THE INSTITUTE OF EDUCATION

Subject: Chemistry

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COURSE: Leaving Certificate

ACADEMIC LEVEL: Higher Level

ACADEMIC YEAR: 2021- 2022

TOPIC: Organic Families 1: The Hydrocarbons

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CONTENTS

Organic Families 1

Q: What is organic chemistry?

- Organic chemistry is a **study of the compounds of carbon**

Q: What is a homologous series?

- A homologous series is **a family of organic compounds** with the **same general formula, similar chemical properties,** with **successive members differing by CH_2**

Note: We will study eight homologous series

Families 1:

- **1) Alkanes**
- **2) Alkenes**
- **3) Alkynes**

} **Hydrocarbons**

Families 2:

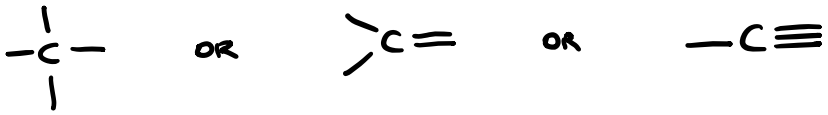
- **4) Alcohols**
- **5) Aldehydes**
- **6) Ketones**
- **7) Carboxylic acids**
- **8) Esters**

} **Also have oxygen**

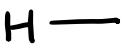
Note: The bonding in organic compounds is almost always covalent
The number of covalent bonds coming from an atom depends on its valency to satisfy the octet rule

Examples:

Carbon (C): Group 4 - Valency 4 ➡ Always **4 bonds** coming from carbon



Hydrogen (H): Group 1 - Valency 1 ➡ Always **1 bond** coming from hydrogen



Oxygen (O): Group 6 – Valency 2 ➡ Always **2 bonds** coming from oxygen

Chlorine (Cl)/Fluorine (F)/Bromine (Br)/Iodine (I): Group 7 - Valency 1 ➡ Always **1 bond** coming from chlorine/fluorine/bromine/iodine

Naming organic compounds – IUPAC systematic naming

Note: Organic compounds are named according to:

a) What **homologous series** they belong to

b) The number of **carbon** atoms **directly connected in a continuous chain**

c) The **type** and **number** of **side groups**/branches present

Important: All organic compounds have a 'root name' that depends on how many carbon atoms they have in a continuous chain

Number of carbons directly connected in a continuous chain	Root name
1	Meth -
2	Eth -
3	Prop -
4	But -
5	Pent -
6	Hex -
7	Hept -
8	Oct -

Note: These root names will apply to the different members of all of the organic families we will study

Q: What are hydrocarbons?

- Hydrocarbons are compounds that **contain** the elements **carbon and hydrogen only**

1) THE ALKANES

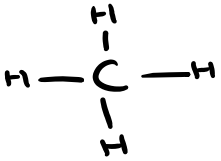
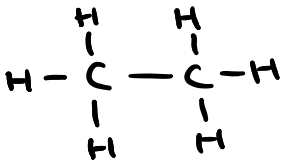
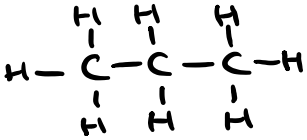
- **General Formula:** C_nH_{2n+2}
- End in **"ane"**
- **Saturated** compounds

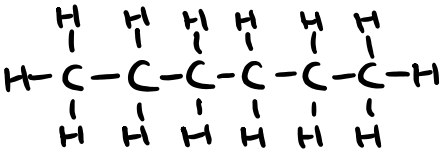
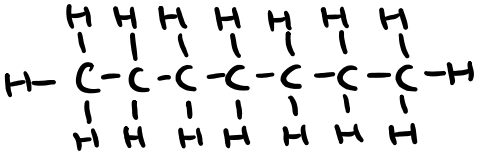
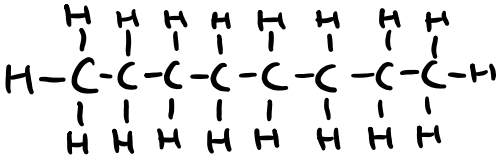
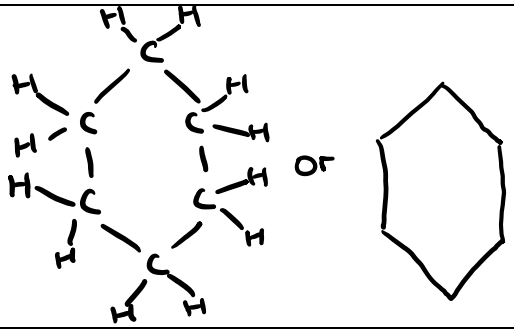
Q: What is a saturated compound?

- A saturated compound has **only single bonds between the carbon atoms** in the molecule

i.e. no double or triple bonds

Alkane basic members:

	IUPAC name	Molecular formula	Structural formula
1st member: (1 carbon present)	Methane	CH_4	
2nd member: (2 carbons present)	Ethane	C_2H_6 (CH_3CH_3)	
3rd member: (3 carbons present)	Propane	C_3H_8 $(CH_3CH_2CH_3)$	
4th member: (4 carbons present)		C_4H_{10}	**Two separate isomers possible**
5th member: (5 carbons present)		C_5H_{12}	**Three separate isomers possible**

6th member: **(6 carbons present)**	Hexane	C_6H_{14} $(CH_3(CH_2)_4CH_3)$	
7th member: **(7 carbons present)**	Heptane	C_7H_{16} $(CH_3(CH_2)_5CH_3)$	
8th member: **(8 carbons present)**	Octane	C_8H_{18} $(CH_3(CH_2)_6CH_3)$	
Cyclic member:	Cyclohexane commonly used non-polar solvent	C_6H_{12} **Notice:** Cyclohexane does not follow the general formula of alkanes but is still regarded as part of the alkane family	

Note: The 6th, 7th and 8th member of the alkanes have many different isomers – only need to know the ones shown for leaving cert :)

Branched organic compounds

- Branched organic compounds occur when there is a group of atoms/side group coming from the main chain in place of a hydrogen

Side groups/Branch names

Methyl – CH_3

Ethyl – C_2H_5

Propyl – C_3H_7

Chloro – Cl

Bromo – Br

Fluoro – F

Important: Side groups are **groups not part of the main continuous carbon chain** in the molecule

Naming more complicated alkanes

1. **Family:** Identify it is an **alkane** **from** its **molecular formula** or from the presence of **only carbons and hydrogens and only single bonds between the carbons**

2. **Main chain:** Identify the **longest continuous chain of directly connected carbons**
   (This does NOT have to be in a straight line)

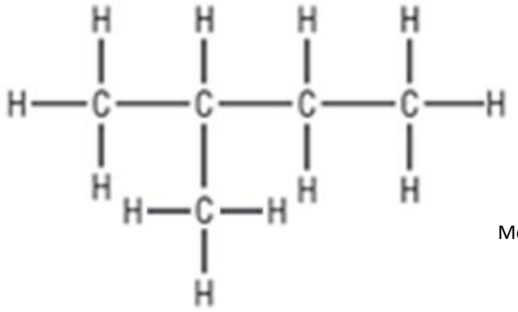
3. **Side groups**: Identify the **name and number of** any **side groups**
   (groups **not part of** the **main chain**)

4. **Numbering:** Number the carbon chain in such a way that the **SIDE GROUPS** are on the **lowest numbered carbons** possible **and name the main chain based on** its **number of carbons** – this may involve numbering backwards

   Give the location/**carbon number** of **each side group**

Note: Put commas between numbers, dashes (-) between numbers and words, and no spaces

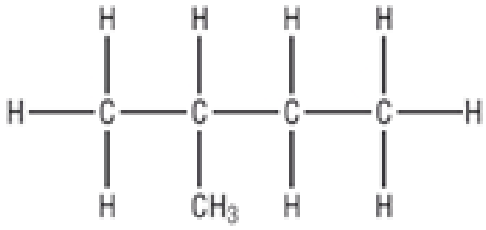
Example: Give the IUPAC systematic name of the compounds shown:



