alc). However, in this reaction TWO organic products are formed, a major and a minor product. Give an account of the chemical processes that occur in this reaction. In your answer you should:

- write an equation for this reaction showing the organic compounds
- name the type of reaction occurring
- explain how the products form
- explain which product you would expect to be the minor product.

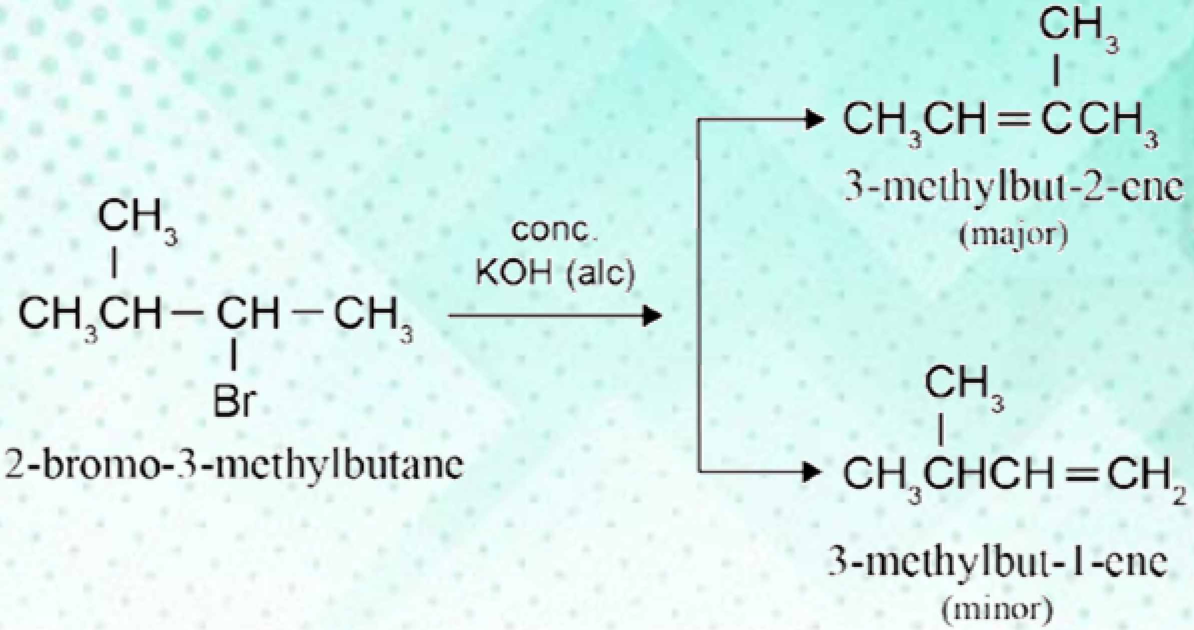
In this **elimination** reaction, because 2-bromo-3-methylbutane is an asymmetric haloalkane, two organic products form. The Br atom is removed from the C2 atom, along with an H atom off an adjacent C atom, to form a C=C double bond.

There are two H atoms that could be removed; one from the C1 atom or one from the C3 atom.

If an H is removed from the C1 atom, 3-methylbut-1-ene will form. If an H is removed from the C3 atom, then 3-methylbut-2-ene forms. Both products are formed, but there is more of one product than the other. These are called major and minor products.

NCEA 2017 Reactions (elimination) Part TWO

Excellence Question



To identify which is which (use '**Saytzeff's Rule**' or the 'poor get poorer'), we look for the C atom adjacent to the C with Br attached, with the fewest H atoms attached initially, as this is the C atom that is most likely to lose another H atom.
Resulting in **3-methylbut-2-ene** being the **major product** and **3-methylbut-1-ene** being the **minor product**.

Note: *if the terms 'Saytzeff's Rule' or 'poor get poorer' are used, they need to be explained to get to M or E level.*

NCEA 2018 Reactions (addition)

Excellence Question

Question: 1d: When but-1-ene is reacted to form bromobutane, C_4H_9Br, two organic products are formed.
Analyse this reaction by:

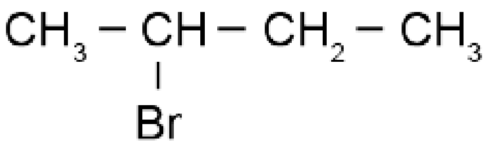
- stating the reagent required
- identifying the type of reaction and justifying your choice
- explaining why there is a mixture of organic products.

Support your answer by drawing structural formulae for but-1-ene and the organic products.

HBr is the reagent. It is an addition reaction because the double bond is broken to form a single C–C bond allowing the H and Br to bond to the carbon atoms forming the haloalkane. There are two products because the reagent, HBr is asymmetric, and the alkene is asymmetric due to the position of the double bond.
There are two carbons forming a double bond that the H and Br can bond to so there are two possible combinations. The carbon with the most hydrogens will gain more hydrogens. This means that 2- bromobutane will be the major product since the carbon at the end has two hydrogens and the middle carbon has only one hydrogen; therefore the H atom will preferentially bond to the end carbon. 1- bromobutane will be the minor product.

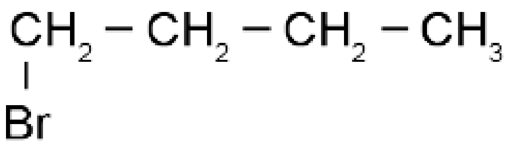
$CH_2=CH-CH_2-CH_3$

but-1-ene



$CH_3-\underset{\displaystyle Br}{\underset{|}{CH}}-CH_2-CH_3$

2-bromobutane



$\underset{\displaystyle Br}{\underset{|}{CH_2}}-CH_2-CH_2-CH_3$

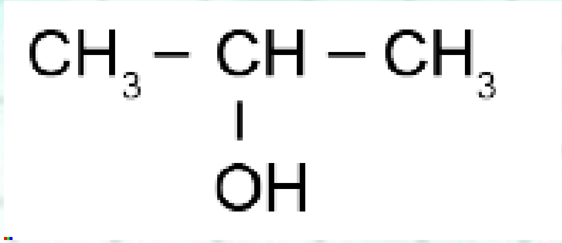
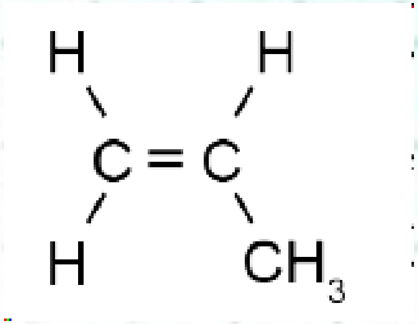
1-bromobutane

NCEA 2018 Reactions (substitution vs elimination)

Excellence Question

Question: 3b: Reacting 2-chloropropane with potassium hydroxide, KOH, can produce different products due to different reactions occurring.
(i) Elaborate on the reactions of 2-chloropropane with potassium hydroxide, KOH.
In your answer you should:

  - identify the conditions of the reagent KOH
  - explain the types of reaction that occur with the reagent in each condition
- draw structural formulae of the organic products.

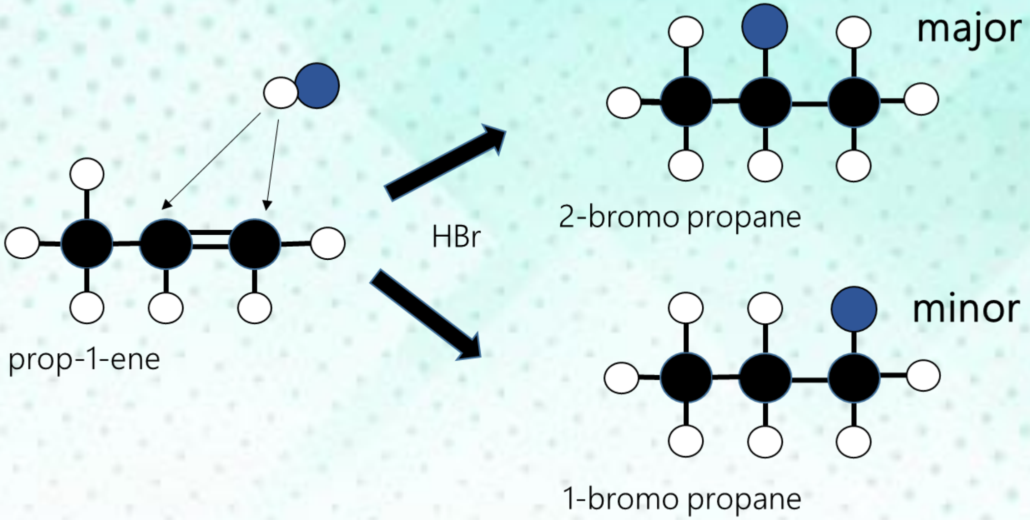
A reaction with dilute aqueous KOH will produce an alcohol, propan-2-ol. This is a substitution reaction. The Cl atom is substituted by an OH group	 $CH_3-\underset{\displaystyle OH}{\underset{\vert}{CH}}-CH_3$
If concentrated KOH(*alc*) is used, an elimination reaction occurs, and the 2-chloropropane forms propene because a H and a Cl atom will be removed, whilst a double bond is formed	

Organic Reactions

NCEA 2019 Reactions (addition)

Excellence Question

Question: 2b: Explain how you identified the major and minor products (**C** and **D**) in the reaction of propene with hydrogen bromide solution, $HBr_{(aq)}$.

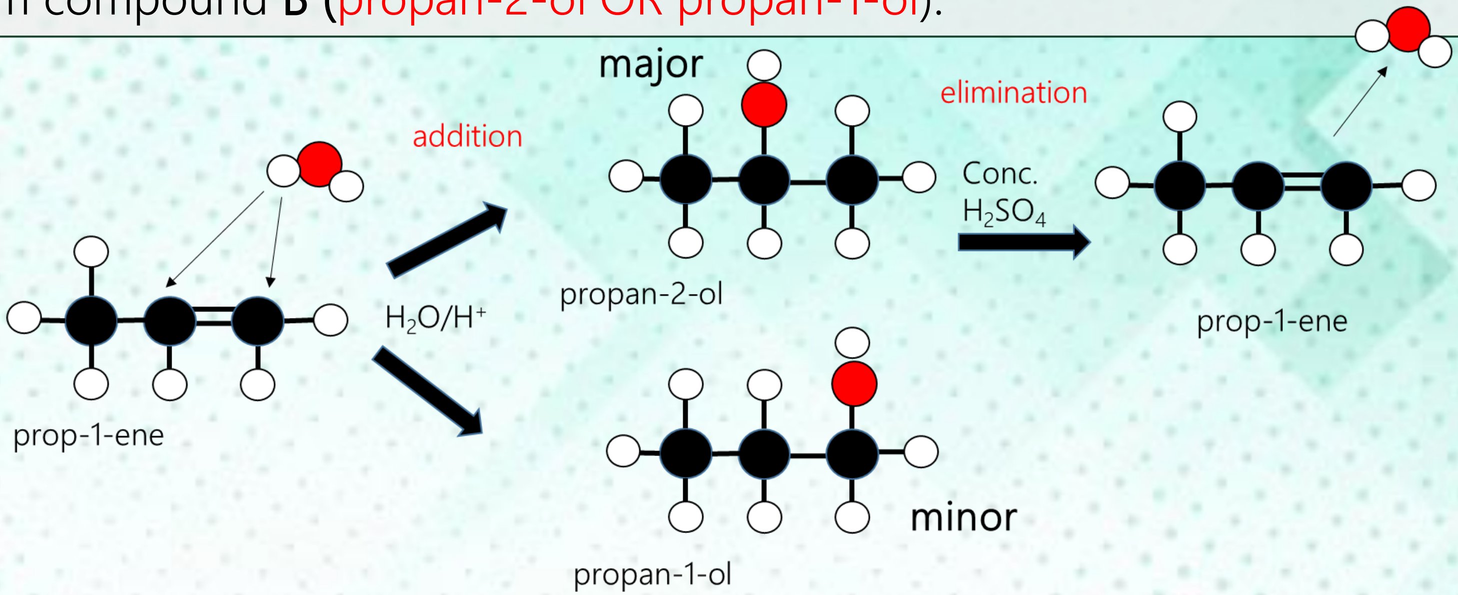


This is an addition reaction to an asymmetric alkene. When the HBr is added to propene when the double bond breaks, there are two possible products. The H atom is more likely to bond to the carbon with more hydrogens. In propene, the second carbon has one hydrogen and the first carbon has two hydrogens therefore the H from HBr bonds to the first carbon and the Br bonds to the second carbon making 2-bromopropane the major product. 1-bromopropane is the minor product where Br bonds to the first carbon.

NCEA 2019 Reactions (Addition vs Elimination)

Excellence Question

Question: 2c: Compare and contrast the reaction that forms compound **B** (propan-2-ol OR propan-1-ol) to the reverse reaction that forms propene, C_3H_6, from compound **B** (propan-2-ol OR propan-1-ol).



The reaction that forms compound **B** is an addition reaction where the double bond is broken to add OH and H to saturate the molecule and form an alcohol. The reverse reaction is the removal of the H and OH to form a double bond in an elimination reaction, forming an unsaturated molecule with a double bond. The elimination reaction uses concentrated sulfuric acid to remove the water, whereas the addition reaction uses dilute sulfuric acid to add the water. The reactions are opposite in that one breaks the double bond to increase saturation and one forms a double bond to decrease saturation.

Organic Reactions

NCEA 2020 Reactions (Addition vs Elimination)

Achieved Question

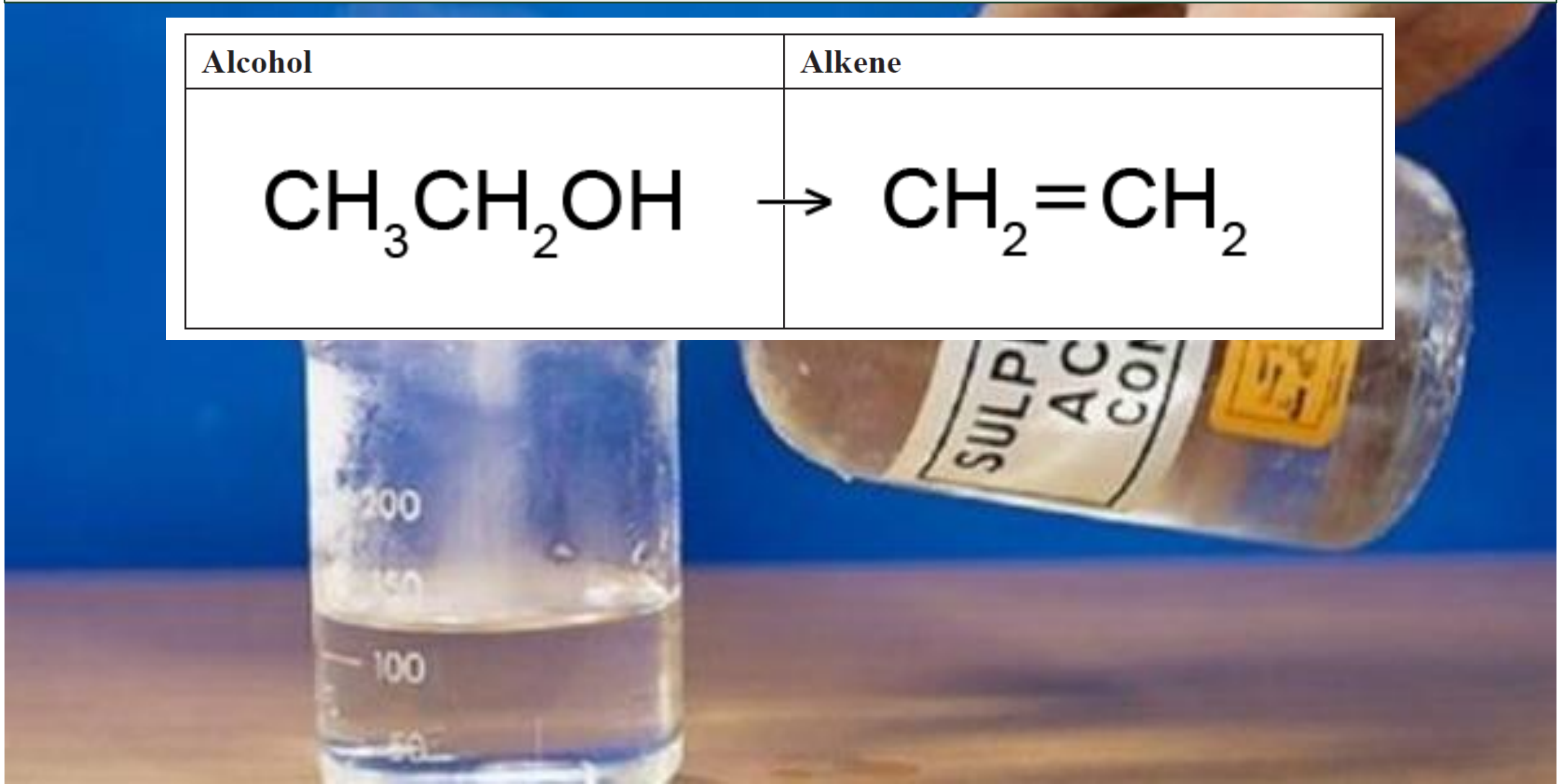
Question: 1c: Depending upon the conditions in which it is used, sulfuric acid, H_2SO_4, can enable the two reactions below to occur.

alcohol → alkene

alkene → alcohol

(i) In the boxes below, draw the structural formula for a molecule containing two carbon atoms that could be used in the reactions above.

Alcohol	**Alkene**
$CH_3CH_2OH \rightarrow$	$CH_2=CH_2$



NCEA 2020 Reactions (Addition vs Elimination)

Excellence Question

Question: 1c: (ii) Elaborate on how sulfuric acid is used in the conversion of both an alcohol to an alkene, and an alkene to an alcohol.
In your answer you should:
- state the conditions required for each reaction
- state the type of reaction occurring in each case, and justify your choices.

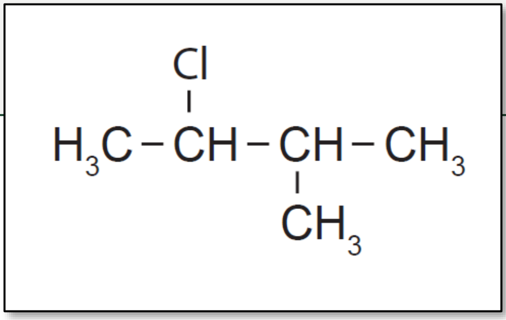
A reaction with **dilute H_2SO_4** will convert an alkene / ethene into an alcohol / ethanol.
This is an **addition reaction** with water, (using H_2SO_4 as a catalyst. The double bond is broken and 1 ´ H (atom) and 1 ´ OH (group) are added to the carbon atoms.

If **concentrated H_2SO_4** (and heat is used), an **elimination reaction** occurs, converting an alcohol / ethanol to an alkene / ethene. 1 ´ H (atom) and 1 ´ OH (group) will be removed. A double bond is formed.

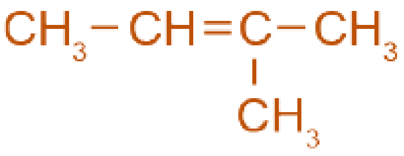
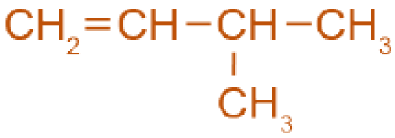
NCEA 2020 Reactions (Elimination)

Achieved Question

Question: 3a: When 3-methyl-2-chlorobutane, shown below, is reacted with $KOH_{(alc)}$ and heated, a mixture of products are formed.
(i) Draw the two products from this reaction.



$H_3C-\overset{Cl}{CH}-\underset{CH_3}{CH}-CH_3$

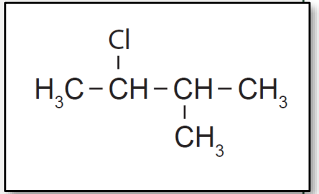
Major product:	**Minor product:**
 $CH_3-CH=\underset{CH_3}{C}-CH_3$ (2-methyl-but-2-ene)	 $CH_2=CH-\underset{CH_3}{CH}-CH_3$ (3-methyl-but-1-ene)

NCEA 2020 Reactions (Elimination)

Excellence Question

Question: 3a: When 3-methyl-2-chlorobutane, shown below, is reacted with $KOH_{(alc)}$ and heated, a mixture of products are formed.
Give an account of the chemical process that occurs in this reaction.
In your answer you should:

- state the type of reaction and explain your choice
- explain why two products form, and justify how you decided which are the major and minor products.

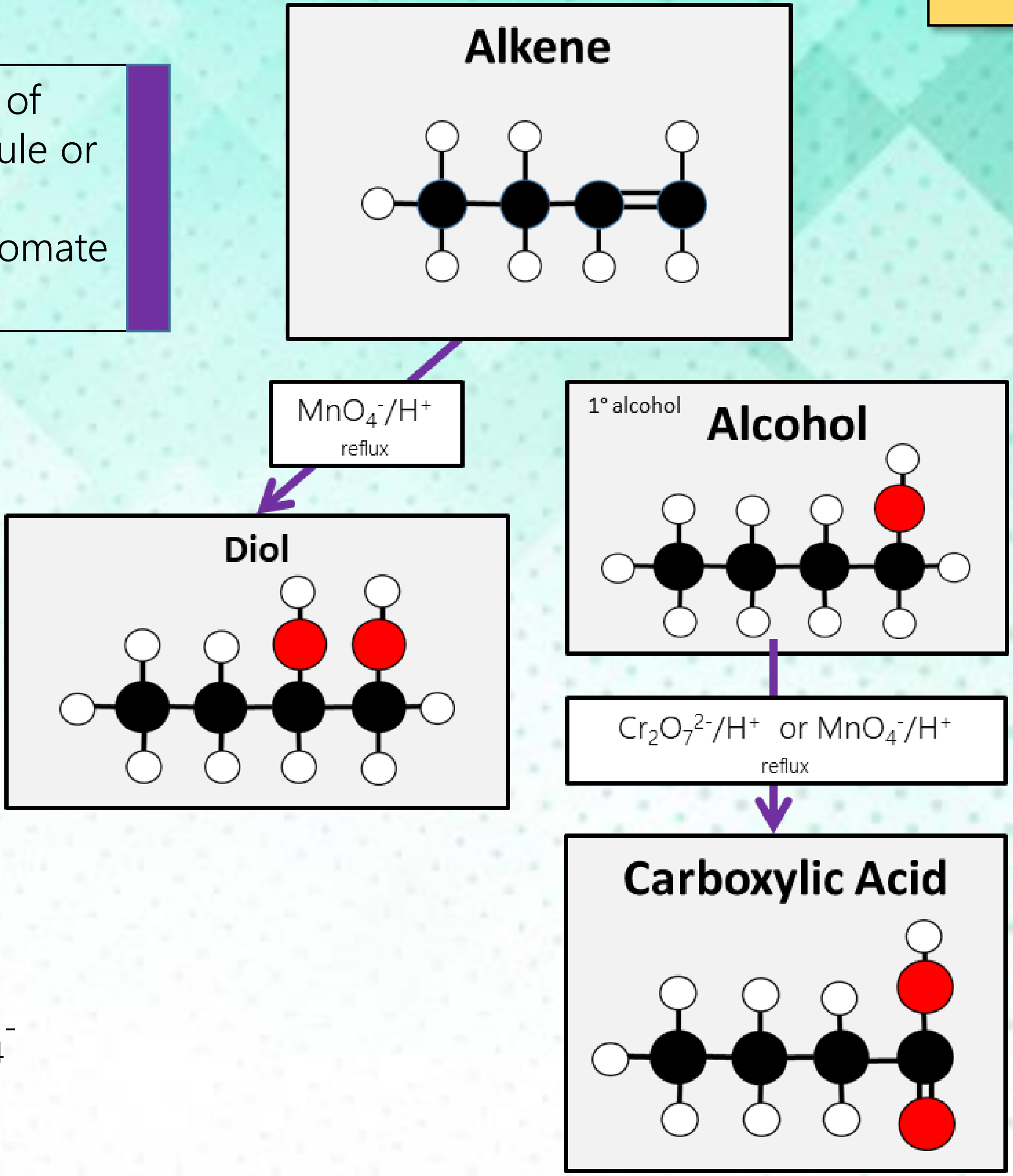


$H_3C-CH(Cl)-CH(CH_3)-CH_3$

This is an **elimination reaction** because a double bond is formed as Cl and H atoms are removed from the molecule.
Two products are formed in this reaction because the double bond can form on either side of the carbon attached to the Cl group. One product is produced in greater quantities (the major product) than the other (minor product).
The major product is identified by the C losing the H atom to form the double bond that already has fewer H atoms directly attached to it. This is the carbon to the right of Cl / carbon 3, as it has 1 hydrogen compared to the carbon to the left of Cl / carbon 1 as it has 3 hydrogen. Carbon 1 is more likely to lose another H atom (‘poor get poorer’ concept). The most common product, the major product, is therefore 2-methyl-but-2-ene, and 3-methyl-but-1-ene is the minor product.