Name backwards

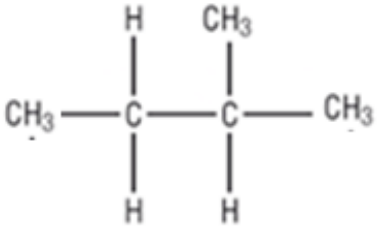
2 - methylbutane

Methyl group is on carbon No. 2 | One methyl side group | Alkane with 4 carbons in longest continuous chain



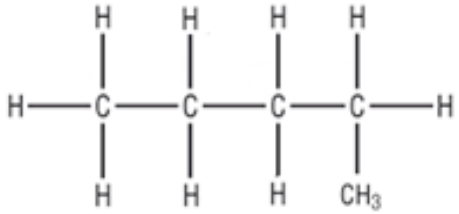
2 - methylbutane

Methyl group is on carbon No. 2 | One methyl side group | Alkane with 4 carbons in longest continuous chain



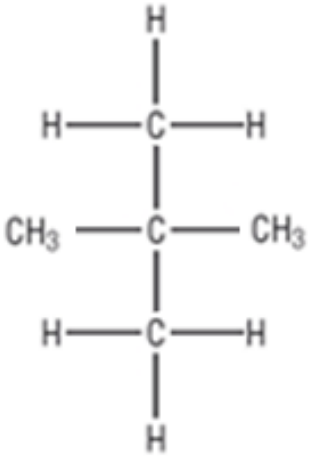
2 - methylbutane

Methyl group is on carbon No. 2 | One methyl side group | Alkane with 4 carbons in longest continuous chain



Pentane

Alkane with 5 carbons in longest continuous chain

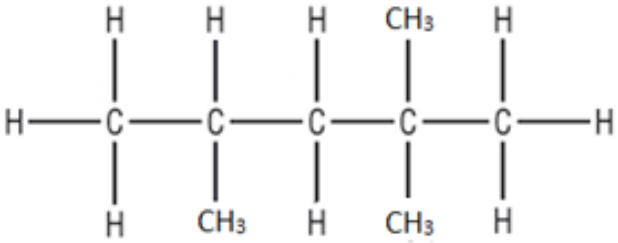


2,2-dimethylpropane

Both methyl groups are on carbon No. 2

Two methyl side groups

Alkane with 3 carbons in longest continuous chain



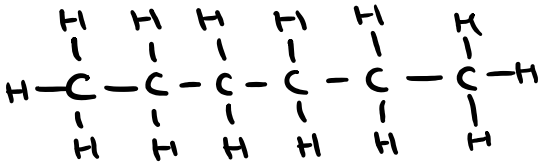
2,2,4-trimethylpentane

Methyl groups are on carbons No. 2 + 2 + 4

Three methyl side groups

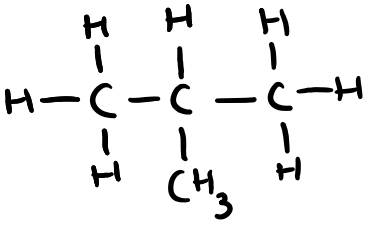
Alkane with 5 carbons in longest continuous chain

$CH_3(CH_2)_4CH_3$ → Draw structural formula



Hexane

$CH_3CHCH_3CH_3$ → Draw structural formula



2-methylpropane

Q: What are structural isomers?

- Structural isomers are **compounds** that have the **same molecular formula** but **different structural formulas**

Making isomers for alkanes

Options:

1. **BRANCHING:** Shorten the chain length and place a carbon(s) in the molecule as a side group instead

   Notes:

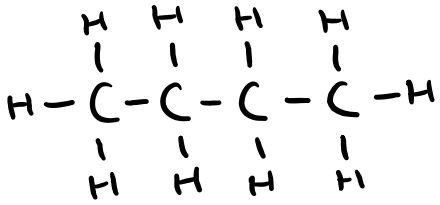
   a) **You can NEVER branch carbons/put a 'side group containing carbon' at the start or end of a molecule**

   b) **If the main chain contains three carbons or less, you CANNOT branch this molecule**

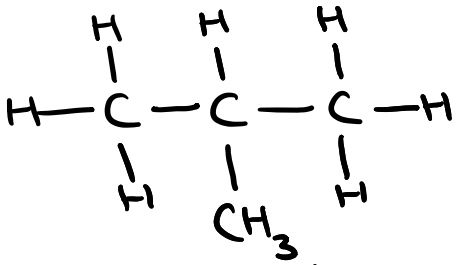
Example:

a) **Draw and give the IUPAC names of two structural isomers of the fourth member of the alkane family**

➢ Fourth member of alkanes has 4 carbons : Molecular formula: C_4H_{10}



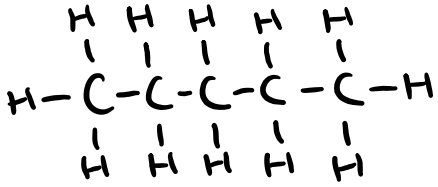
Butane



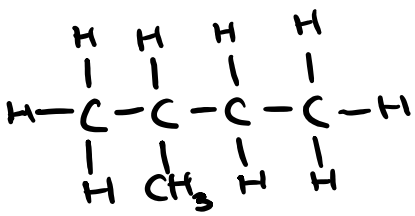
2-methylpropane

b) **Draw and give the IUPAC names of two structural isomers of the fifth member of the alkane family**

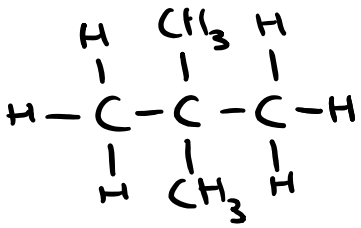
➢ Fifth member of alkanes has 5 carbons : Molecular formula: C_5H_{12}



Pentane



2-methylbutane

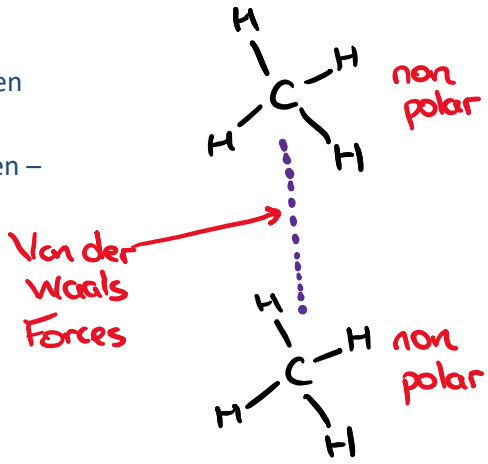


2,2-dimethylpropane

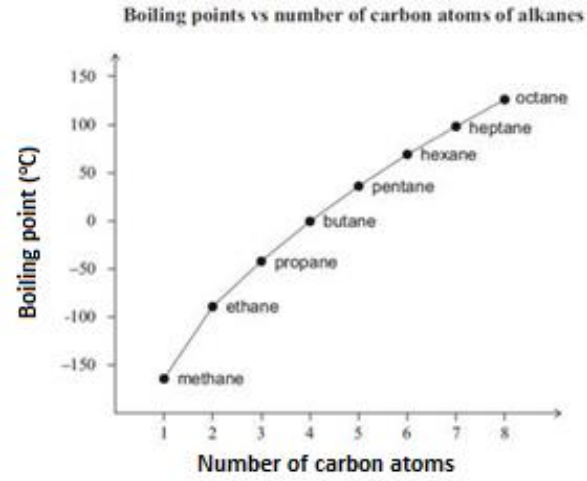
Notice: If two molecules have the same number of each type of element but have a different IUPAC name, they are structural isomers

Physical properties of the alkanes

1. Boiling points



- Alkanes are **non-polar** molecules - have **van der Waals forces** between their molecules
- Van der Waals are **weak** and do not require much energy to be broken – explains why the **first four members** (C_1- C_4) **are gases** at room temperature
- As the **molecular mass** of the alkanes **increases**, the s**trength of intermolecular forces increase** and **boiling point increases**
  - Members **C_5-C_{12} are liquids**
  - Members **C_{16} and higher are waxy solids**



2. Solubilities

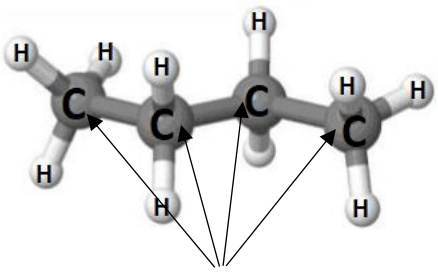
- Alkanes are **non-polar** molecules
- Therefore, they will **not dissolve in polar water** but will **dissolve in non-polar** solvents such as **cyclohexane**

Example Question: Propane and butane have boiling points of – 42.1 ˚C and – 0.5 ˚C, respectively. Explain why propane has a lower boiling point than butane

- Propane and butane are both alkanes- both molecules are **non-polar** and therefore **have van der Waals forces** between their molecules
- However **butane** (C_4H_{10}) has **a larger molecular mass** than propane (C_3H_8) and the **intermolecular forces** between its molecules are **stronger** - more energy is required to break these forces which explains its higher boiling point

Q: Comment on the geometry around each carbon atom in the alkanes

- In alkanes, **every carbon** atom has **tetrahedral** geometry - bonded to four other elements by single covalent bonds



All carbons in alkanes are tetrahedral

Q: Explain how only sigma bonding takes place between carbon atoms in alkane molecules

- Alkanes are **saturated** compounds – contain **only single bonds** between the carbon atoms
- **Single bonds** are always **formed by a sigma bond** i.e. the head on overlap between two atomic orbitals

Q: Give two applications of the alkanes

1. Alkanes are excellent **fuels** - used for heating, cooking and as motor fuel in petrol and diesel

2. Alkanes can be used as **lubricating oil** in machinery

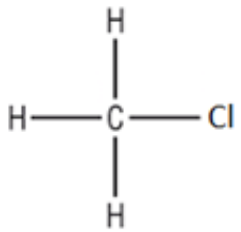
Chloroalkanes

Q: What are chloroalkanes?

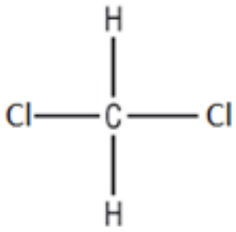
- Chloroalkanes are compounds in which **one or more of the hydrogen atoms in an alkane** molecule have been **replaced by chlorine** atoms

Naming of chloroalkanes

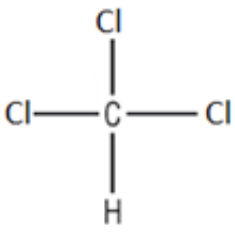
Example: Give the IUPAC name of the compounds shown:



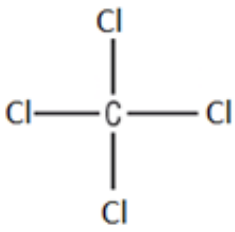
Chloromethane



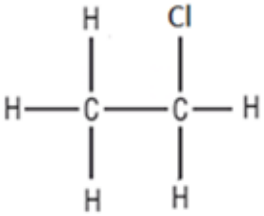
Dichloromethane



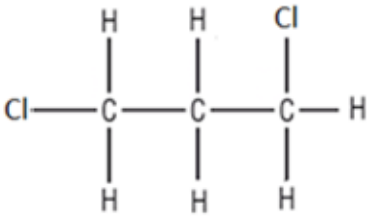
Trichloromethane



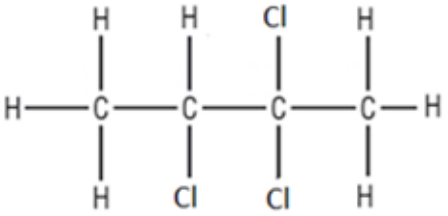
Tetrachloromethane



Chloromethane



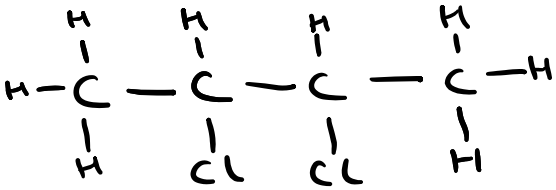
1,4-dichloromethane



2,2,3-trichlorobutane

Example: Give the IUPAC name of the compound $CH_3CHClCHClCH_3$

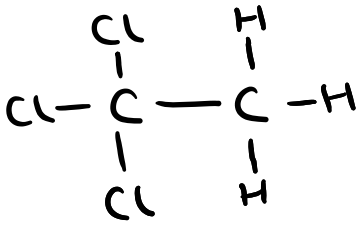
$CH_3CHClCHClCH_3$ → Draw structural formula



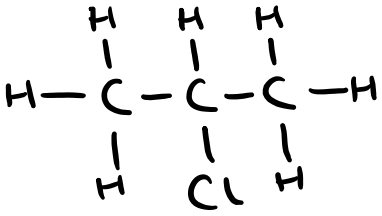
2,3-dichlorobutane

Example: Draw the structural formula of the following compounds

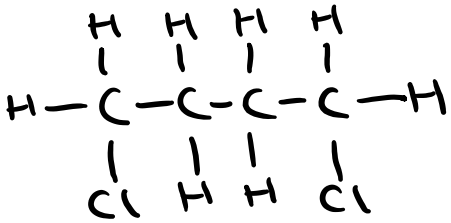
a) 1,1,1 - trichloroethane



b) 2 - chloropropane



c) 1,4 – dichlorobutane



Physical properties of the chloroalkanes

1. Boiling points

- **Higher** boiling points **than** their **corresponding alkanes**
- The carbon-chlorine bond is polar, dipole-dipole forces can form between the molecules

2. Solubilities

- Insoluble in water, **very soluble in non-polar solvents** such as **cyclohexane**
- Most of the molecule is non-polar

Q: Give two applications of the chloroalkanes

a) **Solvents** for non-polar substances – used in **dry cleaning**

b) Dichloromethane is used in **paint stripper**

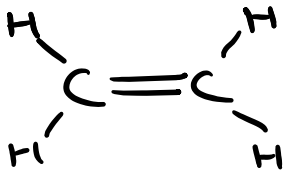
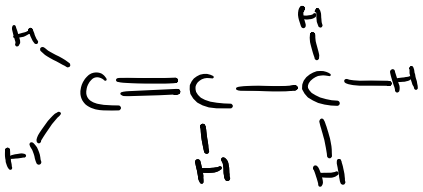
2) THE ALKENES

- **General Formula : C_nH_{2n}**
- End in **"ene"**
- **Unsaturated** compounds containing **one double bond between two of the carbons**

Q: What is an unsaturated compound?

- An unsaturated compound **has double or triple bonds between** some of the **carbon atoms** in the molecule

Alkene basic members:

	IUPAC name	Molecular formula	Structural formula
1st member: **(2 carbons present)** **Notice:** Alkenes have a double bond between two carbons – therefore the simplest alkene has two carbons	Ethene	C_2H_4 (CH_2CH_2)	
2nd member: **(3 carbons present)**	Propene	C_3H_6 (CH_2CHCH_3)	
3rd member: **(4 carbons present)**			**Three separate isomers possible**

Naming more complicated alkenes

1. **Family:** Identify it is an **alkene** from its molecular formula or from the presence of **one carbon-carbon double bond**

2. **Main chain:** Identify the **longest continuous chain of directly connected carbons that contains the double bond** (This does NOT have to be in a straight line)

3. **Numbering:** Number the carbon chain in such a way that the **DOUBLE BOND** is coming from the **lowest numbered carbon** possible **and name the main chain based on** its **number of carbons** – this may involve numbering backwards

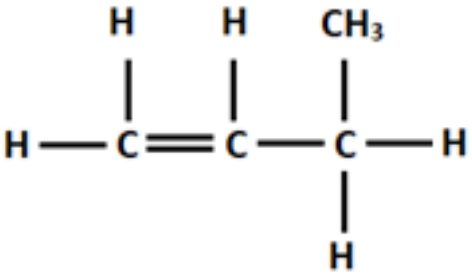
4. **Side groups**: Identify the **name and number of any side groups**
   (groups **not part of** the **main chain**)
   Give the location/**carbon number** of **each side group**