Oxidation Reactions

Oxidation reactions involve a lost of electrons from the organic molecule or a gain of oxygen.
Oxidants include potassium dichromate or potassium permanganate



Alkene

MnO_4^-/H^+
reflux

Diol

1° alcohol

Alcohol

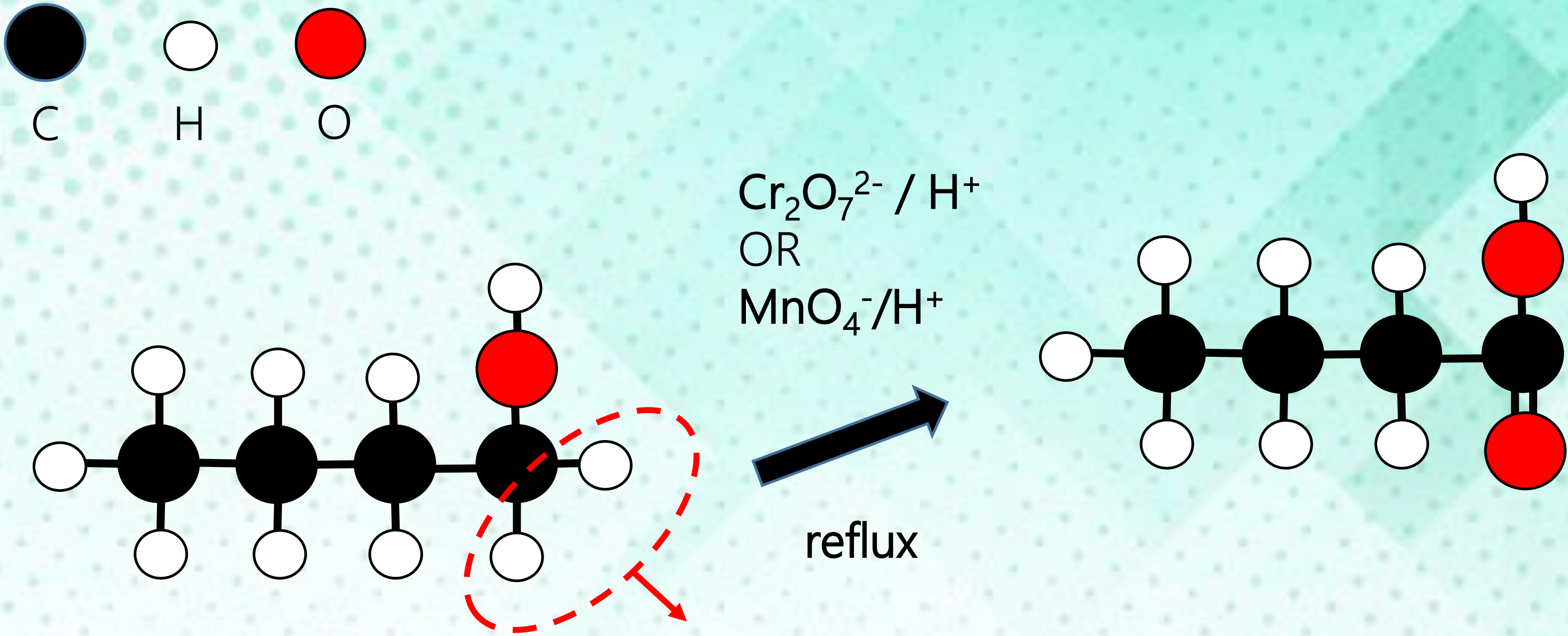
$Cr_2O_7^{2-}/H^+$ or MnO_4^-/H^+
reflux

Carboxylic Acid

oxidation of:

- ❑ primary alcohols to form carboxylic acids with MnO_4^- $/H^+$ or $Cr_2O_7^{2-}/H^+$
- ❑ alkenes with MnO_4^-

Oxidation Reaction of Alcohols



$Cr_2O_7^{2-}$ / H^+
OR
MnO_4^-/H^+

reflux

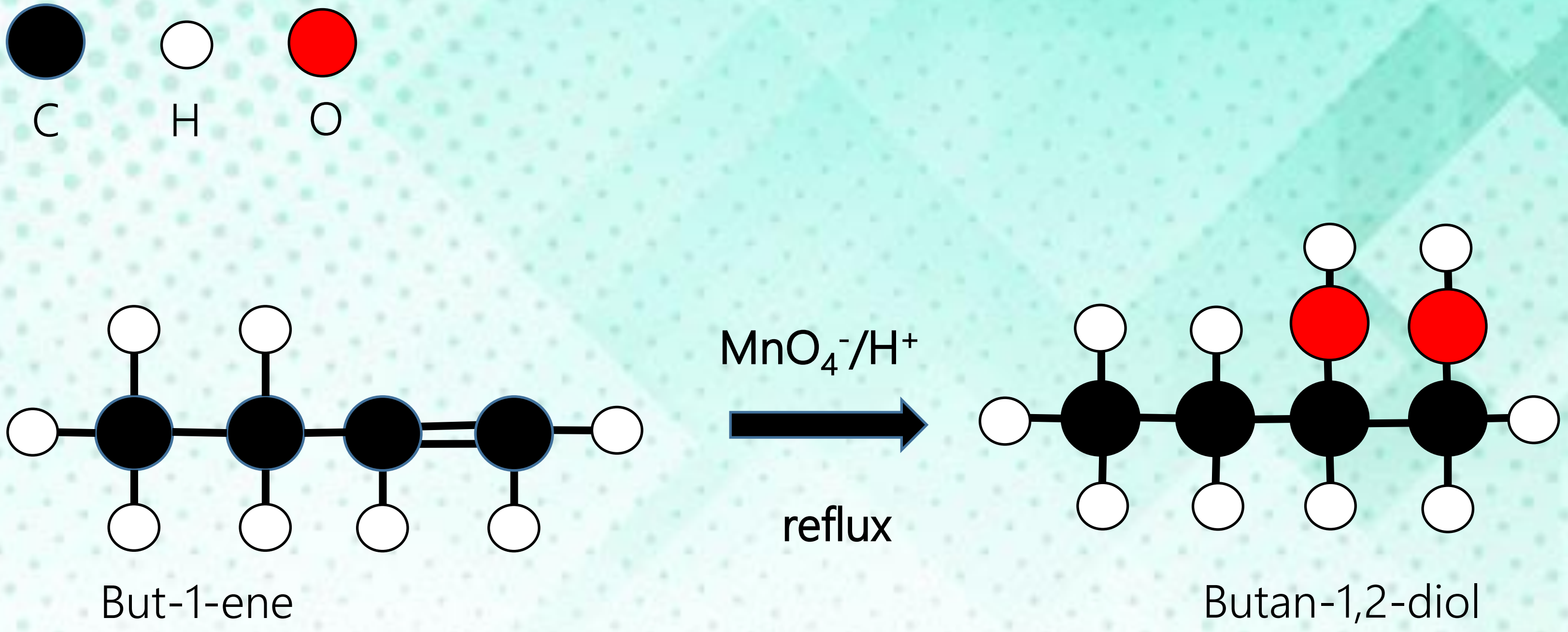
butan-1-ol

butanoic acid

Lose 2 Hydrogen (as water) and add a double bonded Oxygen to end carbon (carbonyl group)

Only primary alcohols form carboxylic acids

Oxidation Reaction of Alcohols



The hydroxyl groups (OH) will bond to the carbons that originally had the double bonds.

Some consider this a type of addition reaction, as the double bond is removed – and additional bonds are added.

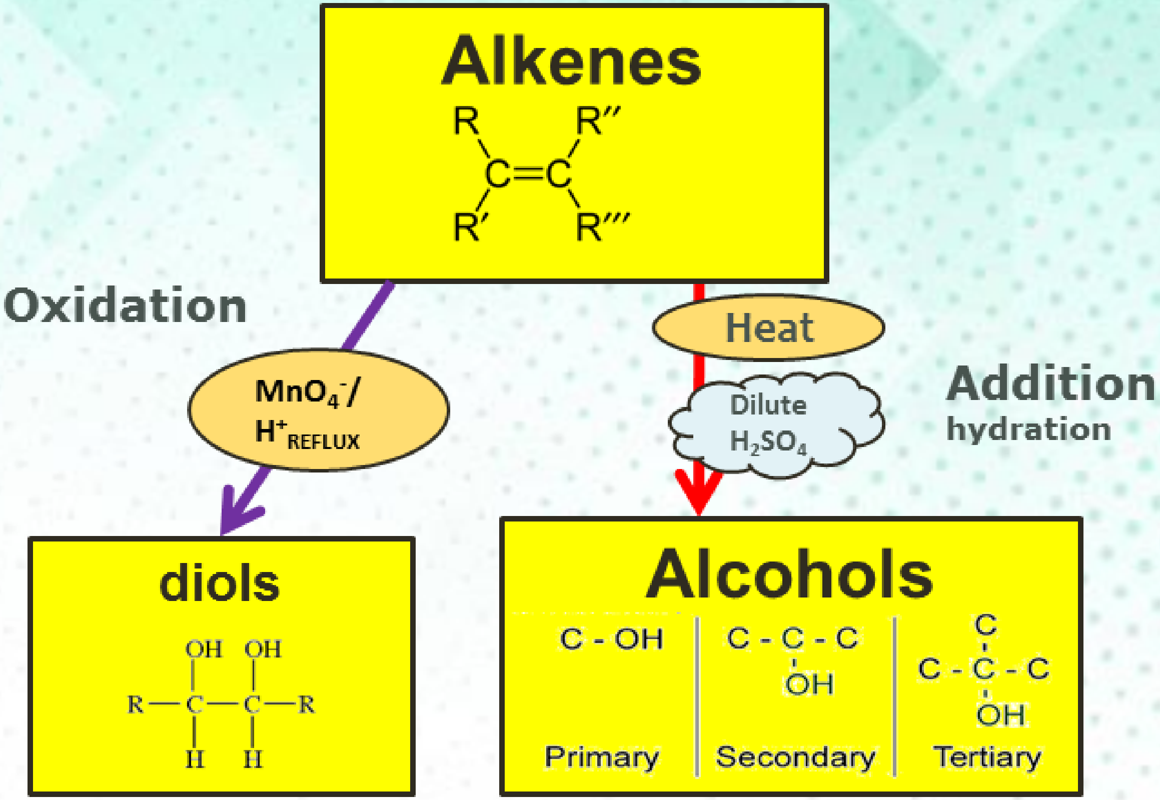
Organic Reactions

Oxidation reactions with alkenes

extra info

Alkenes can also undergo an **oxidation** reaction (this could also be classified as an addition reaction). The reagent is an oxidant, potassium permanganate (acidified) , MnO_4^-/H^+, performed under reflux conditions. **The reaction creates a diol**. Two hydroxyl groups join onto the carbons on either end of the broken double bond.

Compare this to the addition reaction that which occurs with dilute acid added to an alkene. Only a single hydroxyl group is added to make an alcohol.



Alkenes

Oxidation

MnO_4^-/H^+ REFLUX

diols

Heat

Dilute H_2SO_4

Addition hydration

Alcohols

Primary

Secondary

Tertiary

NCEA 2013 Reactions (substitution + oxidation + elimination)

Excellence Question

Question 3a: Butan-1-ol can react separately with each of PCl_5, $Cr_2O_7^{2-}$ / H^+, and concentrated H_2SO_4.
Elaborate on the reactions of butan-1-ol with each of the three reagents.
For each reaction, your answer should include:

- the type of reaction occurring and the reason why it is classified as that type
- the name of the functional group formed in each product
- the structural formula of the **organic** product.

☐ Reaction with PCl_5 is a **substitution** reaction. The hydroxyl group (–OH) is replaced by a chloro group (–Cl). **The product is $CH_3CH_2CH_2CH_2Cl$**

The functional group in the product is a chloro group / chloroalkane (haloalkane).

☐ Reaction with acidified dichromate is **oxidation** as the alcohol is oxidised to a carboxylic acid. **The product is $CH_3CH_2CH_2COOH$**

The functional group in the product is carboxylic acid.

☐ Reaction with concentrated H_2SO_4 is an **elimination** reaction. A hydrogen atom and the –OH group on (adjacent) carbon atoms are removed forming a (carbon-to-carbon) double bond. **The product is $CH_3CH_2CH=CH_2$**

The functional group in the product is a (carbon-to-carbon) double bond / alkene.

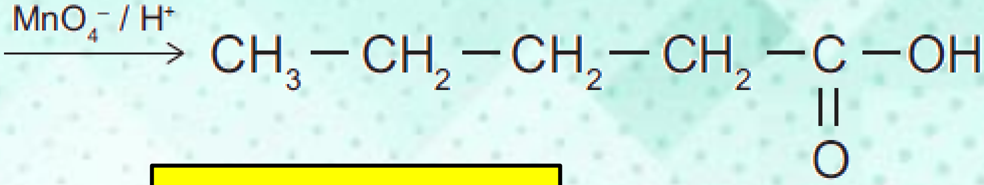
NCEA 2014 Reactions (oxidation)

Achieved Question

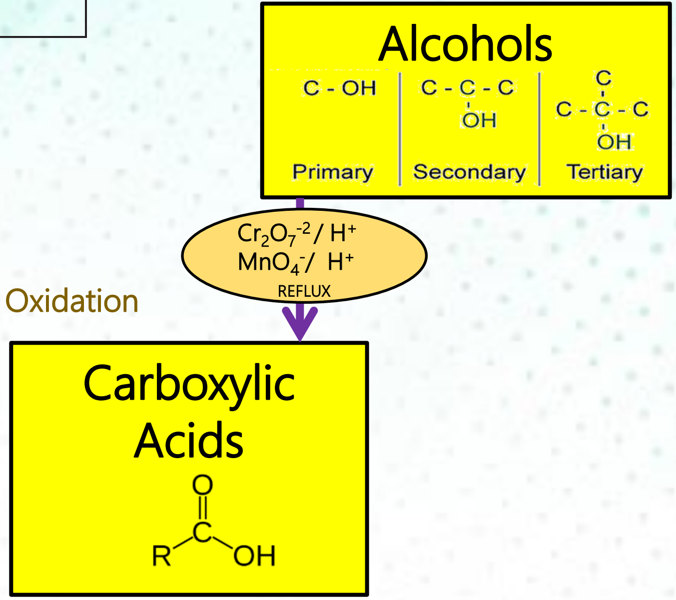
Question: 1b: (i) When primary alcohols are oxidised by acidified permanganate, MnO_4^- / H^+, they form carboxylic acids.

- ☐ Draw the primary alcohol that was oxidised to form the carboxylic acid shown.

$CH_3-CH_2-CH_2-CH_2-CH_2-OH$



$$\xrightarrow{MnO_4^-/H^+} CH_3-CH_2-CH_2-CH_2-\underset{\underset{O}{\|}}{C}-OH$$



Alcohols

C - OH	C - C - C OH	C C - C - C OH
Primary	Secondary	Tertiary

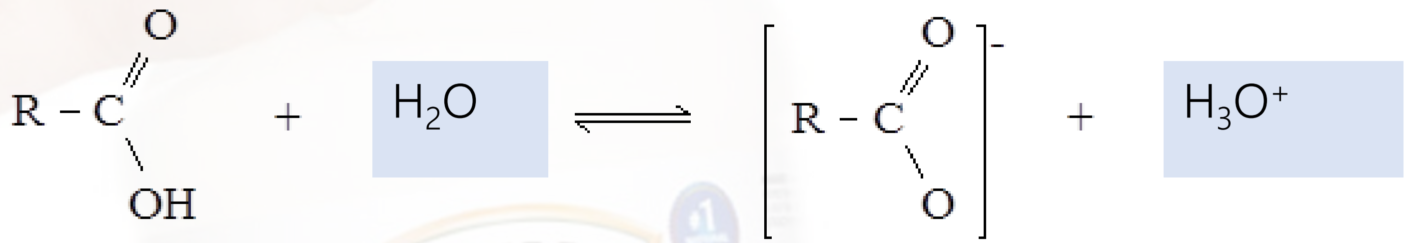
$Cr_2O_7^{-2}/H^+$
MnO_4^-/H^+
REFLUX

Oxidation

Carboxylic Acids

Carboxylic Acid Reactions

Carboxylic Acids are Weak Acids
and are proton donors in water



React with magnesium to give hydrogen gas (a useful test)

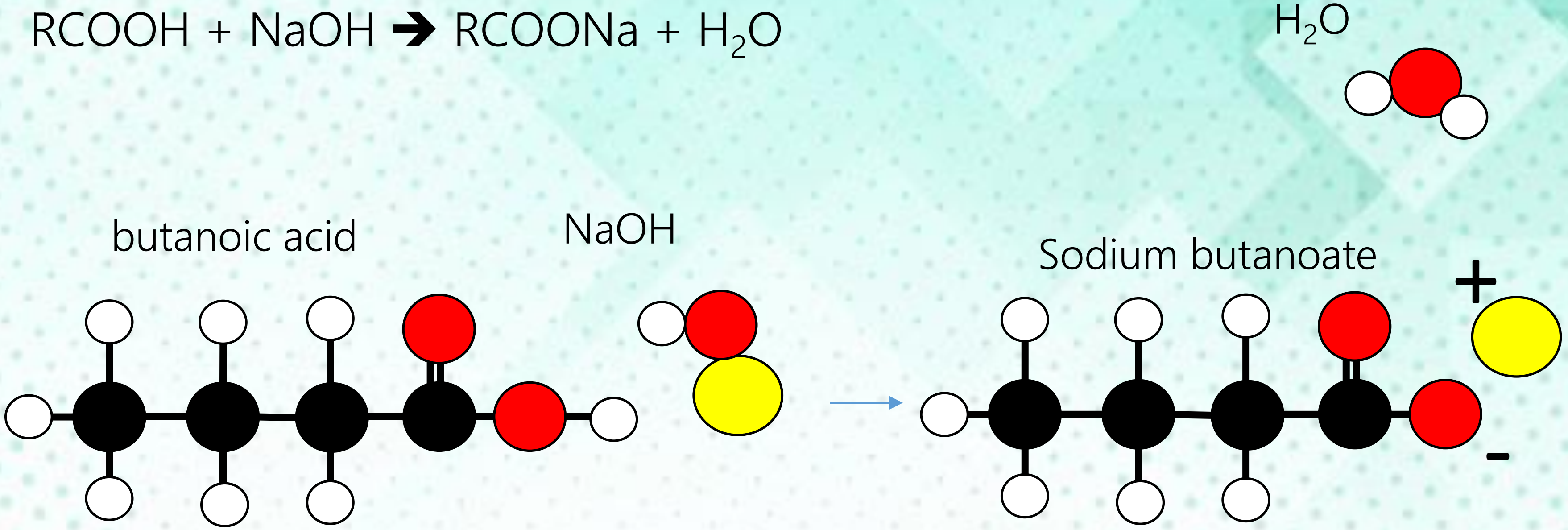
$CH_3COOH + Mg \rightarrow Mg(CH_3COO)_2 + H_{2(g)}$

React with calcium carbonate to give $CO_{2(g)}$ (a useful test)

$CH_3COOH + CaCO_3 \rightarrow Ca(CH_3COO)_2 + \mathbf{CO_{2(g)}} + H_2O$

Acid-Base reactions in carboxylic acid

Carboxylic acids act as a weak acid by partially dissociating and **neutralising** bases:
For example
RCOOH + NaOH ➔ RCOONa + H_2O

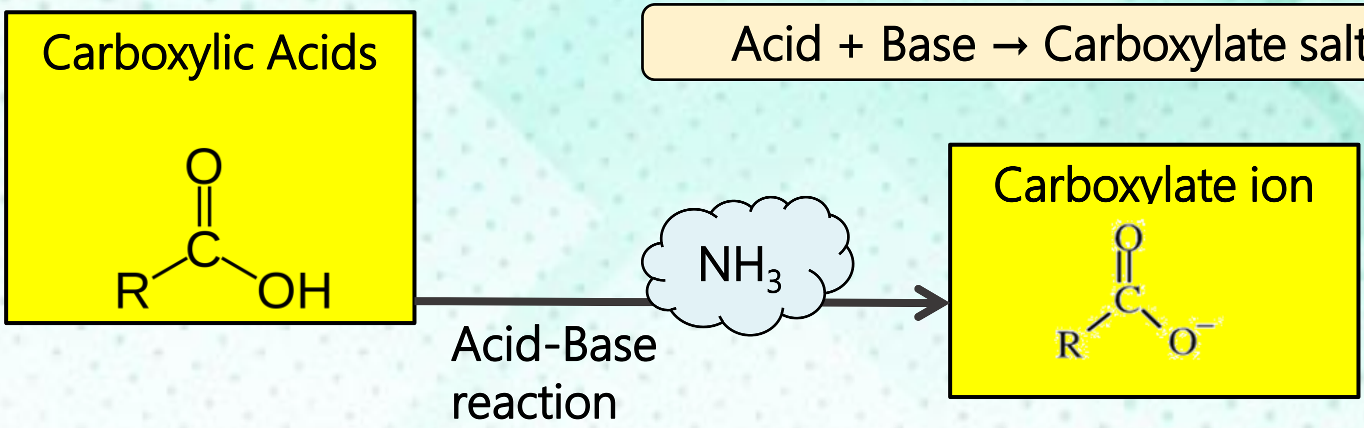


acid + base → salt + water

Acid-Base reactions in carboxylic acid

When carboxylic acids react in an acid-base reaction, they form a conjugate, the carboxylate ion. This ion is an anion and can join with a cation (formed from a base such as NaOH) to produce a neutral salt. It can also form a salt from an amine conjugate (such as $CH_3CH_2NH_3^+$)