5. If required, the number of the **carbon that the double bond is coming from** must be placed **in** the **middle of** the alkene **name** before "ene"

Example: But-1-ene, But-2-ene,

Note: Put commas between numbers, dashes (-) between numbers and words, and no spaces

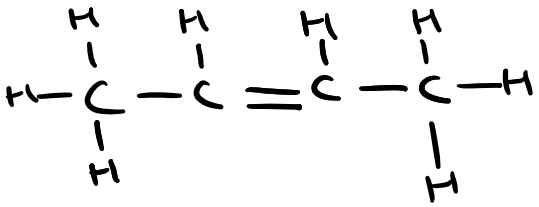
Example: Give the IUPAC systematic name of the compounds shown:



But-1-ene

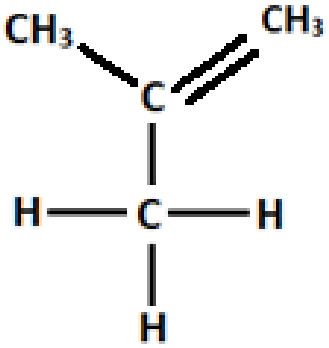
Double bond starts from carbon number 1

$CH_3CHCHCH_3$ → Draw structural formula



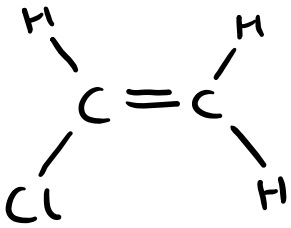
But-2-ene

Double bond starts from carbon number 2



2-methylprop-1-ene
(methylpropene)

$CHClCH_2$ → Draw structural formula



Chloroethene

Making isomers for alkenes

Options:

1. **MOVING THE POSIITON OF THE DOUBLE BOND**
2. **BRANCHING:** Shorten the chain length and place a carbon (s) in the molecule as a side group

Notes:

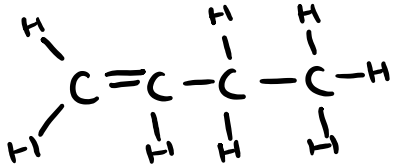
a) **You can NEVER branch carbons/put a 'side group containing carbon' at the start or end of a molecule**

b) **If the main chain contains three carbons or less, you cannot branch this molecule**

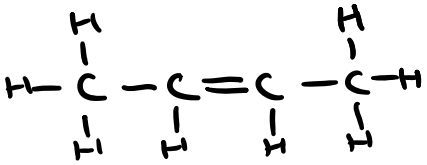
Q: Draw and give the IUPAC names of three isomers of the third member of the alkene series

- Third member of alkenes has 4 carbons : Molecular formula: C_4H_8

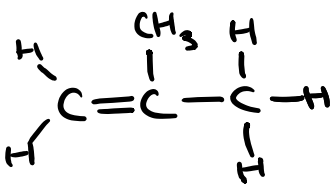
Isomers of C_4H_8:



But-1-ene



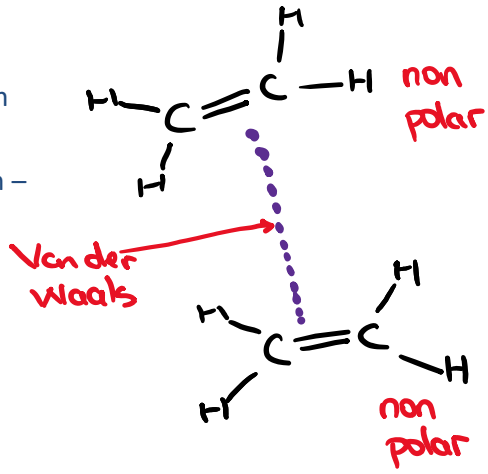
But-2-ene



2-methylprop-1-ene
(methylpropene)

Physical properties of the alkenes

1. Boiling points

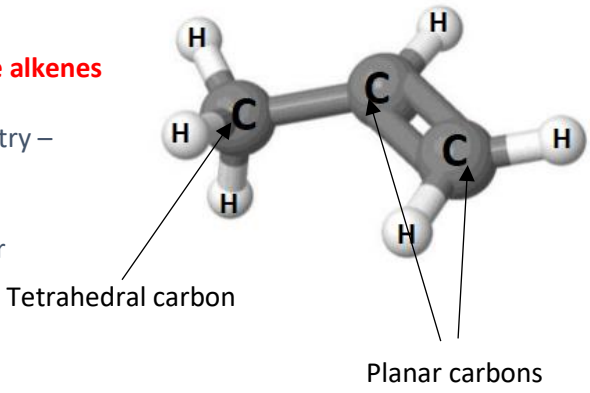


- Alkenes are **non-polar** molecules - have **van der Waals forces** between their molecules
- Van der Waals are **weak** and do not require much energy to be broken – explains why the **first four members** (C_2- C_5) **are gases** at room temperature
- As the **molecular mass** of the alkenes **increases**, the **strength of intermolecular forces increase** and **boiling point increases**
  - higher members are liquids and solids

2. Solubilities

- Alkenes are **non-polar** molecules
- Therefore, they will **not dissolve in polar water** but will **dissolve in non-polar** solvents such as **cyclohexane**

Q: Comment on the geometry around each carbon atom in the alkenes



- In alkenes, each **carbon in the double bond** has **planar** geometry – bonded to three other elements
- All **other carbons**, have **tetrahedral** geometry - bonded to four other elements by single covalent bonds

Q: Explain how sigma and pi bonding take place between carbon atoms in alkene molecules

- Alkenes are **unsaturated** compounds – contain a **double bond** between two of the carbon atoms
- **Double bonds** are **formed by a sigma bond** i.e. the head on overlap of two atomic orbitals **and a pi bond** i.e. the sideways overlap of two p or d atomic orbitals

Q: Account for the greater activity of alkenes compared to alkanes

- Alkenes are **unsaturated** i.e. have a double bond between two carbons
- This double bond has a **high electron density** and includes a **pi bond** which is weaker and more **easily broken**

Q: Give two industrial applications of alkenes

1. Ethene generators are used commercially to **speed up the ripening of fruit**
2. Polymerisation of alkenes is used in the production of **plastics**

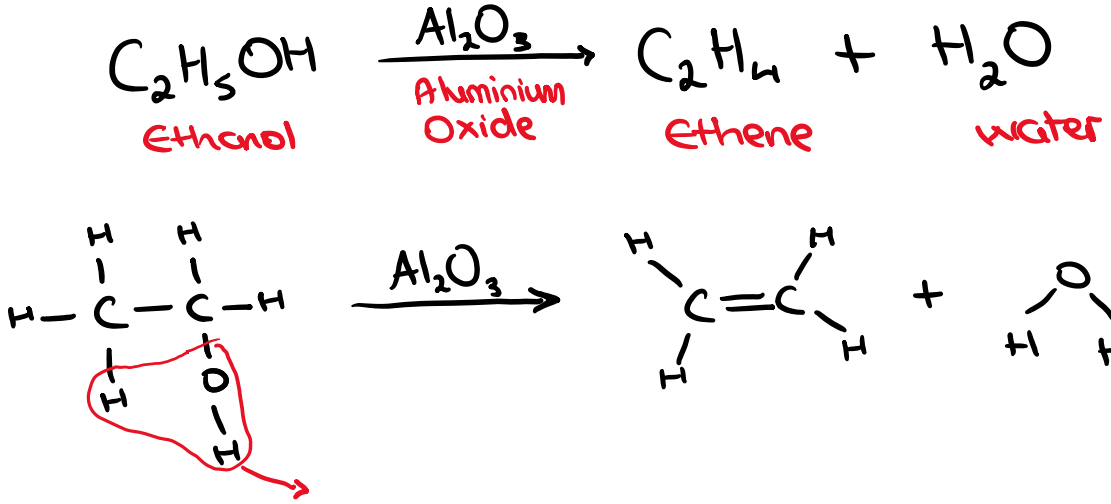
Mandatory Experiment: To prepare ethene and examine its properties

https://www.youtube.com/watch?v=Q2X3bvThK_A

Theory:

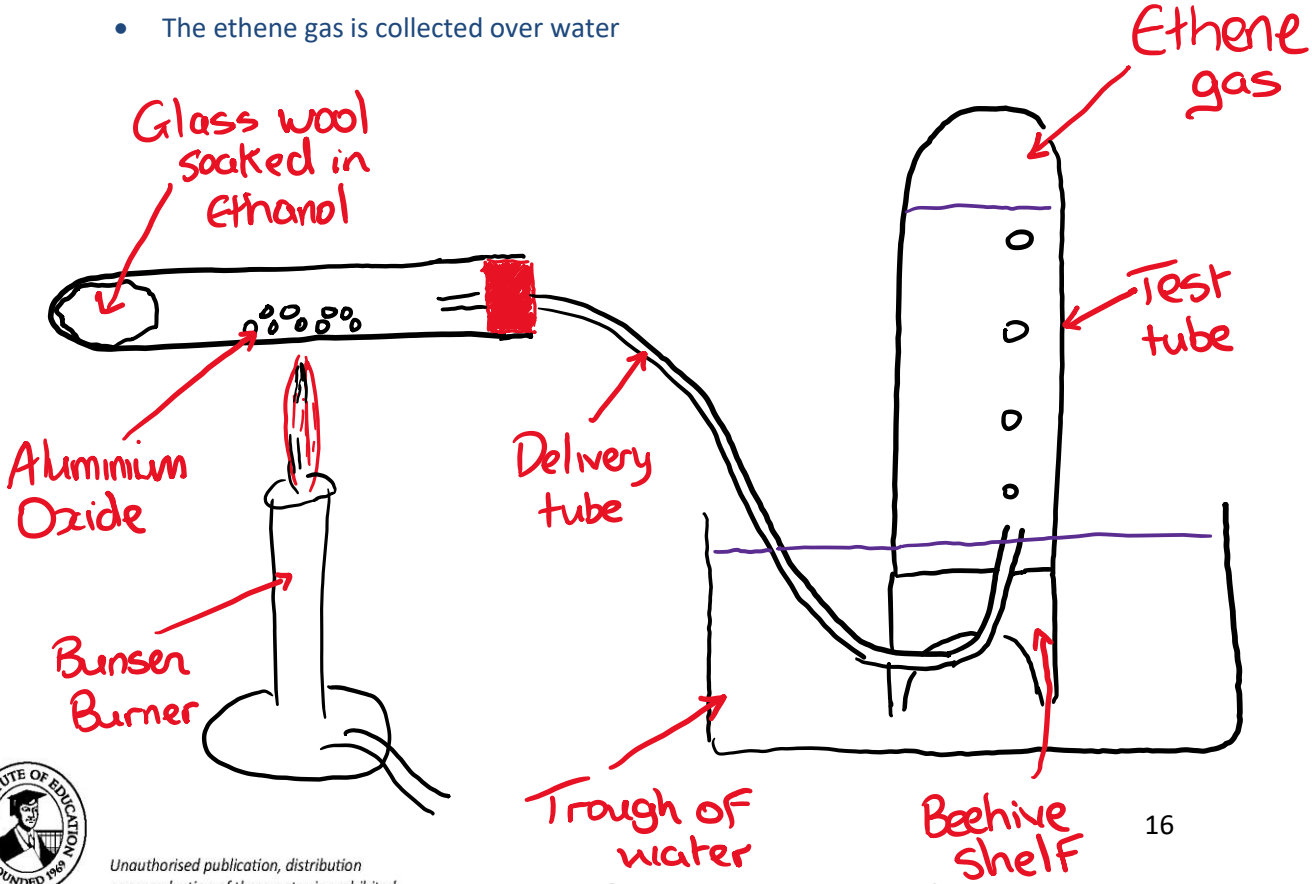
- **Ethanol is dehydrated** (has a molecule of water removed) **using aluminium oxide** (Al_2O_3) to **form ethene gas** (C_2H_4)
- Known as an **elimination reaction**

Equation:



Procedure:

- Aluminium oxide is gently heated. The heat causes the ethanol to vapourise and pass over the aluminium oxide
- The ethanol is dehydrated to from ethene gas
- The ethene gas is collected over water

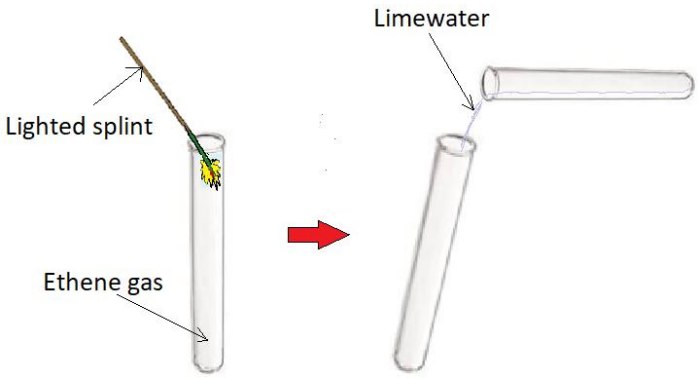


Examining the properties of ethene

(a) Physical properties:

- Ethene is a **colourless** gas with a **sweet smell**
- It is **insoluble in water** but **dissolves in non-polar solvents** **Example:** Cyclohexane

(b) Combustion:



Result:

i) Ethene burns with a **bright yellow flame**

ii) **Limewater** turns **milky white** proving **carbon dioxide** was **formed** in the combustion

- Place a lighted splint into a test tube of ethene gas
- Add limewater to the test tube, stopper and shake

Q: Write a balanced chemical equation for the complete combustion of ethene?

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

Ethene Oxygen Carbon dioxide Water

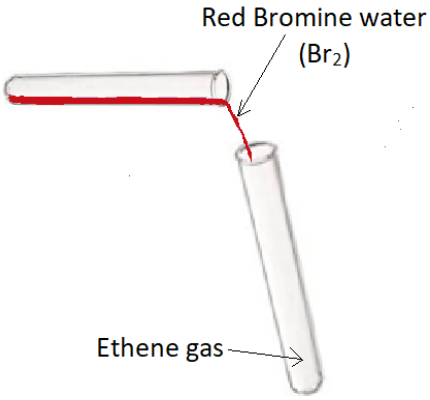
Q: Why does carbon dioxide turn limewater milky white?

- Limewater is calcium hydroxide - when added to carbon dioxide, white calcium carbonate forms

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

Calcium hydroxide (Limewater) Carbon Dioxide Calcium Carbonate Water

(c) Testing for unsaturation – Method 1: Using bromine water



Result:

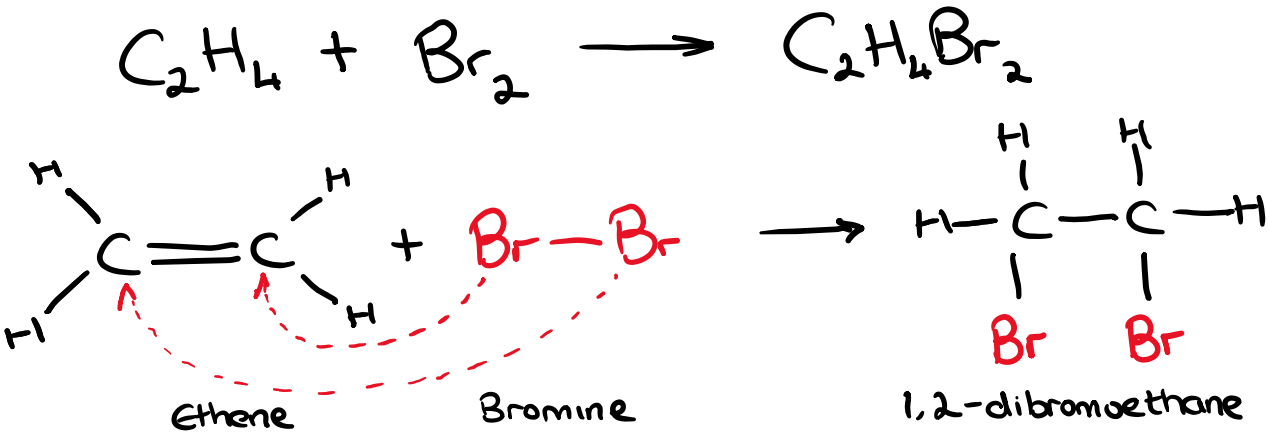
- **Red** bromine water **turns colourless** – ethene is unsaturated