Acid + Base → Carboxylate salt + NH_4^+



Carboxylic Acids

NH_3

Acid-Base reaction

Carboxylate ion

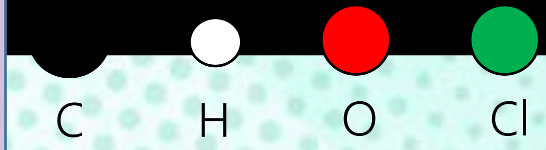
Carboxylic acid also have similar reactions to other acids

carboxylic acid + carbonate → carboxylate salt + water + carbon dioxide

carboxylic acid + metal → carboxylate salt + hydrogen gas

carboxylic acid + oxide → carboxylate salt + water

Acid - Base reactions in Amines



With water - Amines behave like ammonia due to a lone pair of e- proton acceptors (i.e. bases)

Like ammonia itself, water soluble amines form alkaline solutions. They react with water by proton transfer to form OH- ions. This means aqueous solutions of amines **turn litmus blue.**

$$RNH_2 + H_2O \rightarrow RNH_3^+ + OH^-$$

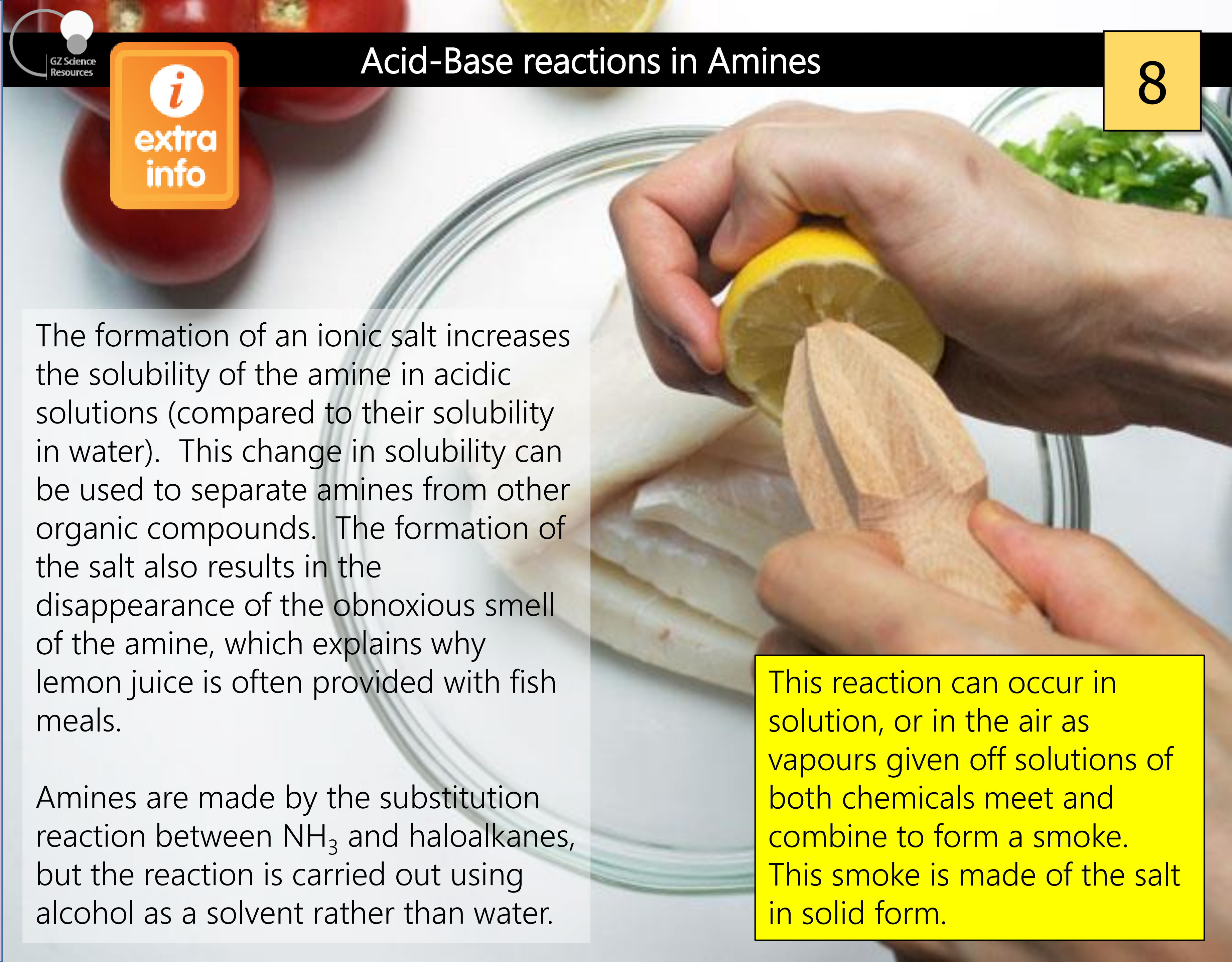
This reaction can occur in solution, or in the air as vapours given off solutions of both chemicals meet and combine to form a smoke. This smoke is made of the salt in solid form.

With an acid - Amines also react with acids to form salts.

$$CH_3NH_2 + HCl \rightarrow CH_3NH_3^+ Cl^-$$

aminomethane → methyl ammonium chloride

Acid-Base reactions in Amines



The formation of an ionic salt increases the solubility of the amine in acidic solutions (compared to their solubility in water). This change in solubility can be used to separate amines from other organic compounds. The formation of the salt also results in the disappearance of the obnoxious smell of the amine, which explains why lemon juice is often provided with fish meals.

Amines are made by the substitution reaction between NH_3 and haloalkanes, but the reaction is carried out using alcohol as a solvent rather than water.

This reaction can occur in solution, or in the air as vapours given off solutions of both chemicals meet and combine to form a smoke. This smoke is made of the salt in solid form.

Background Knowledge

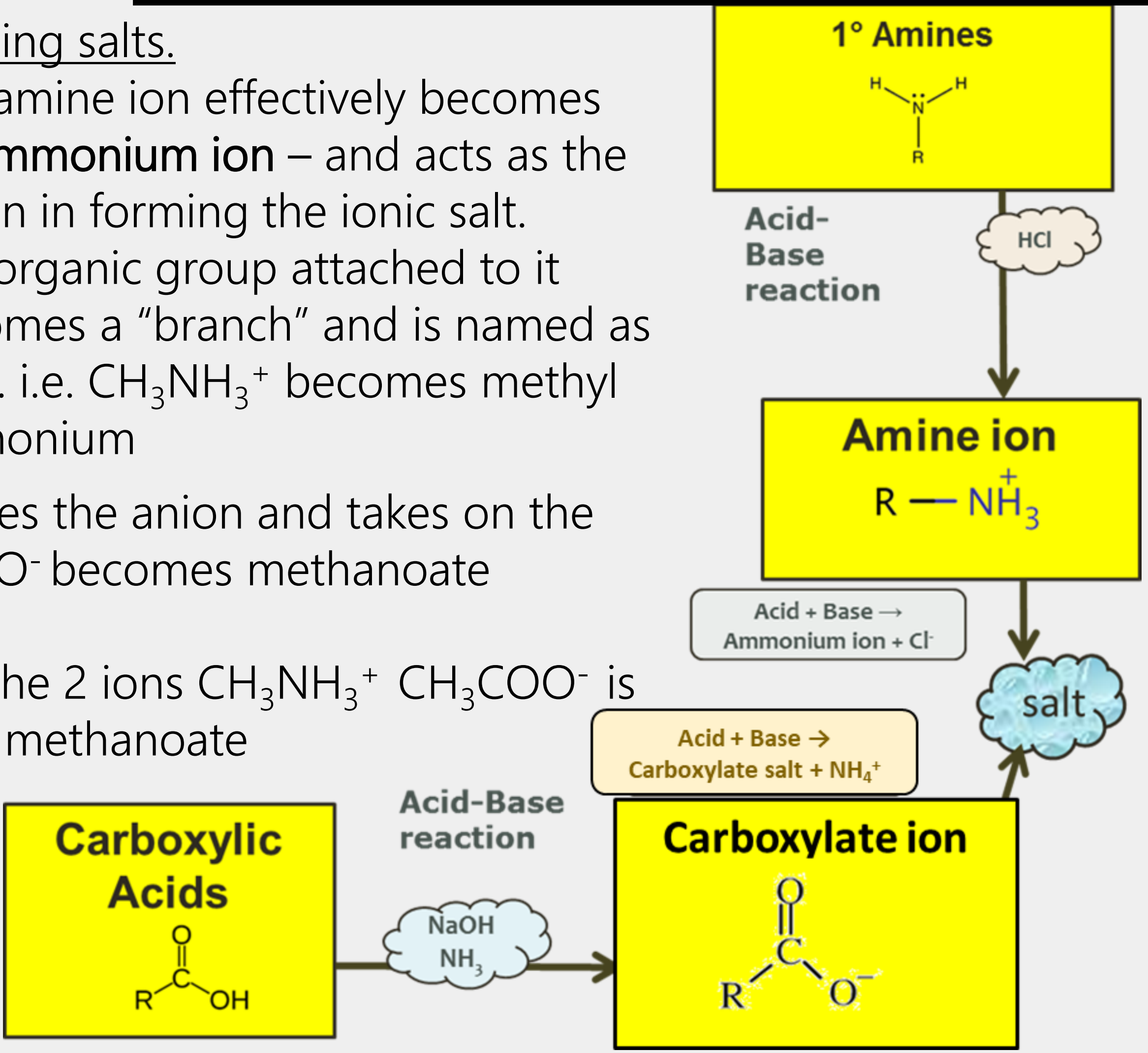
Amine (ammonium) ion + Carboxylic ion reactions

Naming salts.

The amine ion effectively becomes an **ammonium ion** – and acts as the cation in forming the ionic salt. The organic group attached to it becomes a "branch" and is named as such. i.e. $CH_3NH_3^+$ becomes methyl ammonium

The **carboxylic ion** becomes the anion and takes on the suffix –anoate. i.e. CH_3COO^- becomes methanoate

Therefore a salt made of the 2 ions $CH_3NH_3^+$ CH_3COO^- is called methyl ammonium methanoate



1° Amines

Acid-Base reaction

HCl

Amine ion

$R - \overset{+}{N}H_3$

Acid + Base → Ammonium ion + Cl^-

salt

Acid + Base → Carboxylate salt + NH_4^+

Acid-Base reaction

Carboxylic Acids

NaOH

NH_3

Carboxylate ion

Organic Reactions

NCEA 2014 Reactions (acid-base)

Excellence Question

Question: 2c:

Sodium carbonate, hydrochloric acid, and sulfuric acid are each added to separate samples of three organic compounds.

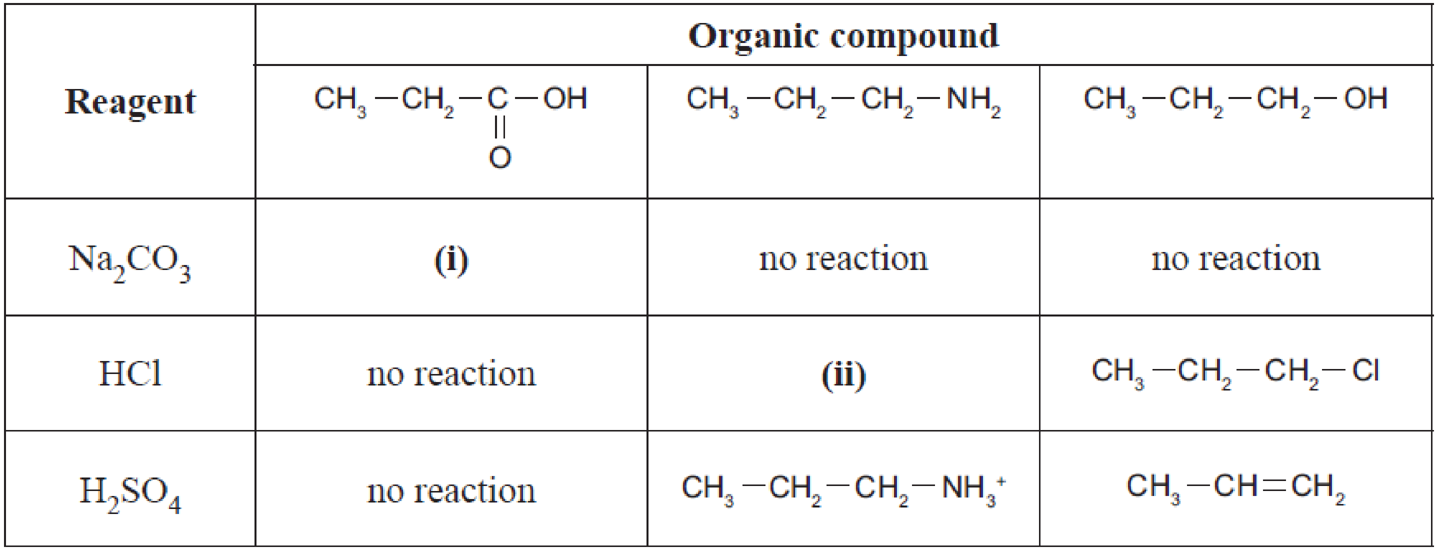
Compare and contrast the reactions that **do** occur between these organic compounds, and the reagents in the table above.

In your answer you should:

☐ give the structure of the organic products **(i)** and **(ii)**

☐ describe the different types of reactions occurring, and give reasons why they are classified as that type

☐ identify any specific conditions that are required for the reactions to occur.



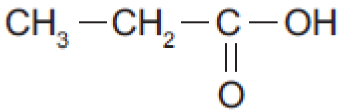
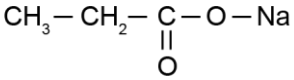
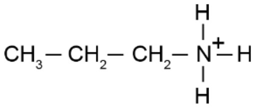
Reagent	**Organic compound**		
	$CH_3-CH_2-\underset{\underset{O}{\|}}{C}-OH$	$CH_3-CH_2-CH_2-NH_2$	$CH_3-CH_2-CH_2-OH$
Na_2CO_3	**(i)**	no reaction	no reaction
HCl	no reaction	**(ii)**	$CH_3-CH_2-CH_2-Cl$
H_2SO_4	no reaction	$CH_3-CH_2-CH_2-NH_3^+$	$CH_3-CH=CH_2$

Organic Reactions

NCEA 2014 Reactions (acid-base)

Excellence Question

Answer: 2c:

Reagent	Organic compound		
	 $CH_3-CH_2-\underset{\underset{O}{\Vert}}{C}-OH$	$CH_3-CH_2-CH_2-NH_2$	$CH_3-CH_2-CH_2-OH$
Na_2CO_3	 $CH_3-CH_2-\underset{\underset{O}{\Vert}}{C}-O-Na$	no reaction	no reaction
HCl	no reaction	 $CH_3-CH_2-CH_2-\overset{H}{\underset{H}{N^+}}-H$	$CH_3-CH_2-CH_2-Cl$
H_2SO_4	no reaction	$CH_3-CH_2-CH_2-NH_3^+$	$CH_3-CH=CH_2$

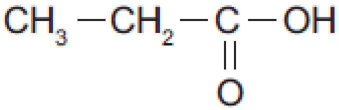
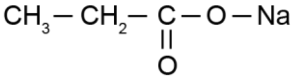
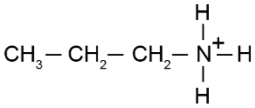
When propan-1-ol reacts with HCl, a substitution reaction occurs; in this reaction the Cl from HCl replaces the –OH group from propan-1-ol, forming a haloalkane.

The reaction between conc. H_2SO_4 / heat, and propan-1-ol is an elimination reaction because an –OH group attached to C1, and a hydrogen atom from C2 are both removed from the organic molecule. A double bond forms between C1 & C2, with the elimination of water, forming propene.

NCEA 2014 Reactions (acid-base)

Excellence Question

Answer: 2c:

Reagent	**Organic compound**		
	 $CH_3-CH_2-\underset{\underset{O}{\|}}{C}-OH$	$CH_3-CH_2-CH_2-NH_2$	$CH_3-CH_2-CH_2-OH$
Na_2CO_3	 $CH_3-CH_2-\underset{\underset{O}{\|}}{C}-O-Na$	no reaction	no reaction
HCl	no reaction	 $CH_3-CH_2-CH_2-\overset{\overset{H}{\vert}}{\underset{\underset{H}{\vert}}{N^+}}-H$	$CH_3-CH_2-CH_2-Cl$
H_2SO_4	no reaction	$CH_3-CH_2-CH_2-NH_3^+$	$CH_3-CH=CH_2$

When propanoic acid reacts with sodium carbonate, an acid-base reaction occurs in which sodium propanoate, water and carbon dioxide are formed. It is acid-base because the propanoic acid donates a proton, forming the propanoate ion.

When propanamine reacts with HCl or H_2SO_4, acid-base reactions occur. Amines are bases and as a result amines accept protons from acids. In these two reactions both sulfuric acid and hydrochloric acid donate protons to the amine to form organic salts.

NCEA 2016 Reactions (Acid-Base)

Merit Question

Question 2b: Solutions of amines are described as bases, and solutions of carboxylic acids are described as acids.
(i) Complete the balanced equation for the reaction between solutions of ethanamine, $CH_3CH_2NH_{2(aq)}$ and hydrochloric acid, $HCl_{(aq)}$.

$CH_3CH_2NH_2(aq) + HCl(aq) \rightarrow$

$CH_3CH_2NH_3^+(aq) + Cl^-(aq)$ OR
$CH_3CH_2NH_3Cl(aq)$

(ii) Explain the statement 'carboxylic acids have acidic properties'.
Refer to the reaction between ethanoic acid, $CH_3COOH_{(aq)}$, and water, $H_2O_{(l)}$ in your answer.

Carboxylic acids have acidic properties because when they react, some of the acid molecules donate H^+ to water molecules.

$$CH_3COOH(aq) + H_2O(l) \rightarrow CH_3COO^-(aq) + H_3O^+(aq)$$

NCEA 2017 Reactions (test + acid-base)

Achieved Question

Question 3b: Describe a simple test that will distinguish between solutions of the final organic compounds **B** and **E**.

Red litmus paper will turn blue in a solution of compound **E**, but will not change in **B**.
Blue litmus paper will turn red in a solution of compound **B**, but will not change in **E**.

Question 3c: Compounds **B** and **E** react together.
(i) Write a balanced equation for the reaction that occurs between compounds **B** and **E**.
(ii) Identify the type of reaction that occurs between compounds **B** and **E**. Justify your answer.

Excellence Question

$CH_3COOH_{(aq)} + CH_3CH_2NH_{2(aq)} \rightarrow CH_3COO^-_{(aq)} + CH_3CH_2NH_3^+{}_{(aq)}$
(or amide condensation reaction)
The reaction between **B** and **E** is an acid-base (neutralisation) reaction. Acid-base reactions involve a proton / H^+ transfer.
Protons / H^+, are released from the carboxylic acid functional group, –COOH, resulting in a salt forming containing the –COO– group.
The proton / H^+ is accepted by the amine functional group, $–NH_2$, this forms a salt containing the $–NH_3^+$ group.

NCEA 2018 Reactions (acid-base)

Merit Question

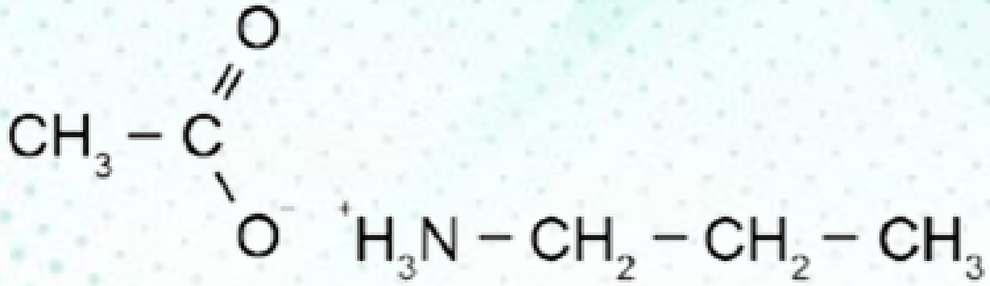
Question: 2a (ii): Give the structural formula and name for the product of the reaction between propan-1-amine, $CH_3CH_2CH_2NH_2$, and ethanoic acid, CH_3COOH to form a salt.

$CH_3CH_2CH_2NH_{2(aq)} + CH_3COOH_{(aq)}$

Name:

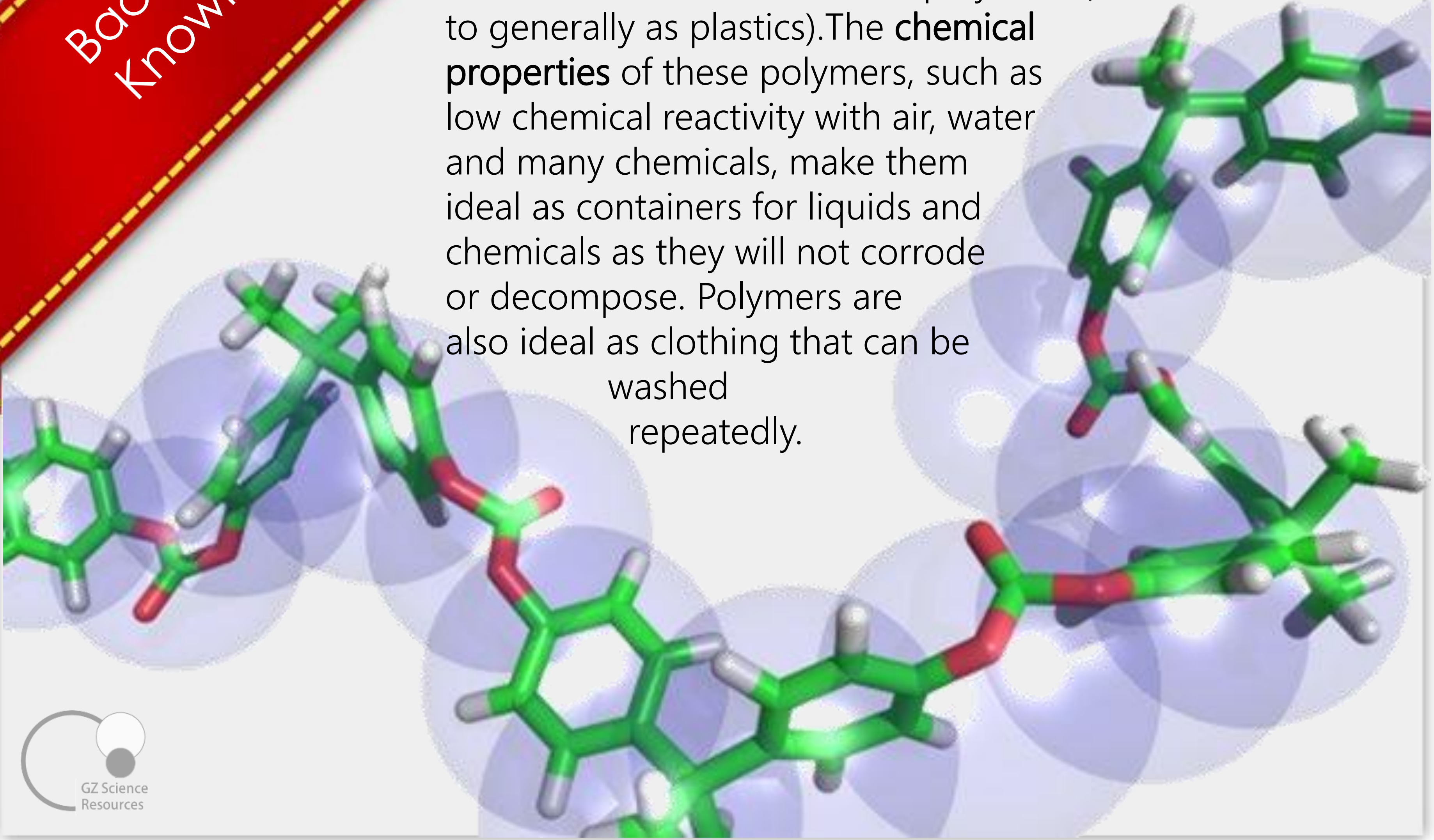
Propyl ammonium ethanoate / propan-1-amine ethanoate

$CH_3CH_2CH_2NH_3$+ CH_3COO–



Background Knowledge

Polymers



Alkenes can be used to make polymers (which we also refer to generally as plastics).The **chemical properties** of these polymers, such as low chemical reactivity with air, water and many chemicals, make them ideal as containers for liquids and chemicals as they will not corrode or decompose. Polymers are also ideal as clothing that can be washed repeatedly.