- Add red bromine water to a test tube of ethene gas, stopper and shake

Q: What type of reaction occurs when bromine is added to ethene gas

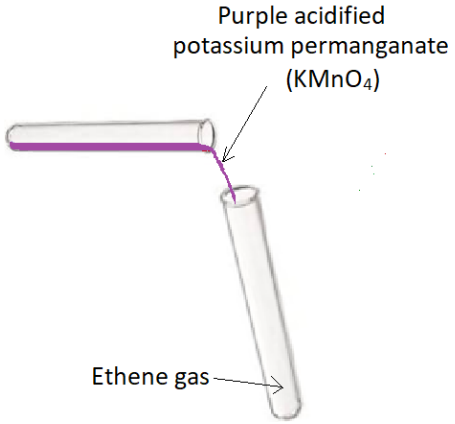
- **Addition reaction** – the adding of a bromine molecule across a double bond, breaking the double bond

Q: Write a balanced chemical equation for this reaction



Notice: The product formed 1,2 dibromoethane is colourless - this proves unsaturation

(d) Testing for unsaturation – Method 2: Using acidified potassium permanganate



Result:

- **Purple** acidified potassium permanganate **turns colourless** - ethene is unsaturated

- Add purple acidified potassium permanganate to a test tube of ethene gas, stopper and shake

Follow up questions

Q: What type of reaction is the preparation of ethene known as?

- **Elimination** reaction or **Dehydration** reaction (removing a molecule of water)

Q: What is the function of the aluminium oxide?

- Aluminium oxide **i)** acts as a **dehydrating agent**.
  ii) Is a **catalyst** for the reaction.

Q: What is the appearance of aluminium oxide?

- Aluminium oxide is a **white powder**

Q: Why is the aluminium oxide gently heated/why is the ethanol not heated directly?

- To avoid the **ethanol vaporising too quickly** and passing over the aluminium oxide too quickly – **little** ethanol **would be converted into ethene**

Q: Outline three safety precautions in this experiment

1) Ethene is flammable – **ensure** the test tube **stopper is airtight** to avoid any ethene escaping
2) **Wear gloves** when handling glass wool – can be an **irritant to skin**
3) **Raise** the **apparatus from** the **water before turning** the **bunsen** burner **off**

Q: Why is the apparatus raised from the water before turning off the Bunsen burner?

- To **avoid "suck-back"** of water up the delivery tube - cold water being sucked back up into the **hot test tube could** cause it to **crack**

Q: Why are the first few test tubes of gas collected discarded?

- The first few test tubes **consist mostly of displaced air** and not ethene gas

Q: Give an industrial application of ethene

- Ethene generators are used commercially to **speed up the ripening of fruit**

Calculation:

Q: When ethanol is converted to ethene by dehydration, a 60% yield can be expected. Assuming this percentage yield, what is the maximum number of 75 cm^3 test tubes of ethene gas that could be collected at room temperature and pressure when 2.4 cm^3 of ethanol, density 0.8 gcm^{-3} can react? (2012)

chemical equation: $C_2H_5OH \xrightarrow{Al_2O_3} C_2H_4 + H_2O$

REMINDER: MUST WORK IN MOLES

Ethanol: $2.4cm^3$ Density = $\frac{mass}{volume}$

$0.8gcm^{-3} = \frac{mass}{2.4cm^3}$

$mass = (0.8gcm^{-3})(2.4cm^3)$

$mass = 1.92g\ C_2H_5OH$

Mr C_2H_5OH
$12(2)+1(5)+16+1$
$= 46$

grams ⟶ moles

$\frac{1.92g}{46} = 0.0417mol\ C_2H_5OH$

$C_2H_5OH \longrightarrow C_2H_4 + H_2O$

molar ratio: 1 1 1

actual moles 0.0417 0.0417 0.0417

Theoretical yield C_2H_4 (100%) $= 0.0417mol$

actual yield C_2H_4 (60%) $= \frac{0.0417}{100} \times 60 = 0.025mol$

moles ⟶ volume @ R.T

$0.025mol \times 24{,}000cm^3 = 601.04cm^3\ C_2H_4$

$\frac{601.04cm^3}{75cm^3} =$ 8 Test tubes needed.

3) THE ALKYNES

- **General Formula –** C_nH_{2n-2}
- End in **"yne"**
- **Unsaturated** compounds containing **one triple bond between two of the carbons**

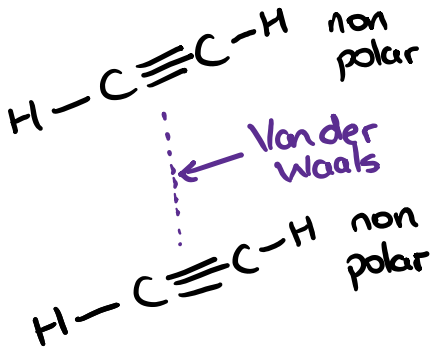
Alkyne basic members:

	IUPAC name	Molecular formula	Structural formula
1st member: **(2 carbons present)** **Notice:** Alkynes have a triple bond between two carbons – therefore the simplest alkyne has two carbons	Ethyne	C_2H_2 (CHCH)	H—C≡C—H

Physical properties of ethyne

1. Boiling point

- Ethyne has a **low boiling point** (-84˚C) – therefore it is a **gas at room temperature**
- Ethyne is a **non-polar** molecule – there are **van der Waals** forces between its molecules
- Van der Waals are **weak** and do not require much energy to be broken



2. Solubility

- Ethyne is a **non-polar** molecule
- Therefore, it will **not dissolve in polar water** but **will dissolve in non-polar** solvents such as **cyclohexane**

Q: Give an application of ethyne

- Ethyne gas (also known as acetylene) is used in oxyacetylene **welding and cutting** – when ethyne is burned in oxygen it burns at extremely high temperatures (> 3000°C)

Mandatory Experiment: To prepare ethyne and examine its properties

https://www.youtube.com/watch?v=98G6_W357sI

Theory:

- Ethyne is prepared by **reacting calcium dicarbide (CaC_2) with water**

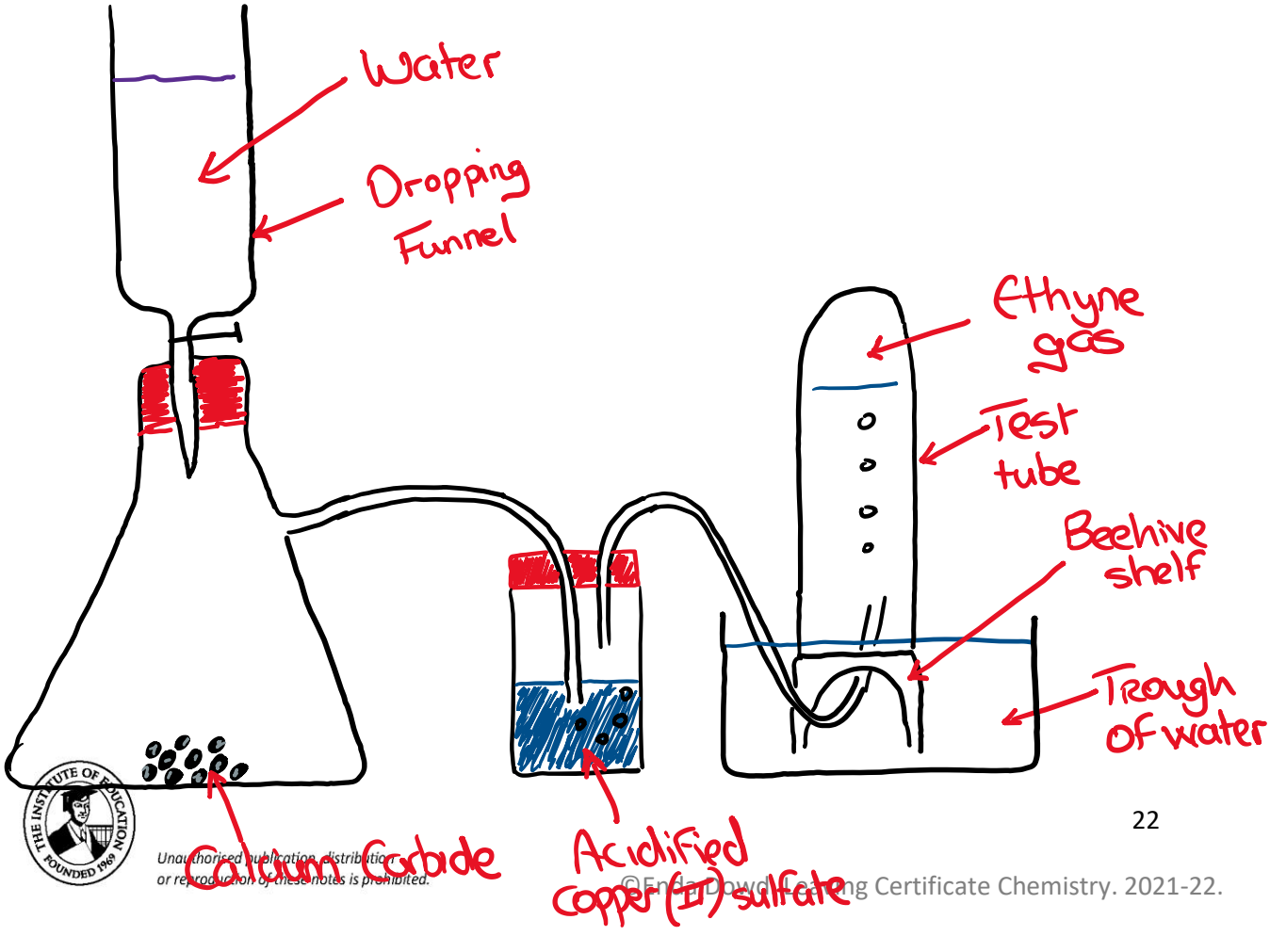
Equation:

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2\uparrow$$

Calcium carbide — water — Calcium Hydroxide — Ethyne

Procedure:

- Calcium carbide is placed in a flask using a spatula
- The apparatus in the diagram is set up
- Water is slowly added from a dropping funnel
- Fizzing will occur in the reaction flask as the ethyne gas is produced
- The ethyne gas produced is passed through acidified copper sulfate to remove impurities
- The pure ethyne gas is collected over water

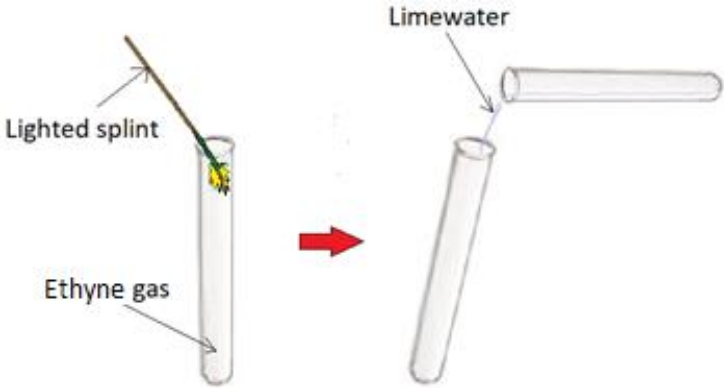


Examining the properties of ethyne

(a) Physical properties:

- Ethyne is a **colourless** gas with a **sweet smell**
- It is **insoluble in water** but **dissolves in non-polar solvents** **Example:** Cyclohexane

(b) Combustion:



- Place a lighted splint into a test tube of ethyne gas
- Add limewater to the test tube, stopper and shake

Result:

i) Ethyne burns with a **very bright, very smoky yellow flame, with a lot of soot formed as a result of unburnt carbon**

ii) **Limewater** turns **milky white** proving **carbon dioxide** was **formed** in the combustion

Q: Compare the flame observed when combusting ethene and ethyne

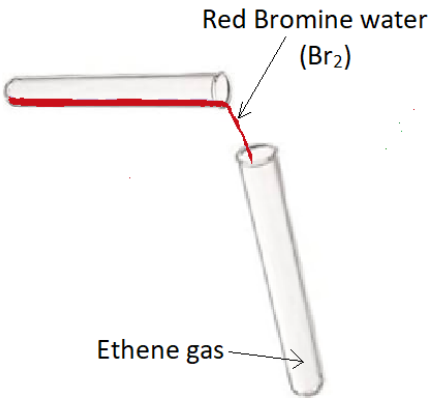
- The flame observed when burning **ethyne is brighter and smokier** than when burning ethene

Q: Write a balanced chemical equation for the complete combustion of ethyne?

$$C_2H_2 + 2\tfrac{1}{2}O_2 \longrightarrow 2CO_2 + H_2O$$

Ethyne Oxygen Carbon Dioxide Water

(c) Testing for unsaturation – Method 1: Using bromine water

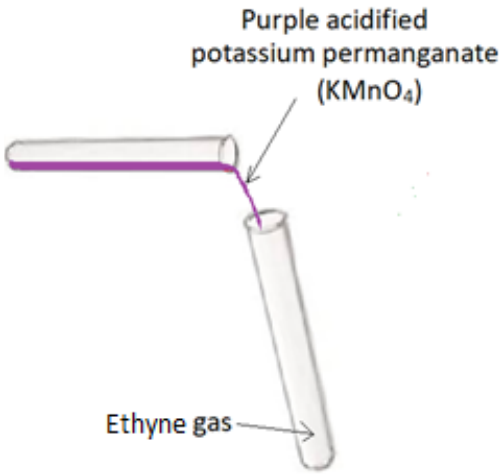


Result:

- **Red** bromine water **turns colourless** – ethyne is unsaturated

- Add red bromine water to a test tube of ethyne gas, stopper and shake

(d) Testing for unsaturation – Method 2: Using acidified potassium permanganate



Result:

- **Purple** acidified potassium permanganate **turns colourless** - ethyne is unsaturated

- Add purple acidified potassium permanganate to a test tube of ethene gas, stopper and shake

Follow up questions

Q: Outline two safety precautions in this experiment

1) Ethyne is **explosive with air**- keep any **naked flame away from** the **apparatus**
2) Use a spatula to place **calcium dicarbide** into the flask- can be an **irritant to skin**

Q: Describe the appearance of calcium carbide

- Calcium carbide is a **grey-black solid**

Q: Give three observations in the reaction flask as the reaction proceeds

1. **Fizzing** is observed
2. A **white substance** forms
3. The **reaction flask gets hot**

Q: Explain why fizzing occurs in the reaction flask

- Ethyne gas is produced

Q: Explain the white substance that forms in the flask as the reaction proceeds

- The white substance forms as a result of the **production of calcium hydroxide ($Ca(OH)_2$)**

Q: Explain why the flask gets warm as the reaction proceeds

- The **reaction** between calcium carbide and water is **exothermic** (gives out heat)

Q: Why must the products of the reaction be passed through acidified copper sulfate?

- The ethyne formed will not be pure, passing it through acidified copper sulfate **removes impurities**

Q: Name three impurities that could be present in the ethyne gas produced that are removed by the acidified copper sulfate?

1. Hydrogen sulfide
2. Phosphine
3. Ammonia

Q: Explain why these impurities may be present in the ethyne gas produced

- Calcium carbide is often contaminated with calcium sulfide, calcium phosphide and calcium nitride

Q: Why are the first few test tubes of gas collected discarded?

- The first few test tubes **consist mostly of displaced air** and not ethyne gas

Q: Give an industrial application of ethyne

- Ethyne is a gas that is used in oxyacetylene **welding and cutting** – when ethyne is burned in oxygen it burns at extremely high temperatures (> 3000°C)

Calculation:

Q: The mass of calcium carbide consumed in the preparation of ethyne was 3.2 g. The equation for the reaction is as follows:

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

Calculate the maximum theoretical number of ethyne molecules produced in this reaction.