GZ Science Resources

Background Knowledge

Polymers

The **physical properties** of polymers such as their density (low) and strength make them ideal for strong yet light containers and clothing. Their ability to be melted and shaped makes production of moulded shapes efficient and cheap, as well as making polymers easy to recycle and reuse.

GZ Science Resources

As polymers are insoluble in water they will not dissolve when exposed to water. Polymers are thermal and electrical insulators they have many uses in electrical applications, appliances and insulating wires.

Background Knowledge

Uses and importance of Polymers from ethene and propene

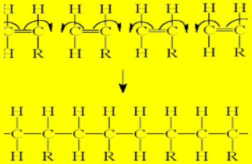
Polythene, made from ethene, is very cheap and strong, and is easily molded. It is used to make, for example, plastic bags, bottles, and buckets.

Polypropene, made from propene, has strong fibers and a high elasticity. It is used, for example, in the manufacture of crates, ropes, and carpets

GZ Science Resources

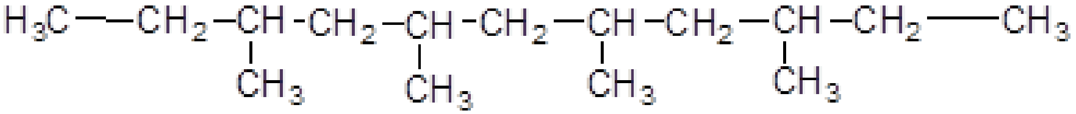
Addition polymers

Polymers

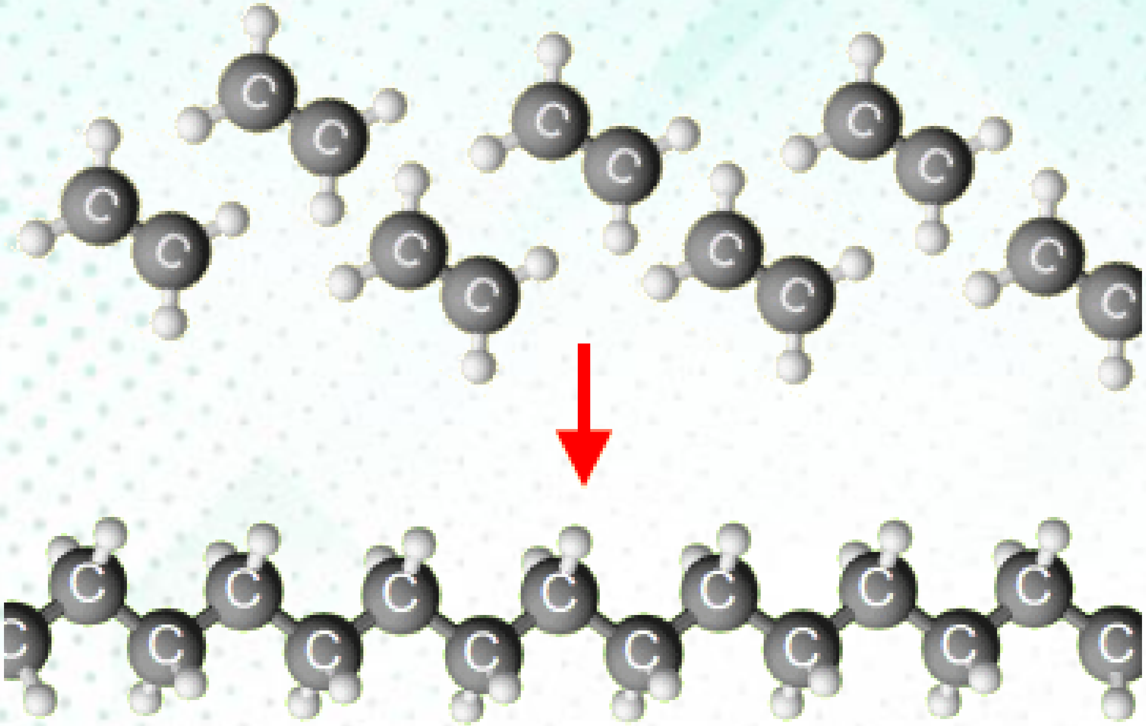


Addition polymers are formed when alkene monomers with a double C=C bond undergo addition to form a polymer with single C-C bonds and spaces are freed up to form bonding spaces e.g. polythene from ethene, P.V.C. from vinyl chloride (chloroethene), polypropene from propene.

$n(CH_3CH=CH_2) \rightarrow$



$$H_3C-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_2-CH_3$$



Naming polymers is not tested for. However, to name most polymers place the prefix poly- in front of the monomer name.

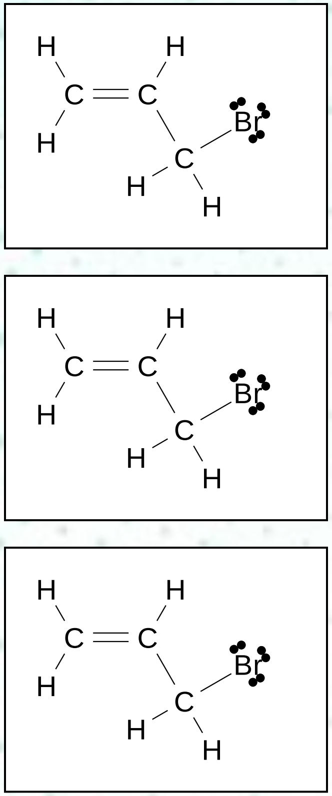
Drawing Addition polymerisation

Monomers - smallest repeating unit with a double bond

Polymers – long chains of monomers joined with single bonds

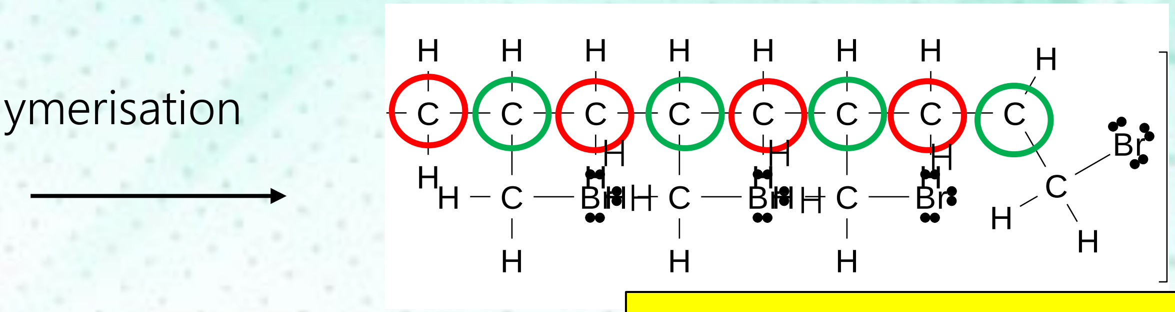
Polymerisation – breaking of the double bond of each monomer and joining together with single bonds

MONOMERS

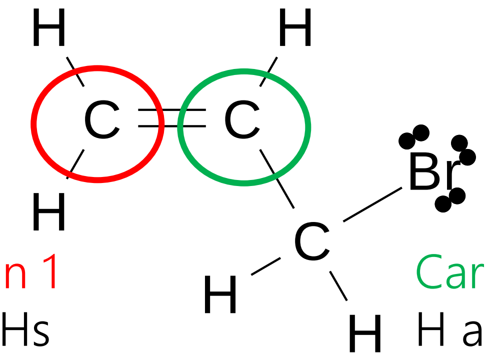


polymerisation

POLYMER



Draw a line of single bonded carbons. Add groups on Carbon 1 (alternate Cs) then add groups on carbon 2



Carbon 1 has 2 Hs

Carbon 2 has 1 H and a CH_2Br

Organic Reactions

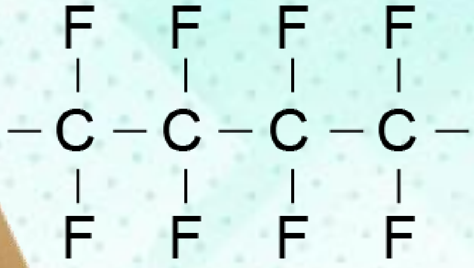
NCEA 2013 Polymers

Achieved Question

Question: 2a: (i) The molecule tetrafluoroethene, shown below, is the monomer for the polymer commonly known as Teflon.

$CF_2{=}CF_2$

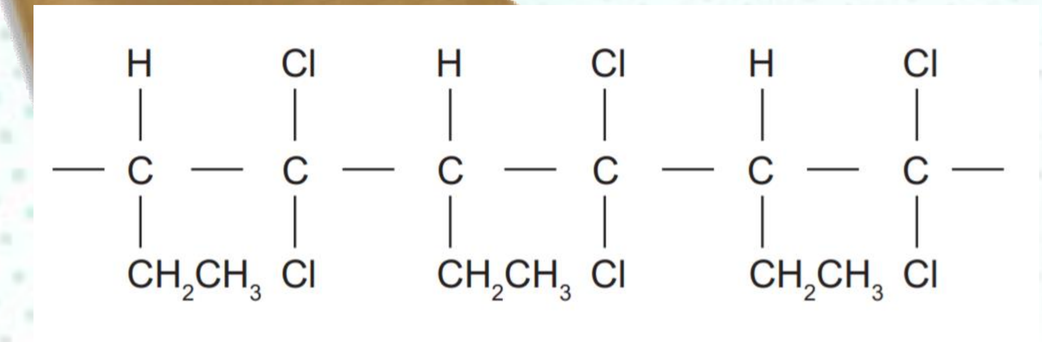
☐ Draw TWO repeating units of the polymer formed.



$$\begin{array}{ccccccccc} & F & & F & & F & & F & \\ & | & & | & & | & & | & \\ - & C & - & C & - & C & - & C & - \\ & | & & | & & | & & | & \\ & F & & F & & F & & F & \end{array}$$

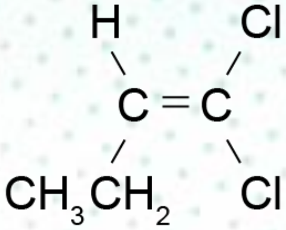
Question: 2a: (ii) The following diagram shows three repeating sections of another polymer.

Draw the structural formula of the monomer molecule used to make this polymer.



$$\begin{array}{ccccccccccccc} & H & & Cl & & H & & Cl & & H & & Cl & \\ & | & & | & & | & & | & & | & & | & \\ - & C & - & C & - & C & - & C & - & C & - & C & - \\ & | & & | & & | & & | & & | & & | & \\ & CH_2CH_3 & & Cl & & CH_2CH_3 & & Cl & & CH_2CH_3 & & Cl & \end{array}$$

$CH_3CH_2CHCCl_2$ or $CH_3CH_2CH{=}CCl_2$ or

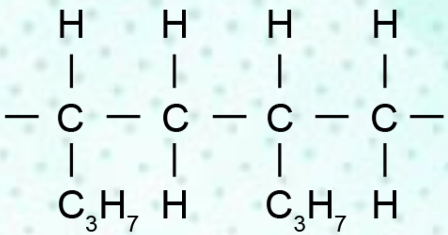


$$\begin{array}{ccc} H & & Cl \\ \backslash & & / \\ C & = & C \\ / & & \backslash \\ CH_3CH_2 & & Cl \end{array}$$

NCEA 2014 Polymers

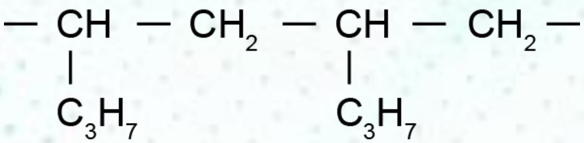
Excellence Question

Question: 3c: (i) Draw TWO repeating units of the polymer formed in **Reaction 5**.

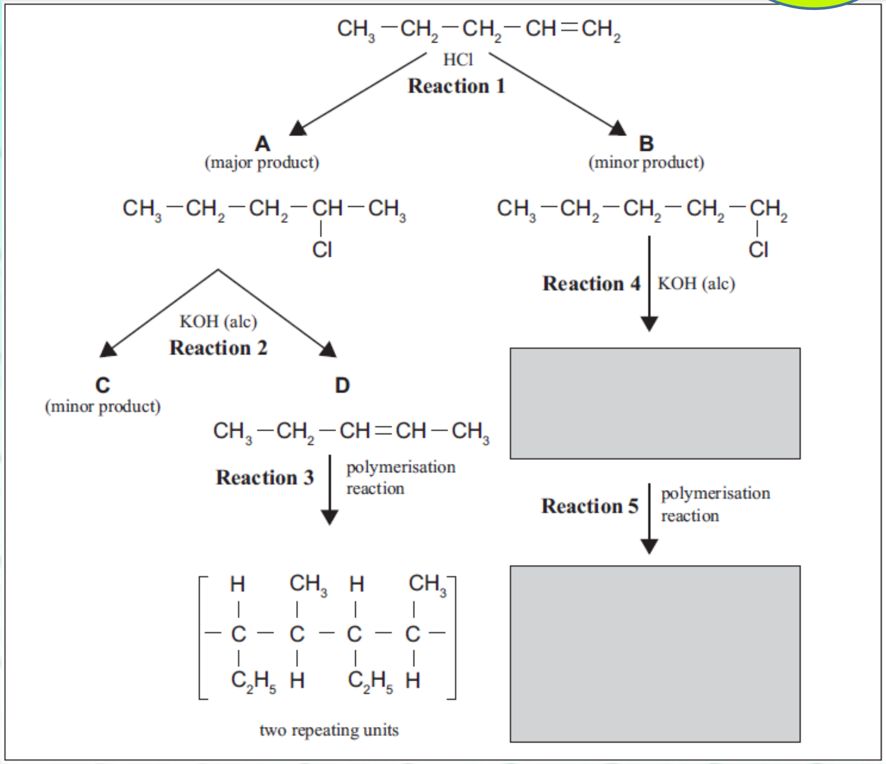


$$\begin{array}{ccccccccc} & H & & H & & H & & H & \\ & | & & | & & | & & | & \\ - & C & - & C & - & C & - & C & - \\ & | & & | & & | & & | & \\ & C_3H_7 & & H & & C_3H_7 & & H & \end{array}$$

or



$$\begin{array}{ccccccccc} - & CH & - & CH_2 & - & CH & - & CH_2 & - \\ & | & & & & | & & & \\ & C_3H_7 & & & & C_3H_7 & & & \end{array}$$



Question: 3c: (ii) Compare and contrast the polymer formed in **Reaction 5** to the polymer formed in **Reaction 3**.
In your answer you should explain why the polymers formed in these two reactions are different.

NCEA 2014 Polymers

Excellence Question

Question: 3c: (ii) Compare and contrast the polymer formed in **Reaction 5** to t
polymer formed in **Reaction 3**.
In your answer you should explain why the polymers formed in these two reactions are different.

The molecular formulae of the two repeating units of both polymers are the same, but the structural formulae are different. (States repeating units are structural isomers.)

Addition polymerisation occurs when the C=C breaks and the carbon atoms in this double bond join to each other from adjacent molecules to form long chains.

In **Reaction 3**, the polymer formed will have a carbon with one hydrogen and a methyl group, and a carbon with one hydrogen and an ethyl group, as its repeating unit, due to the **double bond being on the C2 position**.

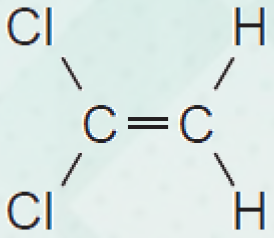
In **Reaction 5**, since the **double bond** is in a different position (**the C1 position**), the polymer formed will have as its repeating unit a carbon atom with 2 hydrogen atoms attached, and a carbon atom with one hydrogen attached and a propyl group attached.

Organic Reactions

NCEA 2015 Polymers

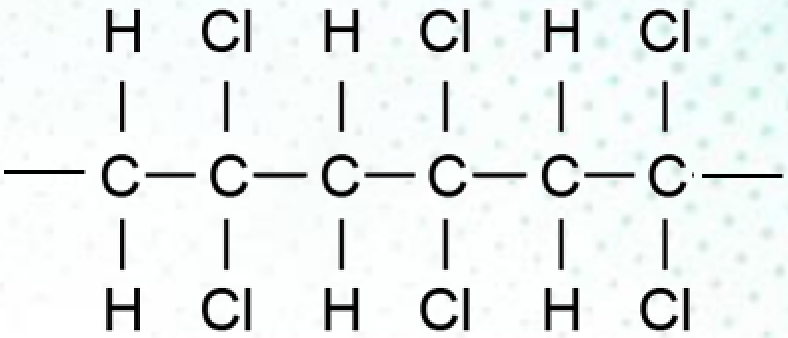
Achieved Question

Question: 2a: (i) Cling Wrap is a polymer that can be made from the monomer 1,1-dichloroethene.



1,1-dichloroethene

☐ Draw THREE repeating units of the polymer formed.

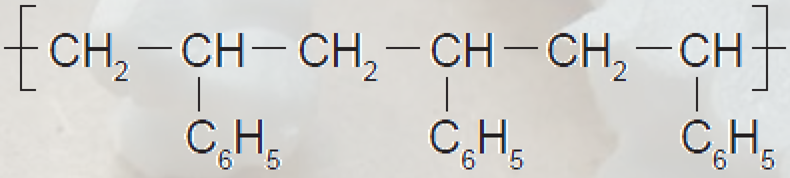


$$-\underset{H}{\overset{H}{C}}-\underset{Cl}{\overset{Cl}{C}}-\underset{H}{\overset{H}{C}}-\underset{Cl}{\overset{Cl}{C}}-\underset{H}{\overset{H}{C}}-\underset{Cl}{\overset{Cl}{C}}-$$

NCEA 2016 Polymers

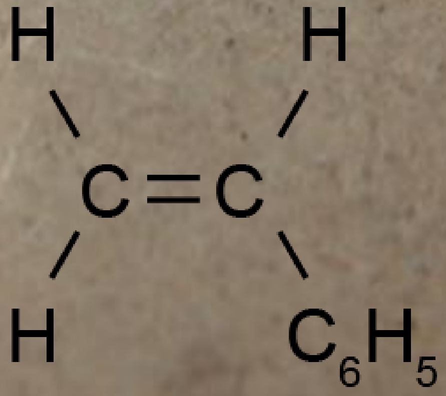
Achieved Question

Question 3b: Polystyrene is a polymer with the structure:



$$\left[CH_2 - \underset{C_6H_5}{\underset{|}{CH}} - CH_2 - \underset{C_6H_5}{\underset{|}{CH}} - CH_2 - \underset{C_6H_5}{\underset{|}{CH}} \right]$$

(i) Draw the monomer used to make the polymer polystyrene.



NCEA 2016 Polymers

Merit Question

Question 3b: (ii) Explain why the formation of polystyrene from its monomer is classified as an addition polymerisation reaction.

Since the monomer for this reaction, styrene, is an alkene, when polymerisation occurs, the double bond in each styrene molecule is broken, freeing up a bonding space on each of the C atoms that was part of the double bond. This allows the monomers to join together by forming covalent bonds to make polystyrene.

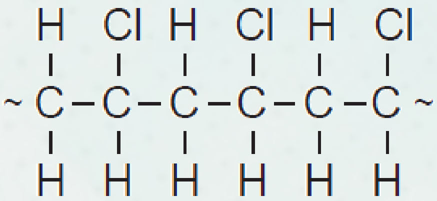
Since double bonds in styrene are being broken and molecules added into the freed up bonding spaces to make polystyrene, this is an addition reaction.

Polymerisation reactions occur when many monomers are chemically joined.

NCEA 2017 Polymers

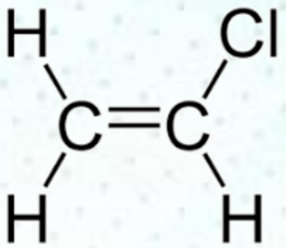
Merit
Question

Question 1a: Polyvinyl chloride (polychloroethene) is often used to make artificial leather. This can then be used to cover chairs, cover car seats, and make clothing. A section of a polyvinyl chloride molecule is shown below.



$$\sim \underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{Cl}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{Cl}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{Cl}{|}}{C}}\sim$$

(i) Draw the monomer from which the polymer polyvinyl chloride would be made.



(ii) Explain the difference in the structures and chemical reactivity of the monomer and polymer, and why the difference is important for the uses of the polymer.

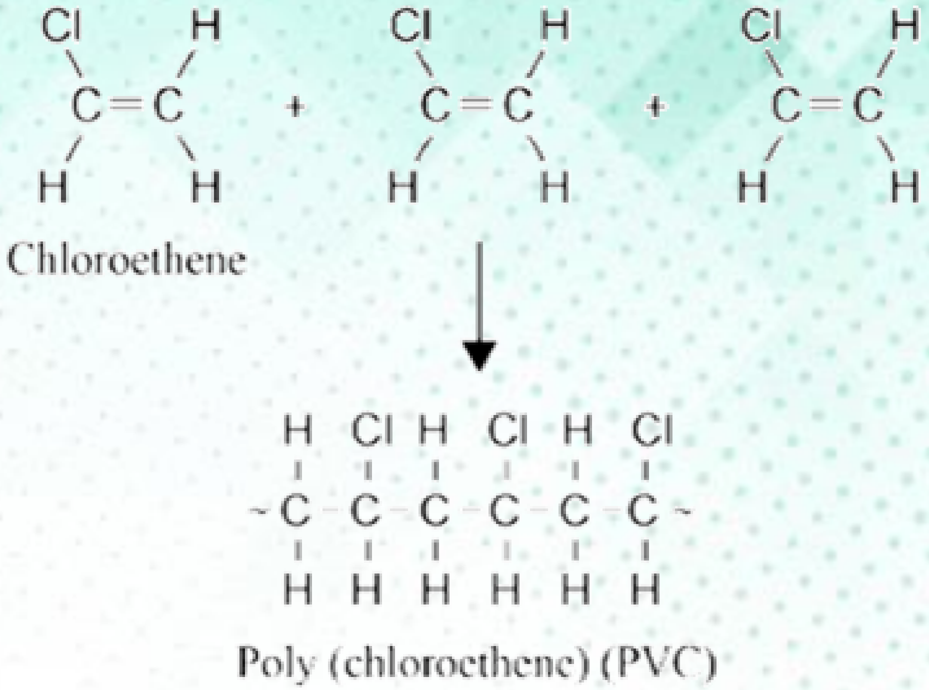
Each monomer contains a reactive double bond, the polymer has none in its structure.
Therefore, the polymer is less chemically active than the monomer (or discusses physical property such as melting point).
This means polymers are less reactive, so they can be used in many ways such as seat covers or clothing because they do not react with water.

NCEA 2017 Polymers

Merit Question

Question 1a (iii): Making polyvinyl chloride (polychloroethene) from its monomer is called ‘addition polymerisation’.
Explain the term ‘addition polymerisation’ using polyvinyl chloride as an example.
Include an equation in your answer.

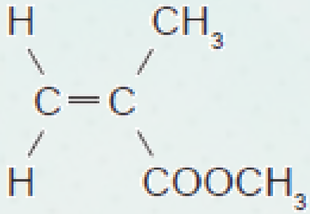
Addition reactions involve two (or more in the case of the polymers) molecules combining to make one molecule.
An addition reaction occurs when double bonds are broken to form a single C–C bond, and two new single covalent bonds.
In addition polymerisation, the monomers, chloroethene / vinyl chloride join in a long chain polymer, polyvinyl chloride, as the double bonds break and the C-atoms from each monomer are able to bond to C-atoms in other monomers.



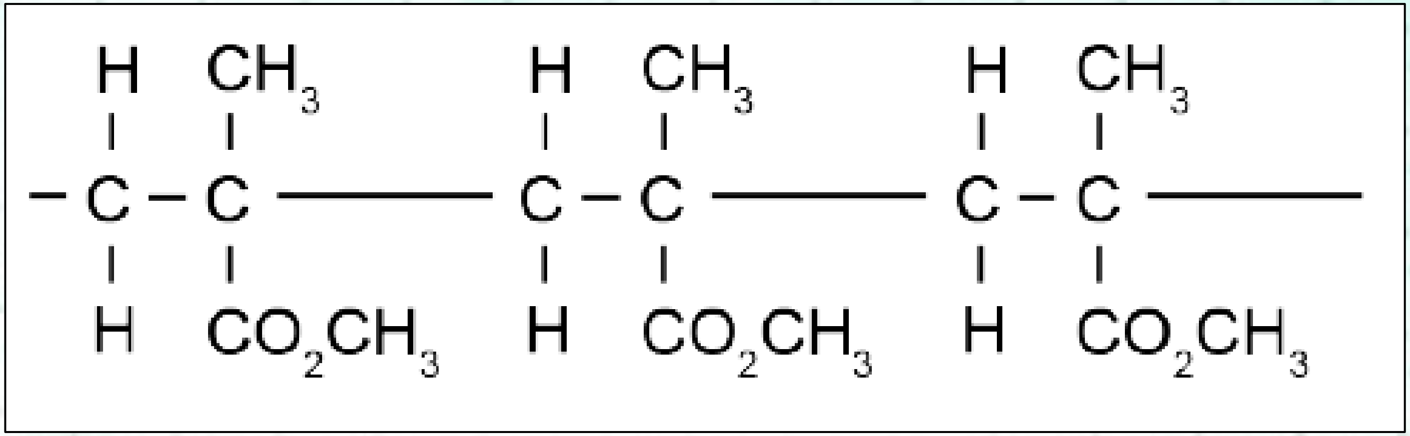
NCEA 2018 Polymers

Achieved Question

Question: 1c: Perspex® is a polymer used as an alternative to glass as it is transparent, lightweight, and shatter resistant. It can be made from the monomer shown below.



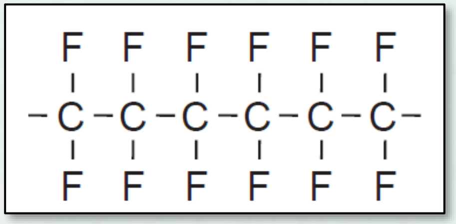
(i) In the box below, draw THREE repeating units of the polymer formed.



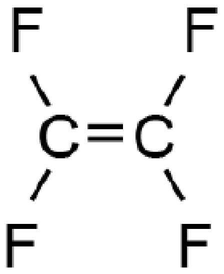
NCEA 2020 Polymers

Merit Question

Question: 2a: A section of the Teflon polymer chain is shown below. Teflon is best known for its use in coating non-stick frying pans and other cookware.



(i) In the box below, draw and name the structure of the monomer used to make this polymer.



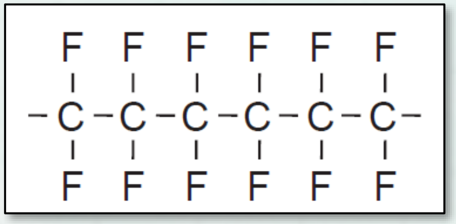
(1,1,2,2)-tetrafluoroethene

Organic Reactions

NCEA 2020 Polymers

Excellence Question

Question: 2a: A section of the Teflon polymer chain is shown below. Teflon is best known for its use in coating non-stick frying pans and other cookware.



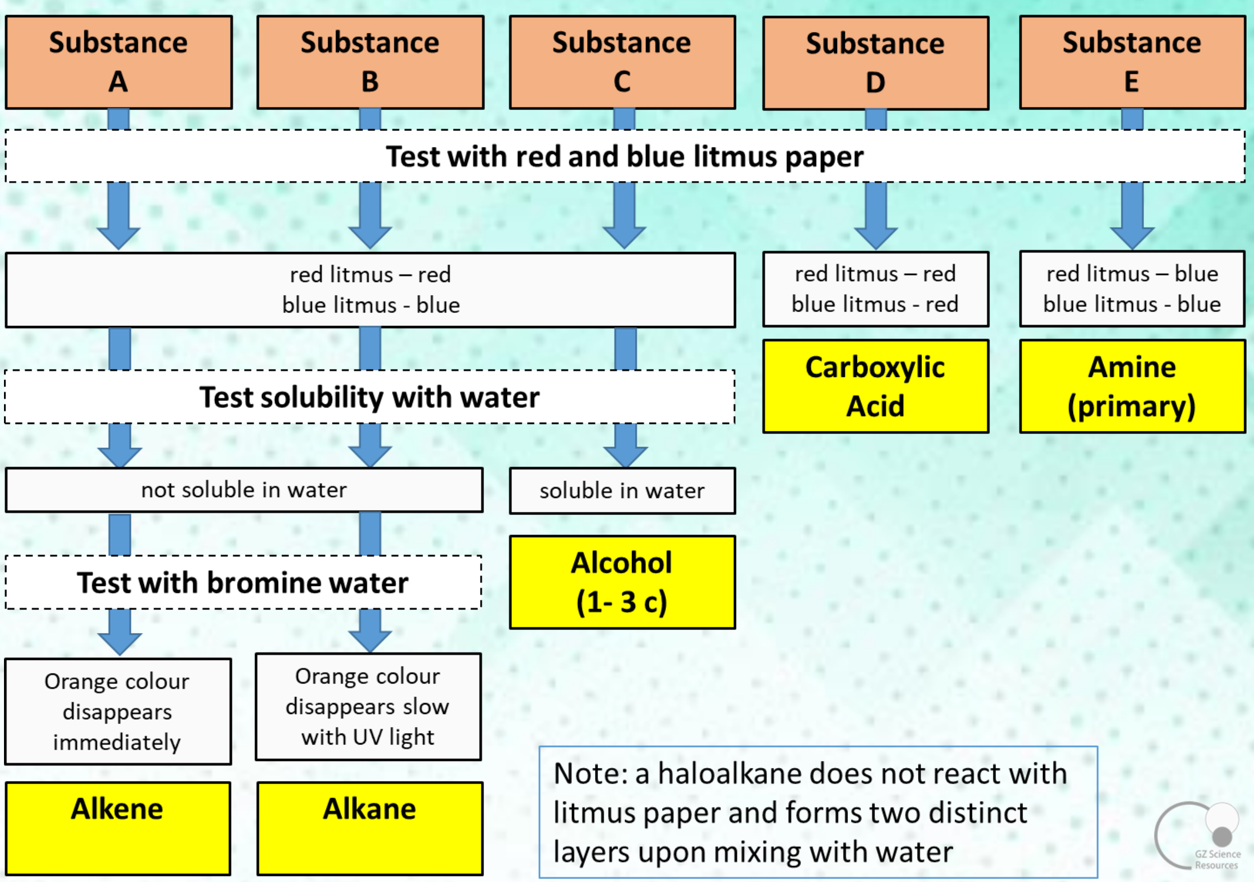
$$\begin{array}{ccccccccccccc} & F & & F & & F & & F & & F & & F & \\ & | & & | & & | & & | & & | & & | & \\ - & C & - & C & - & C & - & C & - & C & - & C & - \\ & | & & | & & | & & | & & | & & | & \\ & F & & F & & F & & F & & F & & F & \end{array}$$

(ii) The chemical reactivity of the monomer and polymer are different.
Analyse this difference.
In your answer you should:

- link the structure of the monomer and polymer to its reactivity
- explain the importance of this difference for Teflon’s use as a polymer.

Each monomer contains a reactive double bond between the two carbons. The polymer has only single carbon-carbon bonds, which are not as reactive. Therefore, the polymer is less reactive, which is important when cooking using Teflon cookware, as it won’t react with any food or liquid or ability to withstand heat whilst cooking.

Identifying unknown Substances



Substance A

Substance B

Substance C

Substance D

Substance E

Test with red and blue litmus paper

A, B, C: red litmus – red, blue litmus - blue

D: red litmus – red, blue litmus - red → **Carboxylic Acid**

E: red litmus – blue, blue litmus - blue → **Amine (primary)**

Test solubility with water

A, B: not soluble in water

C: soluble in water → **Alcohol (1- 3 c)**

Test with bromine water

A: Orange colour disappears immediately → **Alkene**

B: Orange colour disappears slow with UV light → **Alkane**

Note: a haloalkane does not react with litmus paper and forms two distinct layers upon mixing with water

When identifying unknown substances, using the substances physical properties such as solubility, as well as chemical properties, such as whether they turn Litmus Red blue and Litmus Blue red or produce bubbles (CO_2) when reacting with a base can help identify the functional group a substance belongs to. We can also use standard tests such as the observation of Bromine water or potassium permanganate to distinguish between alkanes and alkenes.

NCEA 2013 Identifying unknowns

Excellence Question

Question 2b: Five separate colourless organic liquids are known to be:
pentan-1-ol ethanol pent-1-ene pentane ethanamine.
Write a valid method to show how each of these liquids can be identified using **only** water, litmus paper, and bromine water, $Br_{2(aq)}$.
Your method should allow another student to identify these liquids, and include: the reagent used and any observations made.

Water

Add water to the five liquids. Two solutions will dissolve in water (ethanol, ethanamine), three will not (pentan-1-ol, pent-1-ene and pentane).

Litmus

Use the solutions formed by dissolving in water. Add red litmus paper to both solutions.

One will not change the colour of the litmus paper; this is ethanol.

One will turn red litmus blue; this is ethanamine.

Bromine water

Test the liquids that did not dissolve in water by reacting fresh samples with bromine water. Pent-1-ene will (rapidly) turn the orange solution to colourless. (UV) light is required for the reaction with pentane / Br_2 does not react with pentane / no colour change / slow colour change. The remaining liquid is pentan-1-ol.

NCEA 2015 Identifying unknowns

Excellence Question

Question 1c:

Four separate colourless organic liquids are known to be:

- ethanol
- ethanoic acid
- hex-2-ene
- hexan-1-amine (1-aminohexane).

Write a procedure to identify each of these organic liquids using **only** the reagents listed below.

- acidified dichromate solution, $Cr_2O_7^{2-}$ / $H^+_{(aq)}$
- bromine water, $Br_{2(aq)}$
- sodium carbonate solution, $Na_2CO_{3(aq)}$.

In your answer, you should:

- identify the test reagents used
- describe any observations that would be made
- identify the type of reaction that occurs
- identify the organic product of any reaction.

You do not need to include equations in your answer.

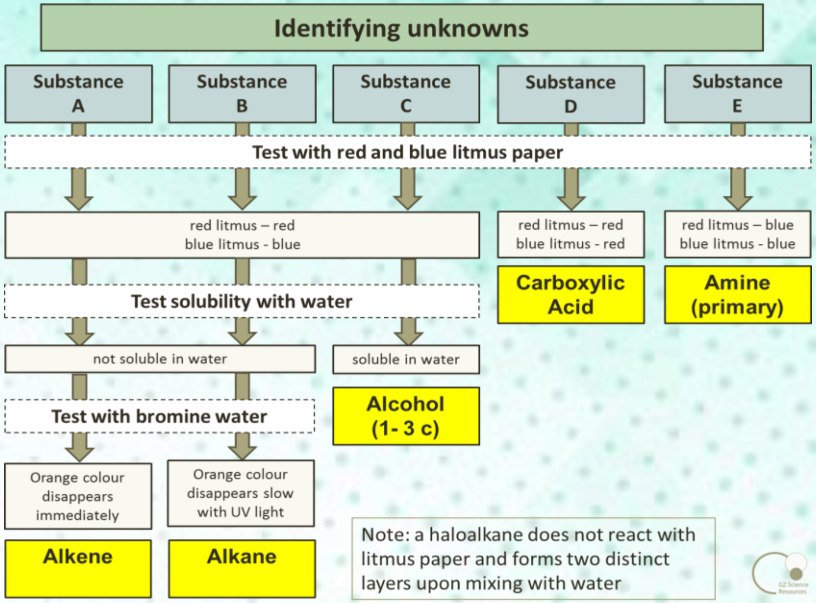
NCEA 2015 Identifying unknowns

Excellence Question

Answer: 1c:

Three liquids will be identified and the fourth will be the 'last one'. The tests used to identify the liquids include:

- ☐ $Cr_2O_7^{2-}$ / H^+ which will turn from orange to green when the **ethanol** is oxidised to ethanoic acid.
- ☐ **Ethanoic acid** can be identified by an acid-base reaction with sodium carbonate. Bubbles of gas will be produced. Sodium ethanoate / ethanoate ion is formed.
- ☐ **Hex-2-ene** can be identified by an addition reaction with bromine water, which turns from red / brown to colourless straightaway when added to the alkene. It will form 2,3-dibromohexane
- ☐ **Hexan-1-amine** will be the chemical left over that will not react with any of the given reagents.



Identifying unknowns

Substance A

Substance B

Substance C

Substance D

Substance E

Test with red and blue litmus paper

red litmus – red
blue litmus - blue

red litmus – red
blue litmus - red

red litmus – blue
blue litmus - blue

Carboxylic Acid

Amine (primary)

Test solubility with water

not soluble in water

soluble in water

Alcohol (1- 3 c)

Test with bromine water

Orange colour disappears immediately

Orange colour disappears slow with UV light

Alkene

Alkane

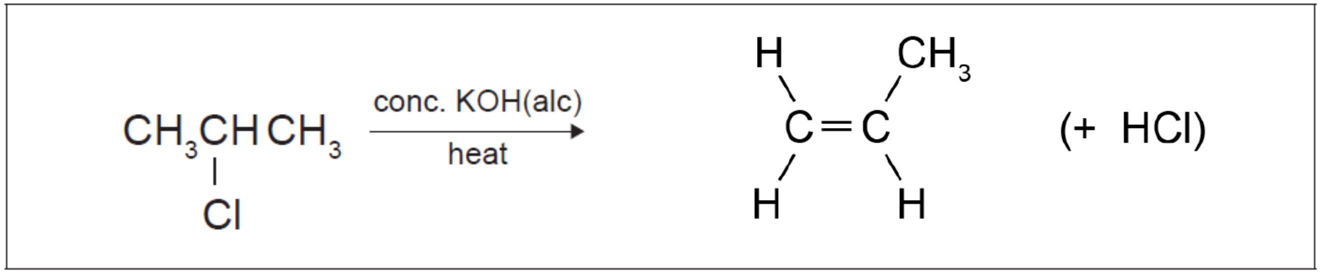
Note: a haloalkane does not react with litmus paper and forms two distinct layers upon mixing with water

NCEA 2017 Identifying Unknowns

Merit Question

Question 1b: A chemistry class was learning about the chemistry of haloalkanes. They were researching the effect of heat and concentrated potassium hydroxide in ethanol, conc. KOH(alc), on the haloalkane 2-chloropropane.

(i) Draw the organic product formed in the following reaction.



(ii) Explain how the functional group of the organic product drawn above could be identified.

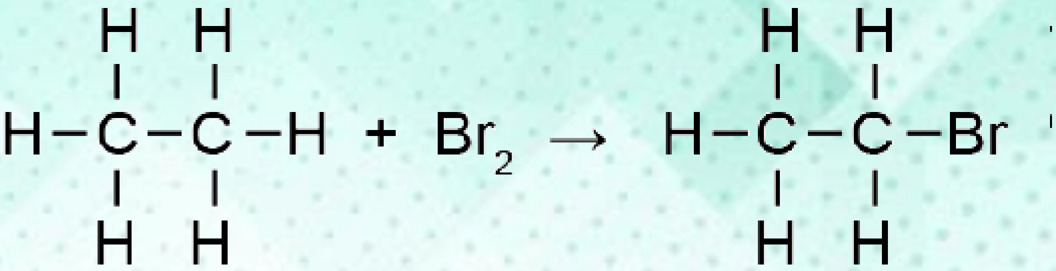
The organic product contains a double bond, it is an alkene and could be identified by reacting with Br_2(*aq*), the orange solution will decolourise when reacted with an alkene; or react with $KMnO_4$, a purple solution that will turn brown when it reacts with an alkene.

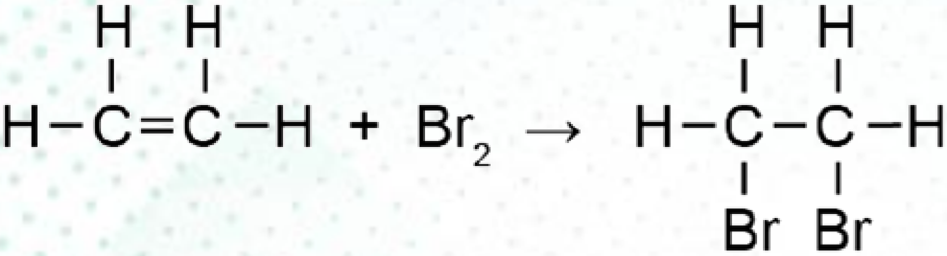
NCEA 2017 Identifying unknowns

Excellence Question

Question 2d: Alkanes and alkenes can be identified by their reactions with a solution of bromine water, $Br_2(aq)$.
Contrast the types of reactions an alkane and an alkene will undergo with an orange solution of bromine water.

Alkanes will slowly react with bromine water in the presence of a UV catalyst. The orange $Br_{2(aq)}$ will decolourise slowly. This is a substitution reaction where one H atom is replaced with a Br atom.





Whereas, alkenes react immediately with orange $Br_{2(aq)}$, decolouring it to yellow / colourless quickly. Unlike alkanes, alkenes do not require a catalyst for the reaction to proceed. This is an addition reaction, where the double bond is broken, and two atoms of Br are added to the organic structure.

NCEA 2018 Identifying Unknowns

Merit Question

Question: 2a: Two bottles of different colourless organic liquids are unlabelled. They are known to be propan-1-amine, $CH_3CH_2CH_2NH_2$, and ethanoic acid, CH_3COOH.
(i) Explain how you could identify these two liquids using only solid sodium hydrogen carbonate, $NaHCO_{3(s)}$.

Ethanoic acid is an acid so will react with the solid sodium hydrogen carbonate to produce carbon dioxide gas as this is an acid-base reaction. Therefore fizzing will be observed. The propan-1-amine is a base and will not react with the $NaHCO_3$.

NCEA 2018 Identifying Unknowns

Excellence Question

Question: 2b: Three more unlabelled bottles of colourless organic liquids are known to contain hexane, hex-1-ene, and ethanol.
Write a procedure to identify each of these liquids using only bromine water, $Br_{2(aq)}$, and water, H_2O.
In your answer you should explain any observations that would be made.
You do not need to include equations in your answer.

- ☐ When bromine water is added to hex-1-ene, it will quickly decolourise from a red-brown colour. This is an addition reaction forming dibromohexane. There will be no colour change with hexane or ethanol.
- ☐ When water is added to hexane and ethanol, two layers will form with hexane. Hexane is a non polar molecule so there will not be any attraction to the water. Ethanol is a polar molecule so it will be miscible with water.

There is no penalty for using only bromine water to distinguish all three liquids.

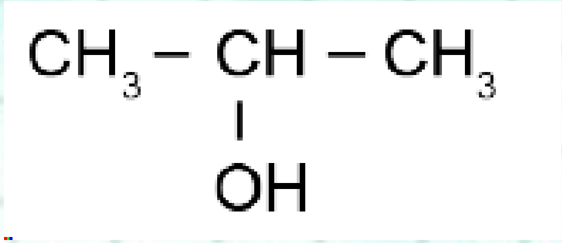
NCEA 2018 Identifying Unknowns

Excellence Question

Question: 3b: (ii) Elaborate on chemical tests that could be used to identify the functional groups of the organic products formed in part (i).
In your answer, you should:

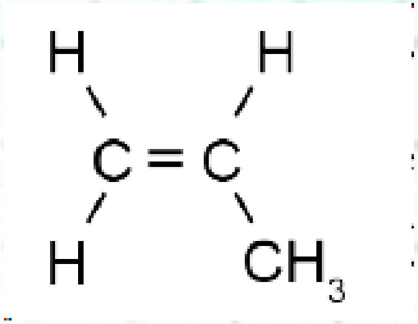
- identify chemicals and conditions required
- describe any observations
- state the type of reaction occurring
- explain why potassium permanganate solution, KMnO4(*aq*), cannot be used to distinguish between these organic products.

☐ The OH group on the alcohol can be identified by a reaction with warm, acidified potassium dichromate, H^+ / $Cr_2O_7^{2-}$. The colour change observed will be orange to green as the alcohol oxidises to a ketone in a redox / oxidation reaction.



$CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

☐ The double bond of propene can be identified using bromine water, which turns colourless from orange-brown rapidly as a dibromoalkane is formed in an addition reaction.



☐ $KMnO_{4(aq)}$ cannot be used because both an alcohol and an alkene will react with it. The alcohol would be oxidised to a ketone and the alkene would form a diol. Colour change purple to colourless/brown or pale pink.

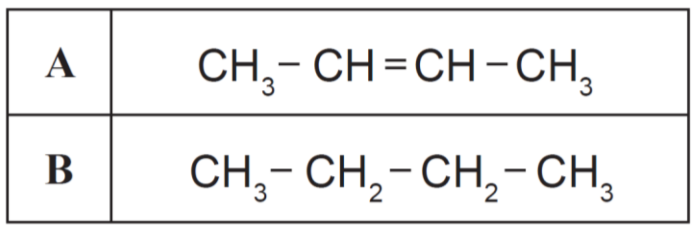
NCEA 2019 Identifying Unknowns

Merit Question

Question: 1c: (iii) Explain how acidified potassium permanganate solution, $KMnO_4$ / $H^+_{(aq)}$, can be used to distinguish between compounds **A** and **B**.

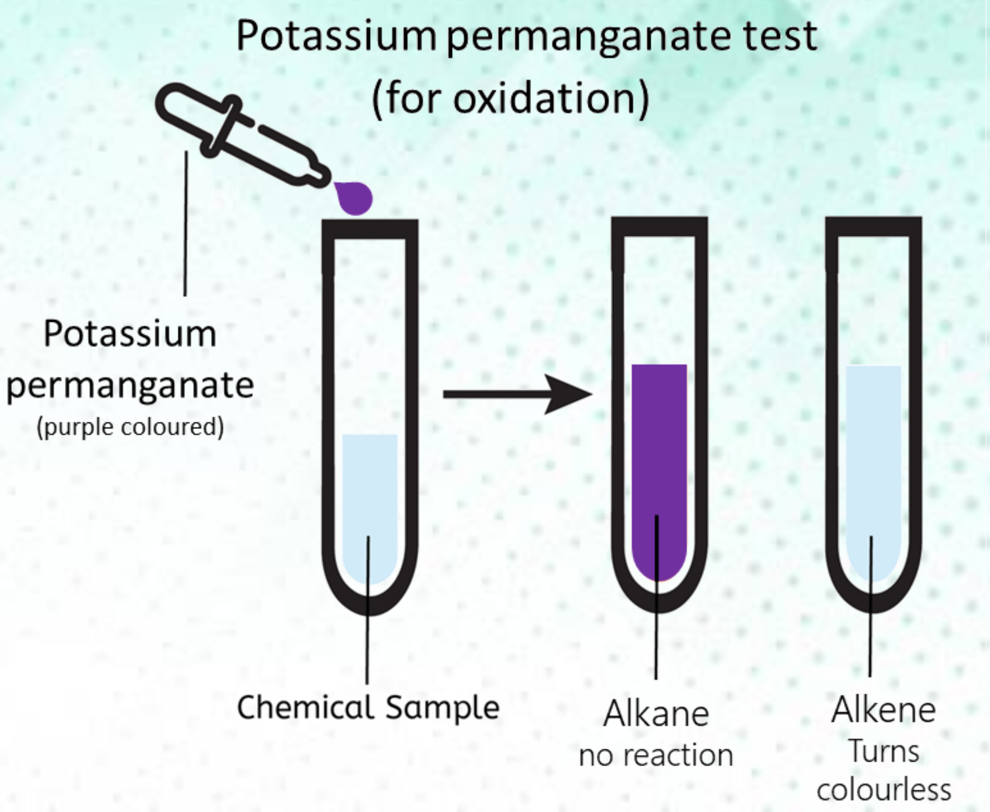
In your answer you should:

- identify the type of reaction
- describe any relevant observations.



A	$CH_3-CH=CH-CH_3$
B	$CH_3-CH_2-CH_2-CH_3$

Potassium permanganate will turn from purple to colourless / pale pink / brown when mixed with compound **A**, whereas there would be no observable change with compound **B**. This is an oxidation reaction.



NCEA 2019 Identifying Unknowns

Excellence Question

Question: 1c: (iv) Compounds **A** and **B** will both react with bromine water, Br2(*aq*). Compare and contrast these reactions by referring to the conditions required, the observations, the products formed, and the type of reaction.

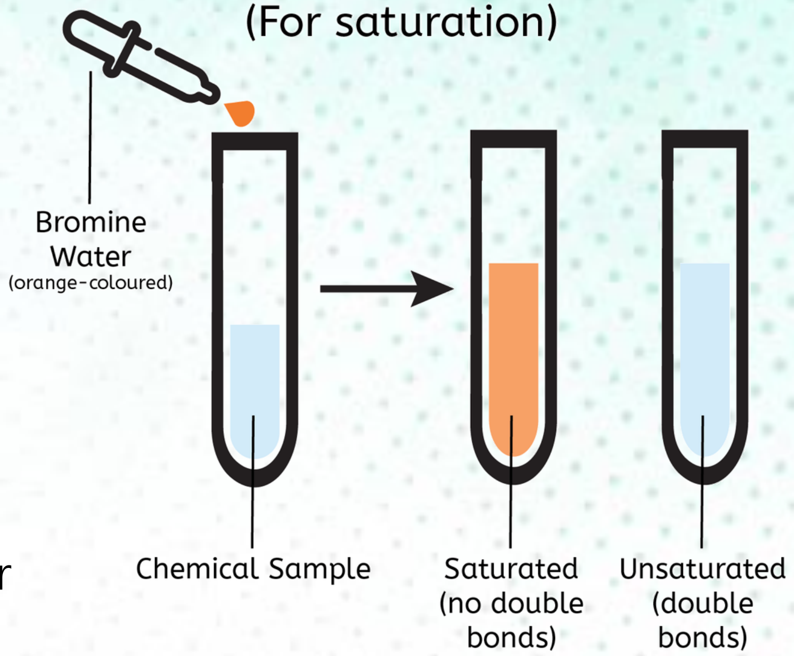
A	$CH_3-CH=CH-CH_3$
B	$CH_3-CH_2-CH_2-CH_3$

Compound **B** reacting with bromine water will be a slow reaction requiring UV light as a catalyst. It will form 1-bromobutane / 2-bromobutane and HBr. The bromine water will decolourise from a red-brown / orange / brown/ yellow colour. This is a substitution reaction where the H on one carbon is substituted by a Br atom. The H atom that is removed bonds with the remaining Br atom to form hydrogen bromide.

Compound **A** reacting with bromine water is a fast reaction, forming 2,3-dibromobutane. The bromine water decolourises from a red-brown colour. This is an addition reaction, where the double bond is broken and two Br atoms are added.

Bromine Water Test

(For saturation)

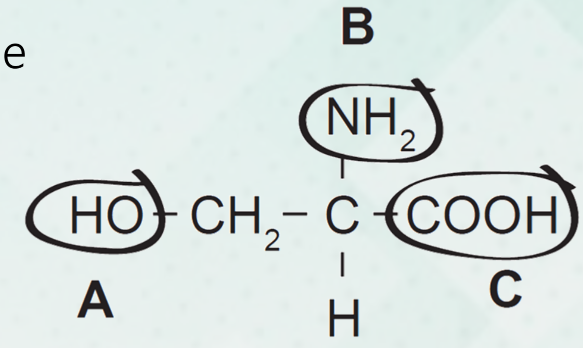


NCEA 2019 Identifying Unknowns

Excellence with (ii)

Question: 3a (i) : Each circled functional group is found in different organic molecules commonly used in school laboratories:
Using the list below, choose a reagent and describe the observations that could identify each of these functional groups.

- red litmus paper • blue litmus paper
- bromine water, $Br_{2(aq)}$
- acidified dichromate solution, $H^+ / Cr_2O_7^{2-}{}_{(aq)}$



	Functional Group	Chemical test	Observations
A	alcohol	Acidified dichromate solution	Orange to green
B	amine	Red litmus paper	Turns blue
C	carboxylic acid	Blue litmus paper	Turns red

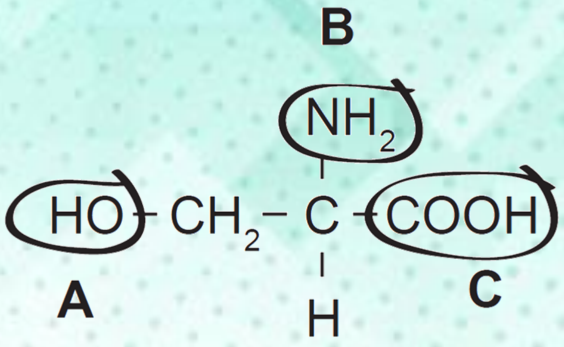
NCEA 2019 Identifying Unknowns

Excellence with (i)

Question: 3a (ii) : Describe an alternative method to distinguish between functional groups **B** and **C**.
Identify the reagent needed, the expected observations, and explain the type of reaction occurring.

Sodium carbonate, Na_2CO_3, solid or solution can be used as it will fizz
with **C**, which is a carboxylic acid in an **acid-base reaction** / neutralisation. The amine functional group of **B** would not react, as it is a base like the sodium carbonate.
Any carbonate or hydrogen carbonate is acceptable.

OR add a strip of Mg metal to both **B** and **C**.
C will fizz, producing gas as it is an **acid-metal reaction** because **C** is a carboxylic acid.
The amine (**B**) functional group would not react with the Mg metal.



NCEA 2020 Identifying Unknowns (Part ONE)

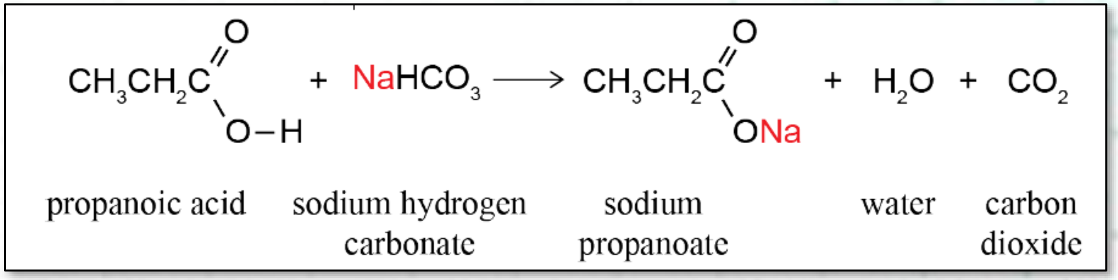
Excellence Question

Question: 3b (i) The labels have fallen off bottles of three colourless liquids. They are known to be ethanol, hexene, and propanoic acid. Explain how you would identify the liquids, using a solution of sodium hydrogen carbonate, $NaHCO_{3(aq)}$, and your knowledge of the physical and chemical properties of the compounds. In your answer you should: state any observations

- link your observations to chemical or physical properties of the organic molecule
- write chemical equations for any reactions that occur, including the structural formula of organic products.

When sodium hydrogen carbonate solution is added to each of the three liquids: Ethanol and hexene can be distinguished, as ethanol will be soluble/mix in the aqueous solution no layers seen and hexene will be insoluble and will form two layers.

Propanoic acid can be identified, as bubbles of CO_2 will be seen (and there will be one layer) due to it being an acid-base reaction / neutralisation /acid carbonate reaction.



$CH_3CH_2COOH + NaHCO_3 \longrightarrow CH_3CH_2COONa + H_2O + CO_2$

NCEA 2020 Identifying Unknowns (Part TWO)

Excellence Question

Question: 3b (ii) Explain how you could use an alternative reagent to do a chemical test that would allow you to distinguish between hexene and propanoic acid. In your answer you should:

- identify a reagent
- state the observations that would allow you to distinguish the compounds
- identify any reaction type occurring.

Bromine water

The bromine water with propanoic acid will remain red-brown / orange / brown / yellow colour OR react slowly in presence of UV light with the red-brown / orange / brown / yellow colour fading to colourless..

Bromine water with hexene will have a colour change from red-brown / orange / brown / yellow colour to colourless. This is an addition reaction.

OR

Acidified Potassium permanganate

The potassium permanganate with propanoic acid will remain purple. There will be no reaction.

Potassium permanganate will have a colour change from purple to colourless in the hexene. This can be considered an addition and / or an oxidation reaction.

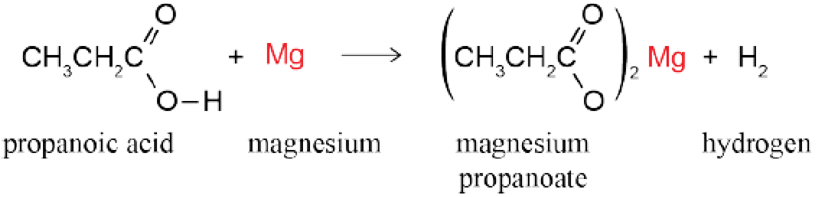
NCEA 2020 Identifying Unknowns

Excellence Question

Question: 3b (ii) Explain how you could use an alternative reagent to do a chemical test that would allow you to distinguish between hexene and propanoic acid. In your answer you should:
- identify a reagent
- state the observations that would allow you to distinguish the compounds
- identify any reaction type occurring.

OR Non Acidified Potassium Permanganate
The potassium permanganate with propanoic acid will remain purple. There will be no reaction.
Potassium permanganate will have a colour change from purple to brown in the hexene. This can be considered an addition and / or an oxidation reaction.

Valid test (not Litmus)
E.g. a reactive metal will identify propanoic acid, as bubbles of gas will be observed. This is a metal acid reactions. E.g. magnesium metal

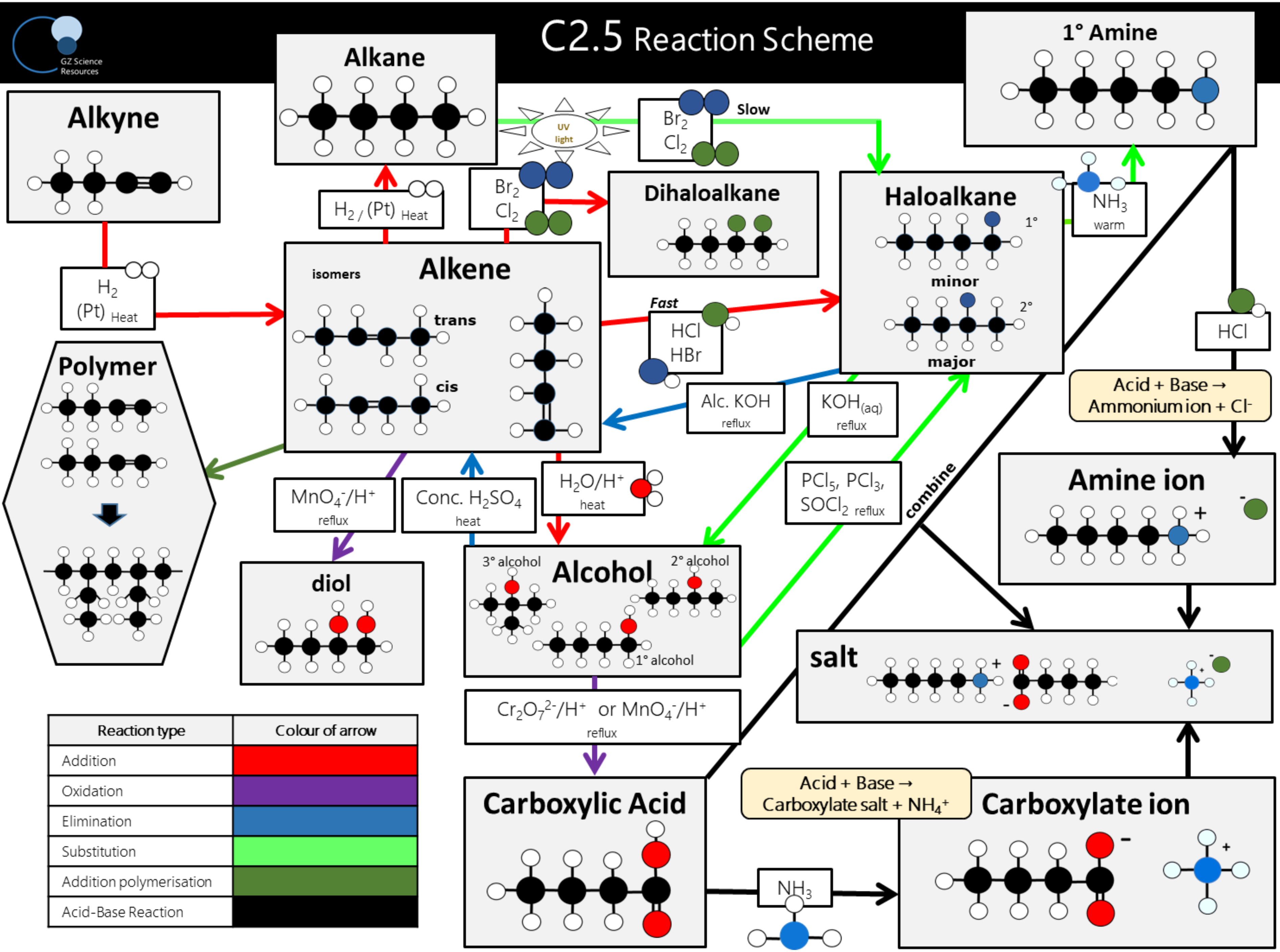


$$CH_3CH_2COOH + Mg \longrightarrow (CH_3CH_2COO)_2Mg + H_2$$

Hexene with magnesium no reaction as no bubbles will be observed.

GZ Science Resources

C2.5 Reaction Scheme



Alkane

UV light

Br_2
Cl_2

Slow

1° Amine

Alkyne

H_2 / (Pt) Heat

Br_2
Cl_2

Dihaloalkane

Haloalkane

1°

minor

2°

major

NH_3
warm

H_2
(Pt) Heat

isomers

Alkene

trans

cis

Fast

HCl
HBr

HCl

Alc. KOH
reflux

$KOH_{(aq)}$
reflux

Acid + Base → Ammonium ion + Cl^-

Polymer

MnO_4^-/H^+
reflux

Conc. H_2SO_4
heat

H_2O/H^+
heat

PCl_5, PCl_3, $SOCl_2$ reflux

combine

Amine ion

diol

3° alcohol

Alcohol

2° alcohol

1° alcohol

salt

$Cr_2O_7^{2-}/H^+$ or MnO_4^-/H^+
reflux

Acid + Base → Carboxylate salt + NH_4^+

Carboxylic Acid

Carboxylate ion

NH_3

Reaction type	Colour of arrow
Addition	🟥
Oxidation	🟪
Elimination	🟦
Substitution	🟩
Addition polymerisation	🟩
Acid-Base Reaction	⬛

Organic Reactions

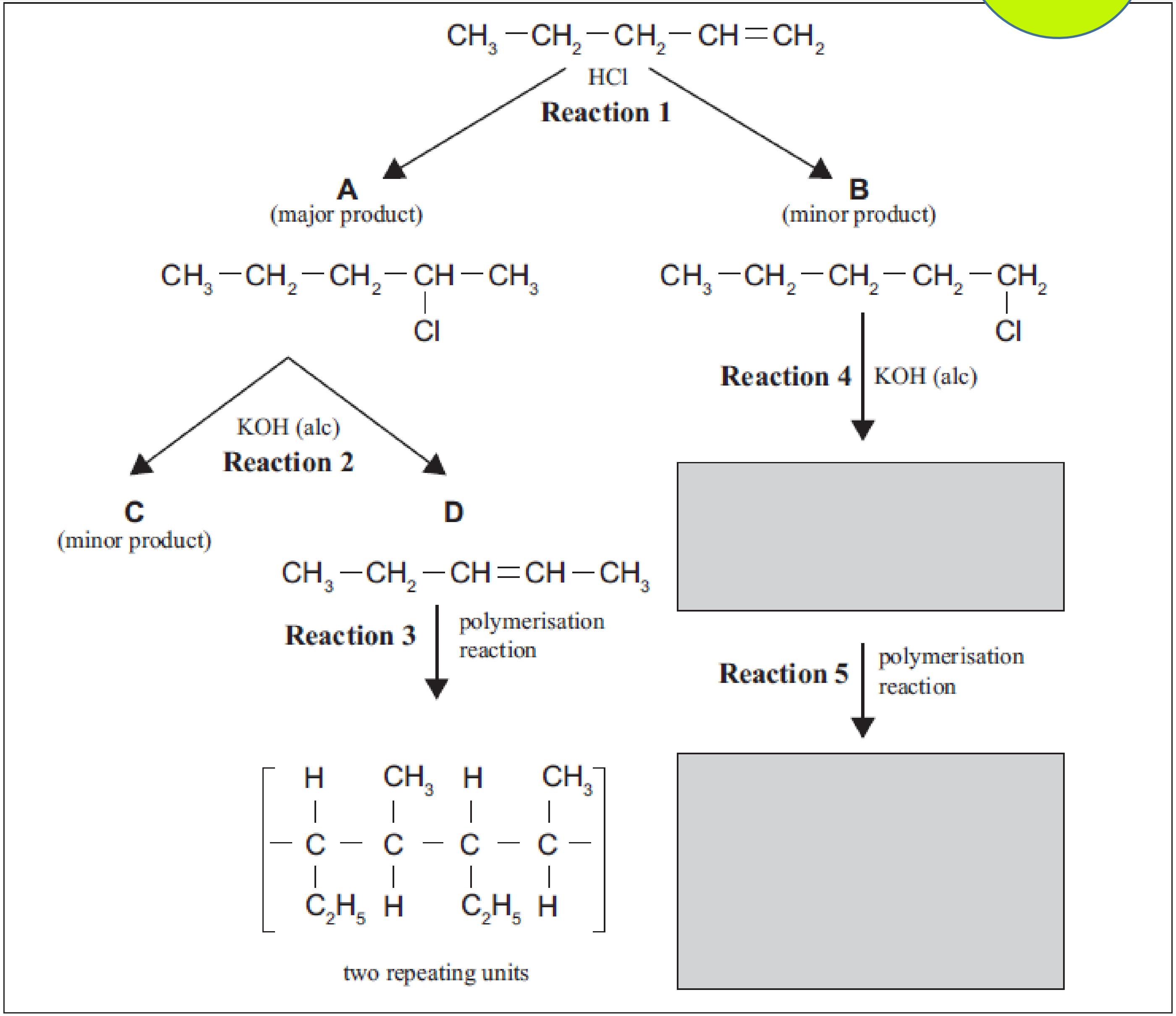
NCEA 2014 Reactions (scheme)

Merit Question

Question: 3a:

(i) Explain why **Reaction 1** from the reaction scheme, shown again below, is classified as an addition reaction.

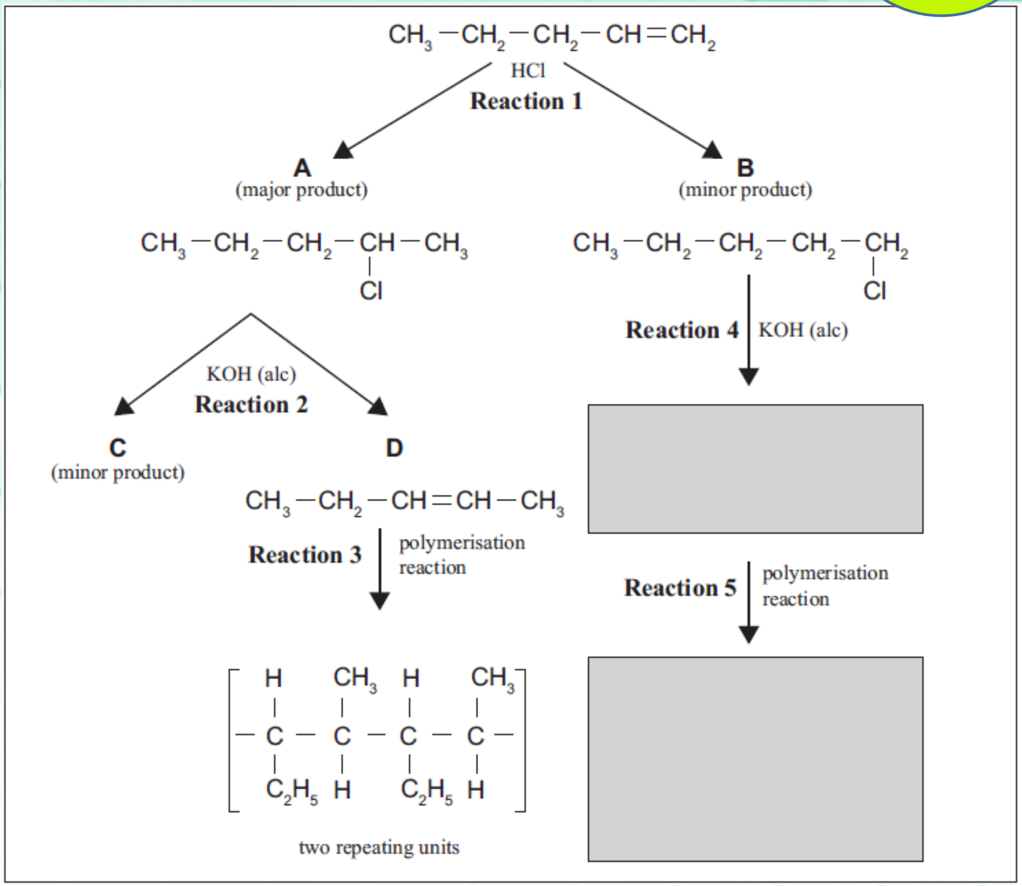
It is an addition reaction because the double bond is breaking and an H and a Cl are being added to each of the carbons that were in the double bond.



NCEA 2014 Reactions (scheme)

Merit Question

Question: 3a: (ii) Explain why compound **A** is the **major** product for **Reaction 1**



It is the major product because the hydrogen atom from HCl more often adds onto the carbon atom in the double bond which already contains the most hydrogen atoms; in this case, C1. Therefore the Cl atom from the HCl joins onto the carbon atom in the double bond which had the least number of hydrogen atoms; in this case, C2.

Markovnikov's rule - sometimes called the "rich get richer" rule
The **major** product is the one in which the H atom of HCl attaches to the C atom with the **most H atoms** already

NCEA 2014 Reactions (scheme)

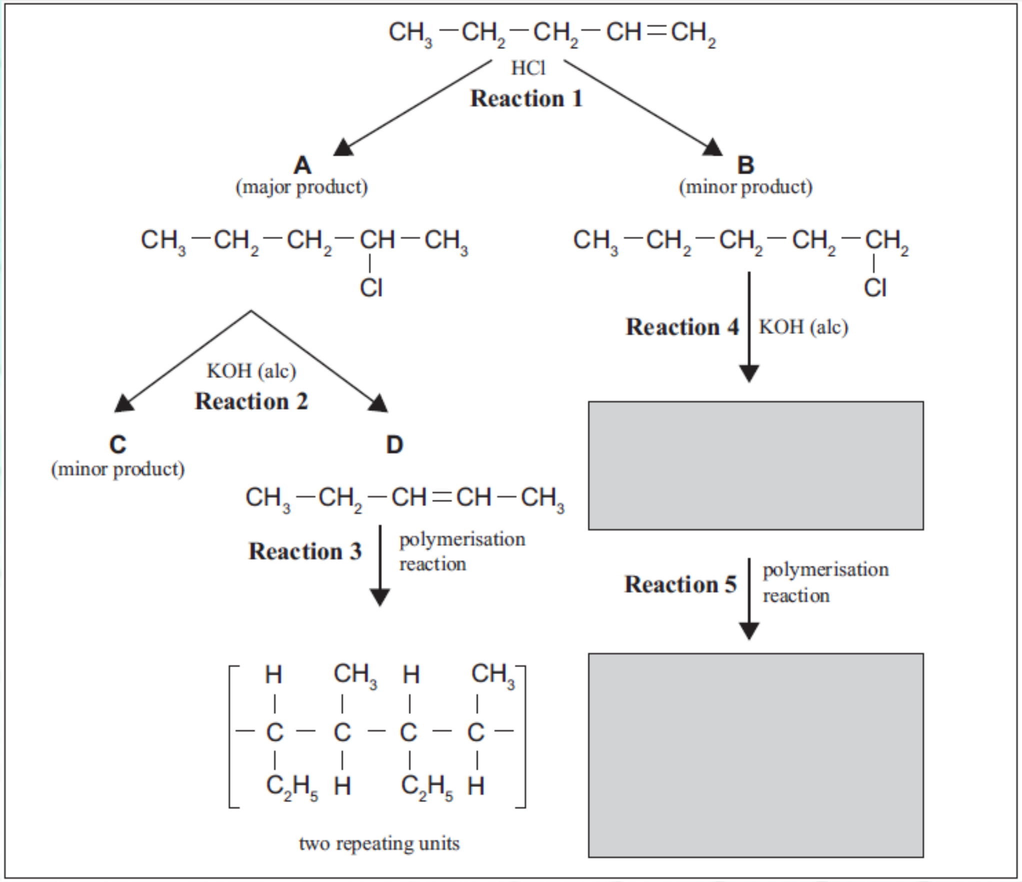
Merit Question

Question: 3b: (i) Explain why **Reaction 2** from the reaction scheme is classified as an elimination reaction.

It is an elimination reaction because two atoms are being **removed** from the molecule and **a double bond is being formed** between the carbon atoms from which the atoms have been removed.

Question: 3b: (ii) Reaction 4 is also an elimination reaction.

☐ Draw the structural formula of the product formed

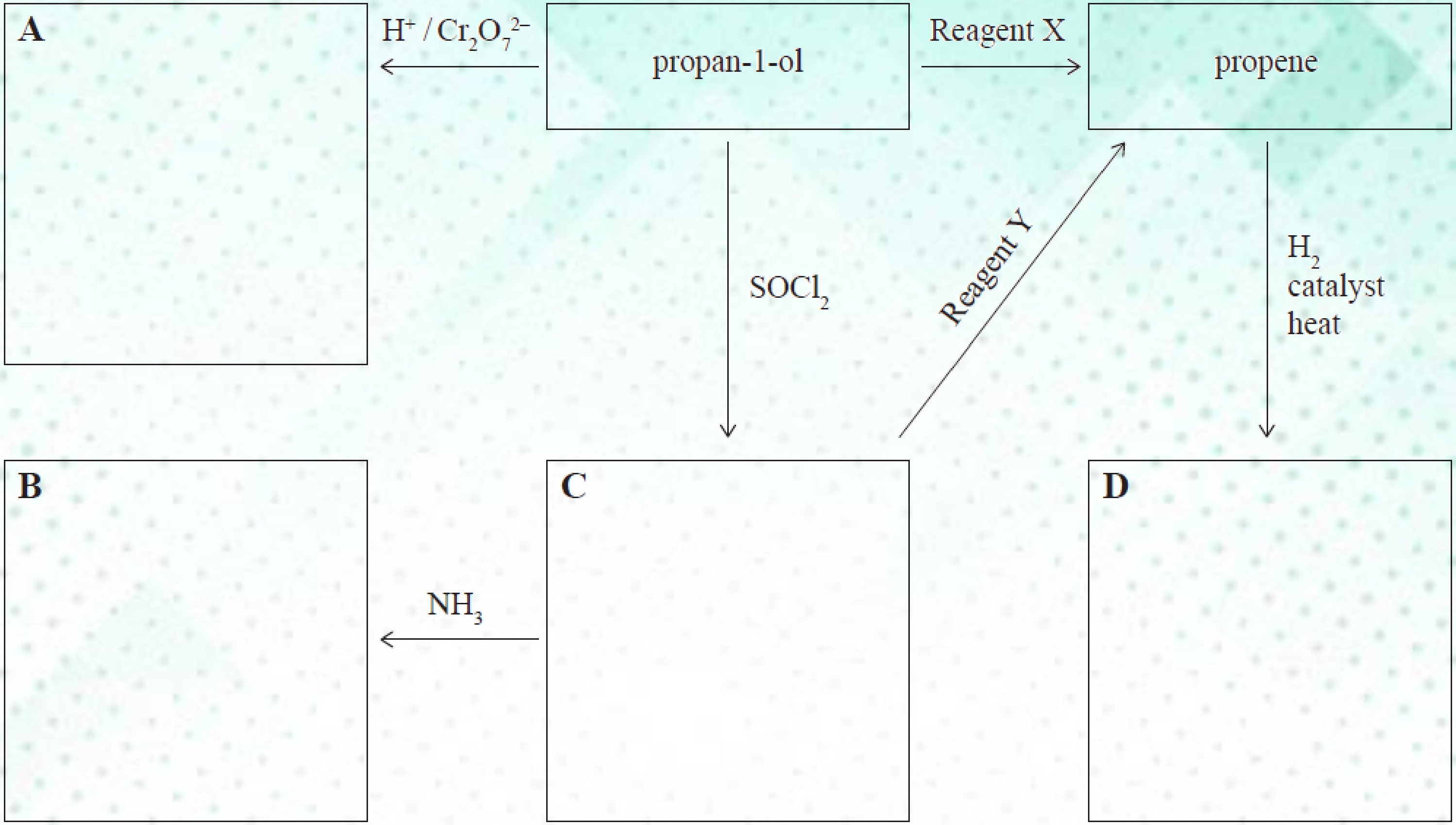


$$CH_3-CH_2-CH_2-CH=CH_2$$

NCEA 2015 Reactions (scheme)

Merit Question

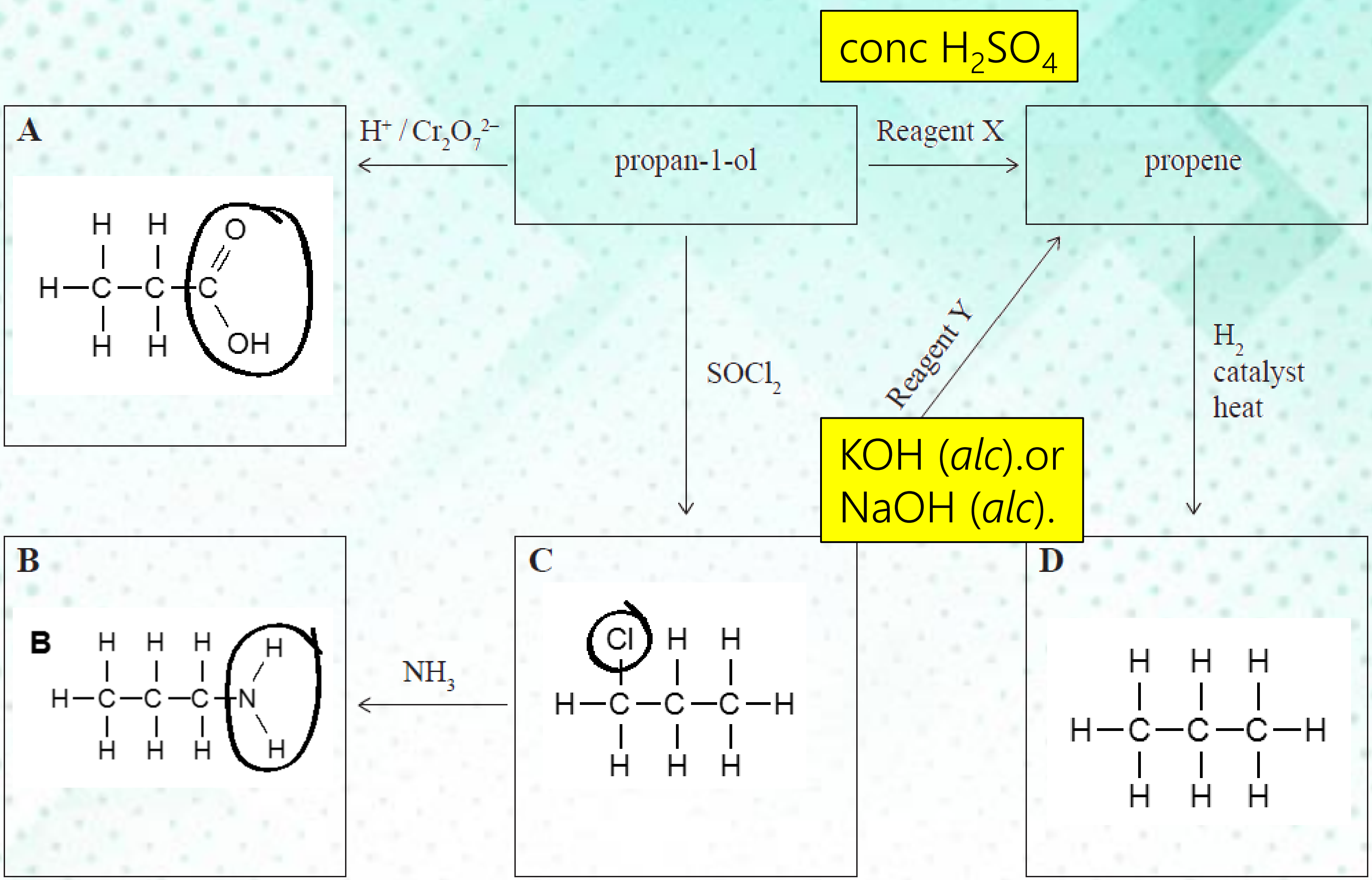
Question: 3a: (i) Complete the scheme above by drawing the structural formulae of the organic compounds A to D.
(ii) Circle the functional group of each of the organic compounds A, B, and C that you have drawn.
(iii) Identify reagents X and Y.



NCEA 2015 Reactions (scheme)

Merit Question

Answer: 3a: (i) Complete the scheme above by drawing the structural formulae of the organic compounds A to D.



conc H_2SO_4

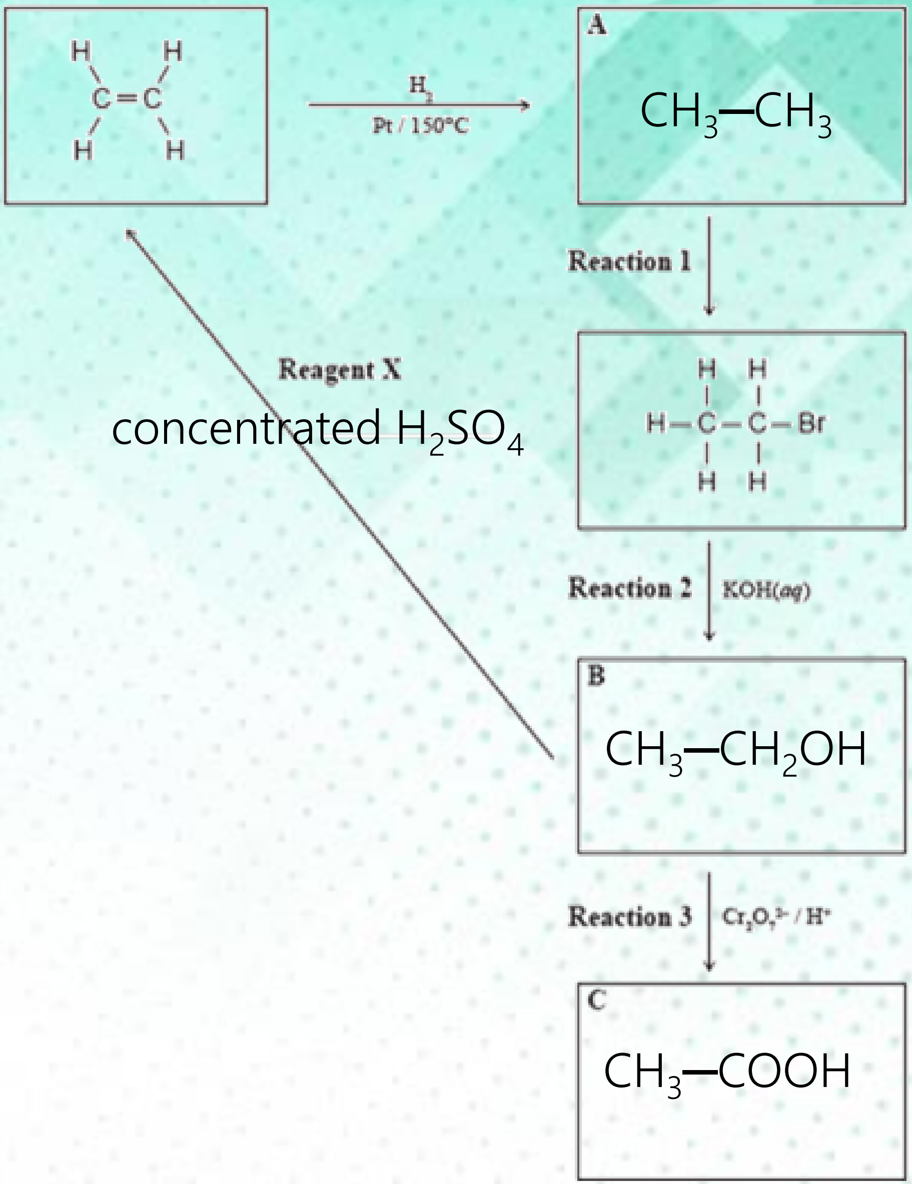
KOH (*alc*).or NaOH (*alc*).

NCEA 2016 Reactions (scheme)

Merit Question

Question 3a (i) : Complete the following chart by drawing the structural formulae for the organic compounds **A**, **B**, and **C** and identifying reagent **X**.

(ii) Identify the type of organic reaction occurring in each of Reactions 1, 2, and 3.



A: $CH_3—CH_3$

Reagent X: concentrated H_2SO_4

B: $CH_3—CH_2OH$

C: $CH_3—COOH$

Reaction **1**: substitution
Reaction **2**: substitution
Reaction **3**: oxidation

NCEA 2017 Reactions (scheme)

Excellence Question

Question 3a: (i) Complete the following reaction scheme by drawing the structural formulae for the organic compounds **A**, **C**, and **D**, and identifying *reagents 2 and 3*.

(ii) Identify the types of reactions that occur to produce compounds **A, B, C, D**, and **E**:

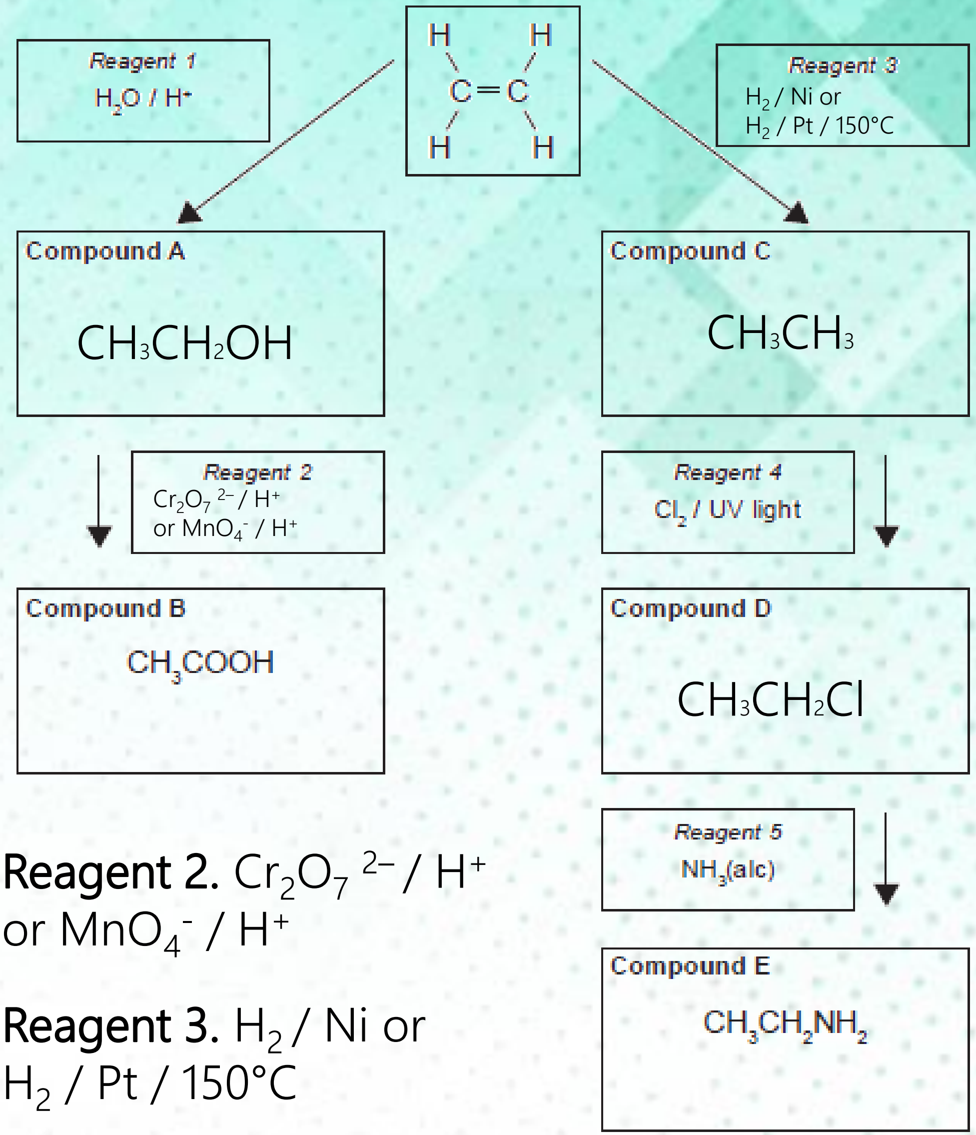
A. Addition (hydration)

B. oxidation

C. Addition (hydrogenation)

D. Substitution (halogenation)

E. substitution



Reagent 1
H_2O / H^+

Reagent 3
H_2 / Ni or
H_2 / Pt / 150°C

Compound A
CH_3CH_2OH

Compound C
CH_3CH_3

Reagent 2
$Cr_2O_7{}^{2-}$ / H^+
or MnO_4^- / H^+

Reagent 4
Cl_2 / UV light

Compound B
CH_3COOH

Compound D
CH_3CH_2Cl

Reagent 5
NH_3(alc)

Compound E
$CH_3CH_2NH_2$

Reagent 2. $Cr_2O_7{}^{2-}$ / H^+ or MnO_4^- / H^+

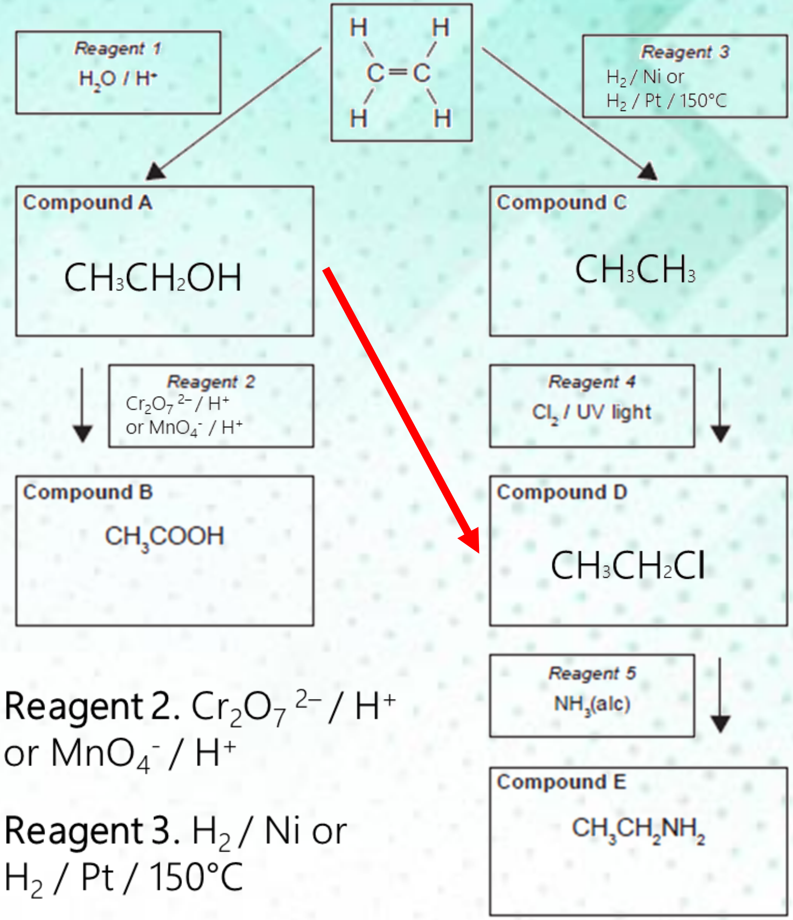
Reagent 3. H_2 / Ni or H_2 / Pt / 150°C

NCEA 2017 Reactions (scheme)

Merit Question

Question 3d: Explain how compound **A** from the reaction scheme could be directly converted into compound **D**.

PCl_3 / PCl_5 / $SOCl_2$ can be used to convert compound **A**, CH_3CH_2OH, an alcohol, to the chloroalkane, CH_3CH_2Cl. This is a substitution reaction where the –OH group in compound **A** is replaced by a Cl atom from PCl_3 / PCl_5 / 2.



Reagent 2. $Cr_2O_7{}^{2-}$ / H^+ or $MnO_4{}^-$ / H^+

Reagent 3. H_2 / Ni or H_2 / Pt / 150°C

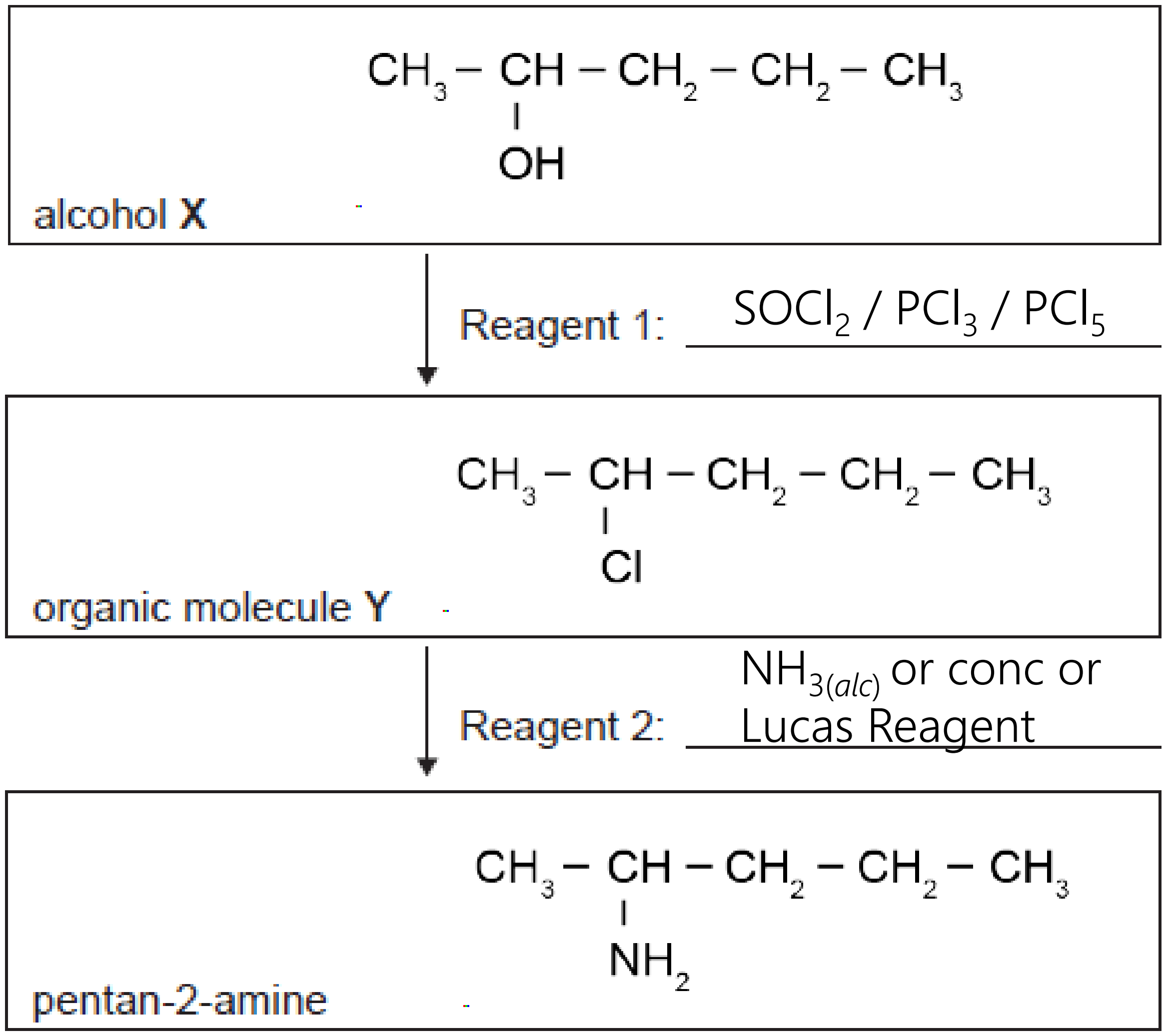
NCEA 2018 Reactions (scheme)

Excellence Question

Question: 2c:

Many organic reactions take more than one step in order to convert from one organic molecule to another. Two steps are required to produce pentan-2-amine from an alcohol. Use the information given to analyse the reactions.

(i) Draw the structural formulae of the compounds, and name the reagents involved in the process.



$$\underset{\displaystyle OH}{CH_3-\overset{}{CH}}-CH_2-CH_2-CH_3$$

alcohol **X**

Reagent 1: $SOCl_2$ / PCl_3 / PCl_5

$$\underset{\displaystyle Cl}{CH_3-\overset{}{CH}}-CH_2-CH_2-CH_3$$

organic molecule Y

Reagent 2: $NH_{3(alc)}$ or conc or Lucas Reagent

$$\underset{\displaystyle NH_2}{CH_3-\overset{}{CH}}-CH_2-CH_2-CH_3$$

pentan-2-amine

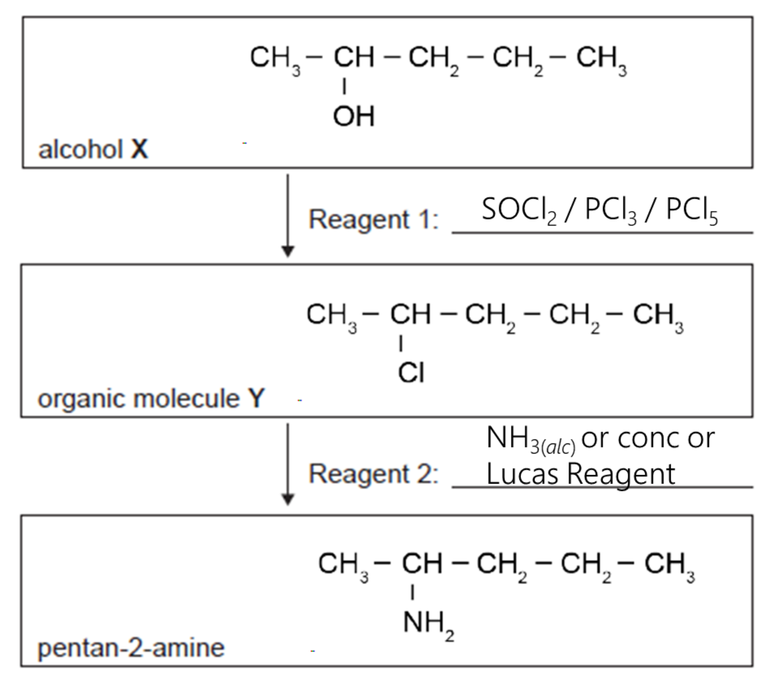
Organic Reactions

NCEA 2018 Reactions (scheme)

Excellence Question

Question: 2c: (ii) Elaborate on the reactions in the scheme below.
In your answer you should identify:

- any conditions needed for each step of the conversion
- the names of alcohol X and organic molecule Y
- the type of reaction that is occurring for each step of the conversion.

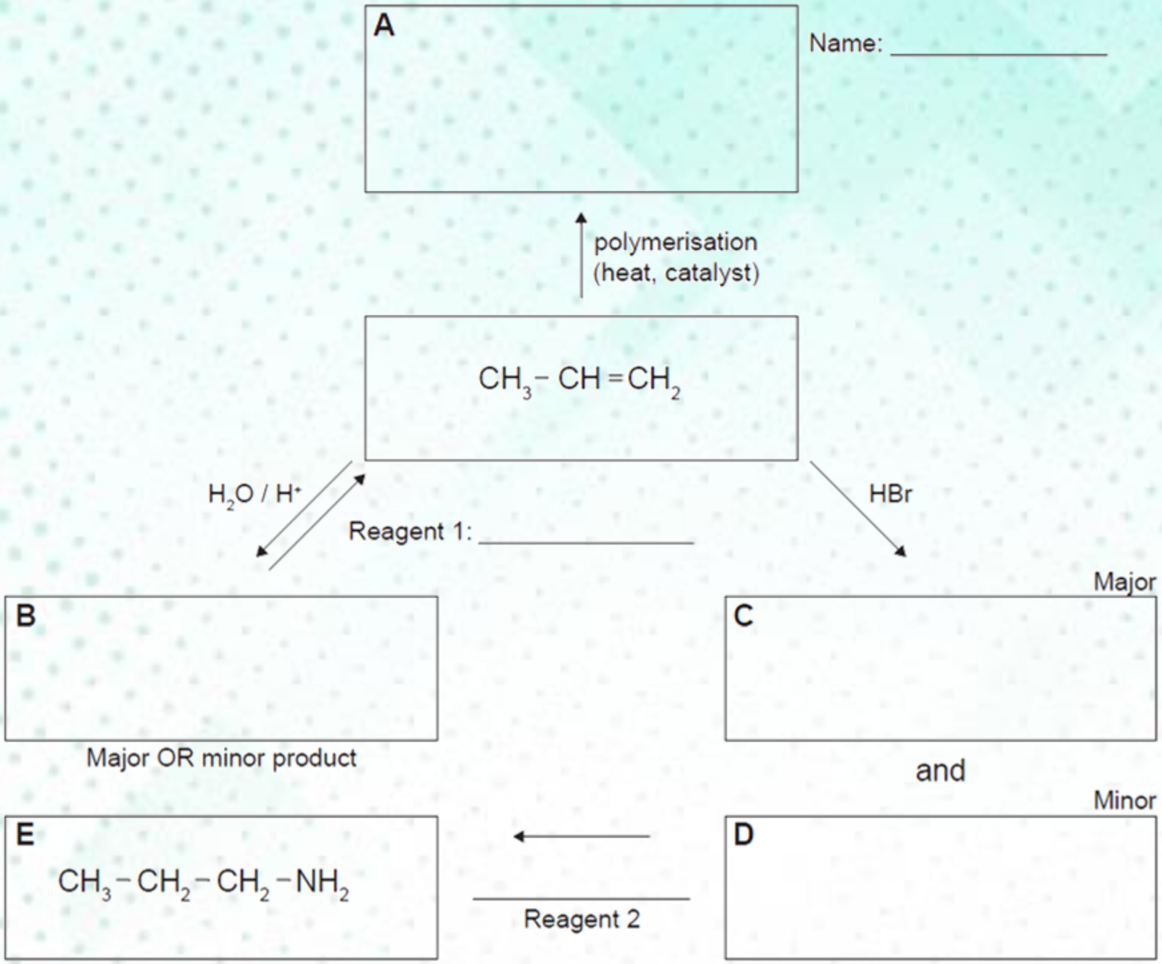


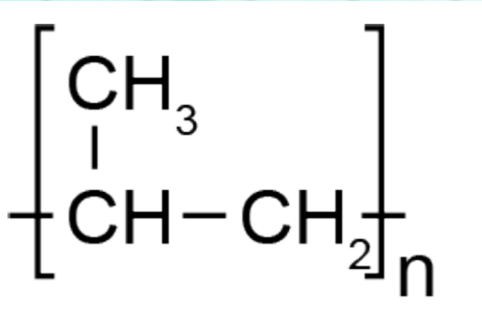
Both reactions are substitution reactions because one atom or group of atoms is substituted by another. In the first step, the OH group on the alcohol, pentan-2-ol is substituted by a Cl atom to make a chloroalkane, 2-chloropentane.
The reagent used is $SOCl_2$.
To convert the chloroalkane to an amine requires conc $NH_{3\ (alc)}$.
This causes the Cl to be substituted by an NH_2 to form the amine. (This is so that the OH group in aqueous ammonia does not get substituted onto the chloroalkane.)

NCEA 2019 Reactions (scheme)

Excellence Question

Question: 2a: Complete the following reaction scheme for propene, C_3H_6, by drawing the structural formulae for the organic compounds **A** to **D**, naming compound **A** and identifying Reagents **1** and **2**, including any conditions.





A: Polypropene

R1: conc sulfuric acid

R2: conc NH_3 (alc)

B: propan-2-ol OR propan-1-ol

C: 2-bromopropane

D: 1-bromopropane

NCEA 2019 Reactions (scheme)

Excellence With (ii)

Question: 3b: The conversion of bromoethane to chloroethane requires two steps, with alcohol as an intermediate product.
(i) Use this information to complete the reaction scheme below by drawing the structural formulae of each organic molecule and naming the intermediate alcohol and the reagents required.

Bromoethane: $CH_3\text{-}CH_2\text{-}Br$

Reagent 1: KOH(aq)

$CH_3\text{-}CH_2\text{-}OH$

Reagent 2: $SOCl_2$ / PCl_3 / PCl_5 / HCl

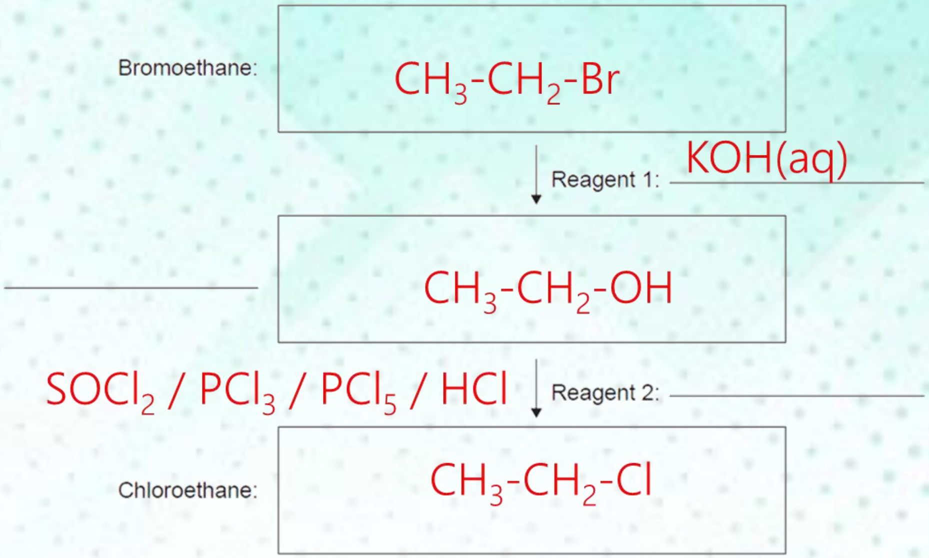
Chloroethane: $CH_3\text{-}CH_2\text{-}Cl$

NCEA 2019 Reactions (scheme)

Excellence With (i)

Question: 3b: (ii) Elaborate on the reaction scheme for this conversion.
In your answer, you should identify:

- any conditions needed for each step of the conversion
- the type of reaction occurring for each step of the conversion.



Bromoethane: CH_3-CH_2-Br

Reagent 1: KOH(aq)

CH_3-CH_2-OH

$SOCl_2$ / PCl_3 / PCl_5 / HCl Reagent 2:

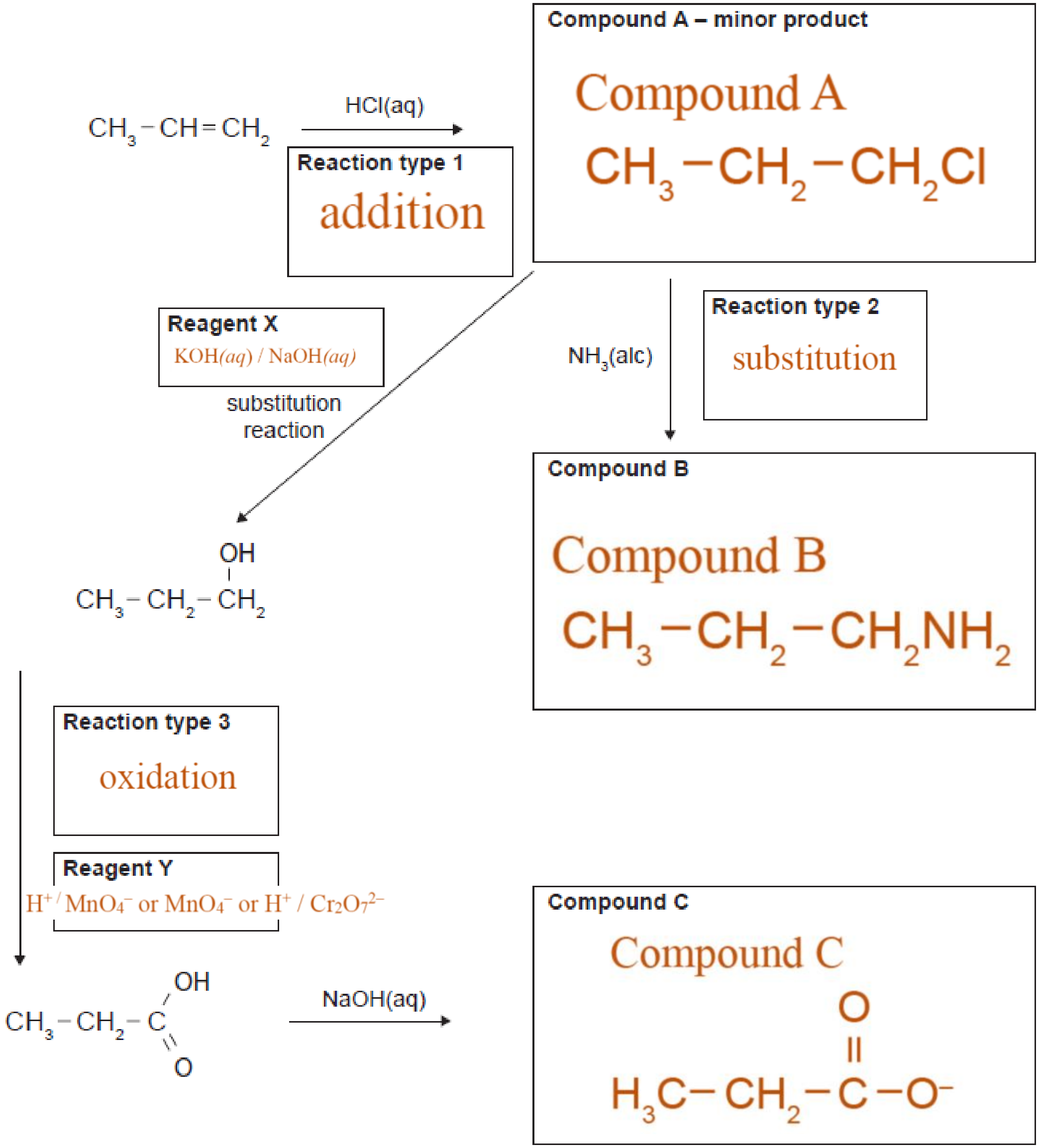
Chloroethane: CH_3-CH_2-Cl

Both reactions are a substitution. In the first step, KOH is in aqueous solution to enable the OH to be substituted for the bromine atom to form ethanol. In the second step, $SOCl_2$ / PCl_3 / PCl_5 can be used to substitute the OH for a chlorine atom.

NCEA 2020 Reactions (scheme)

Excellence Question

Question: 1d: Complete the following reaction scheme by drawing the structural formulae for the organic compounds A, B and C, identifying reagents X and Y, and reaction types 1, 2, and 3.



$CH_3-CH=CH_2$ $\xrightarrow{HCl(aq)}$

Reaction type 1

addition

Compound A – minor product

Compound A

$CH_3-CH_2-CH_2Cl$

$NH_3(alc)$

Reaction type 2

substitution

Compound B

Compound B

$CH_3-CH_2-CH_2NH_2$

Reagent X

KOH(*aq*) / NaOH(*aq*)

substitution reaction

$CH_3-CH_2-CH_2OH$

Reaction type 3

oxidation

Reagent Y

H^+/MnO_4^- or MnO_4^- or $H^+/Cr_2O_7^{2-}$

$CH_3-CH_2-C(=O)OH$ $\xrightarrow{NaOH(aq)}$

Compound C

Compound C

$H_3C-CH_2-C(=O)-O^-$