(2017 Q2 (e))

CaC_2 : 3.2g grams ⟶ moles

$\frac{3.2g}{64} = 0.05 mol\ CaC_2$

Mr CaC_2
$40+12(2)$
$=64$

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

molar ratio 1 2 1 1

actual moles 0.05 0.05

C_2H_2 : moles ⟶ molecules

$0.05 mol \times 6 \times 10^{23} = 3 \times 10^{22}\ C_2H_2$ molecules produced

Organic chemistry – Families 1 – Questions

Q1:

a) **What is organic chemistry?**

b) **What is meant by a homologous series?**

c) **Name the eight homologous series studied in leaving cert chemistry.**

d) **What are hydrocarbons?**

Q2:

a) **What is the general formula of the alkanes?**

b) **Alkanes are saturated compounds. Explain the underlined term.**

c) **Give the IUPAC systematic name of the first three members of the alkanes. For each member named, give its molecular formula and draw its structural formula**

d) **Give the IUPAC systematic name, the molecular formula, and draw the structural formula of the unbranched sixth member of the alkane family**

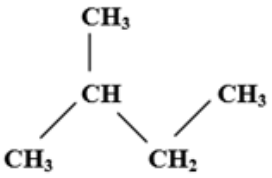
e) **Give the IUPAC systematic name, the molecular formula, and draw the structural formula of the unbranched seventh member of the alkane family**

f) **Give the IUPAC systematic name, the molecular formula, and draw the structural formula of the unbranched eight member of the alkane family**

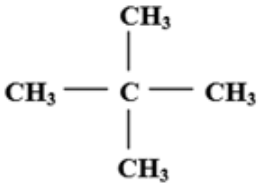
g) **Give the IUPAC systematic name of a cyclic member of the alkane family. Write the molecular formula and draw the structural formula of this member. Give a widespread application of this member of the alkanes**

h) ***Give the IUPAC names of the following:**

i. $CH_3(CH_2)_2CH_3$
ii. $CH_3(CH_2)_5CH_3$
iii. $CH_3CH(CH_3)CH_2CH_3$
iv. $CH_3C(CH_3)_2CH_2CH(CH_3)CH_3$
v. $CH_3CH(CH_3)CH_2C(CH_3)_2CH_3$
vi.



v.



i) *Draw the structural formula of each of the following:

i. Methylpropane

ii. Methylbutane

iii. Dimethylpropane

iv. Octane

v. 2,2,4-trimethylpentane

How are compounds ii. and iii. related?

Identify another pair of molecules in the list that are related in the same way

j) What are structural isomers?

k) *Give the IUPAC systematic names of two structural isomers of the fourth member of the alkane series and draw the structural formula of each

l) *Give the IUPAC systematic names of three structural isomers of the fifth member of the alkane series and draw the structural formula of each

m) Explain why the first four members of the alkanes exist as gases at room temperature

n) Ethane has a boiling point of – 89 ˚C while pentane has a boiling point of 36.1 ˚C. Account for pentane's higher boiling point.

o) Comment on the solubility of alkanes in i) water ii) cyclohexane

p) Comment on the geometry around the carbon atoms in alkane molecules

q) What is a sigma bond?

r) Explain how only sigma bonding is found between the carbons in the alkanes.

s) Give two applications of the alkanes

Q3:

a) **What are chloroalkanes?**

b) ***Draw the structural formula of:**

i. **Chloromethane**

ii. **Dichloromethane**

iii. **Trichloromethane**

iv. **Tetrachloromethane**

v. **1,2-dichloroethane**

vi. **1,1,2-trichloroethane**

vii. **2-chloro-2-methylpropane**

c) ***Chloroform is no longer used as an anaesthetic in hospitals. A less toxic and less flammable compound commonly called halothane $F_3CCHCLBr$, is now used. The systematic name for halothane is 2-bromo-2 chloro-1,1,1 -trifluoroethane. Draw the structural formula of a molecule of this compound.**

d) ***Give the IUPAC names the following compounds:**

i. CCl_4

ii. CH_3CHCl_2

iii. CH_2ClCH_2Cl

iv. $CH_3CH_2CHClCH_3$

v. $CH_2ClCH_2CH_2CH_2Cl$

e) **The boiling point of butane is -1^oC while the boiling point of chlorobutane is 78.5^oC. Account for the lower boiling point of butane.**

f) **Comment of the solubility of chloroalkanes.**

g) **Give two uses of chloroalkanes.**

Q4:

a) **What is the general formula of the alkenes?**

b) **The alkenes are unsaturated compounds. Explain the underlined term.**

c) **Give the IUPAC systematic name of the first two members of the alkanes. For each member named, give its molecular formula and draw its structural formula**

d) ***Give the IUPAC names of the following compounds:**

i. CH_2CHCH_3
ii. CH_3CHCH_2
iii. $CH_2CHCH_2CH_3$
iv. $CH_3CHCHCH_3$
v. $CH_3CH_2CHCH_2$
vi. $CH_2CCH_3CH_3$
vii. $CH_3CCH_3CH_2$

e) ***Draw the structural formula of each of the following:**

i. **Methylpropene**

ii. **But –1– ene**

iii. **But –2– ene**

How are compounds i., ii. and iii. related?

f) ***Give the IUPAC systematic names of three structural isomers of the third member of the alkene series and draw the structural formula of each**

g) **Explain why the first four members of the alkenes exist as gases at room temperature while higher members are liquids**

h) **Explain why alkenes are poorly water soluble and highly soluble in cyclohexane.**

i) **Comment on the geometry around the carbon atoms in alkene molecules**

j) **What is a pi bond?**

k) **Explain how sigma bonding and pi bonding are found between the carbons in the alkenes.**

l) **Account for the greater reactivity of the alkenes compared to their corresponding alkanes.**

m) **Give two applications of the alkenes**

Q5:

a) Draw a labelled diagram of the apparatus assembled to prepare ethene in the laboratory.

b) Write a balanced chemical equation for the reaction involved when preparing ethene

c) What name is given to the type of reaction involved when preparing ethene?

d) How is the ethanol kept in the test tube?

e)

i. What solid is placed in the test tube?
ii. Give two functions of this solid
iii. What is the precise appearance of this solid?

f) Why is this powder heated gently and the ethanol itself is not heated?

g) Give three safety precautions in this experiment

h) Why is it important that the apparatus is raised from the water before heat source is turned off before?

i) Why are the first test tubes of gas collected discarded?

j) Give an industrial use of ethene gas.

k) Give two physical properties of the ethene gas collected

l) A lighted splinter was placed in a test tube of ethene gas collected. A sample of limewater was then added to the products of the combustion.

i. Describe how the ethene burned
ii. Write a balanced chemical equation for the combustion of ethene.
iii. What is the chemical name and chemical formula of limewater?
iv. What is observed when the limewater is added to the products of the ethene combustion?
v. Write a balanced chemical equation to show why this (from iv.) is observed.

m) Ethene is n unsaturated compound. Describe <u>two</u> tests that can be performed on the ethene gas to show this including what would be observed.

n)

i. Write a balanced chemical equation for the reaction between ethene gas and bromine
ii. What type of reaction occurs between ethene and bromine
iii. Name the product formed from the reaction between ethene and bromine

o) *2019

A student prepared ethene, starting with 2.9 cm^3 of ethanol (density 0.8 g cm^{-3}). Calculate the volume of ethene gas produced in 26% yield when measured at room temperature and pressure.

Q6:

a) **What is the general formula of the alkynes?**

b) **Explain why the alkynes are unsaturated compounds.**

c) **Explain how sigma bonding and pi bonding are found between the carbons in the alkynes**

d) **Give the IUPAC systematic name of the first member of the alkynes. Give its molecular formula and draw its structural formula.**

e) **What is the common name for this first member of the alkynes?**

f) **Explain why this alkyne is poorly water soluble but is highly soluble in cyclohexane**

g) **Give an industrial use of this alkyne.**

Q7:

a) **Draw a labelled diagram of the apparatus assembled to prepare ethyne in the laboratory.**

b) **Write a balanced chemical equation for the reaction involved when preparing ethyne**

c) **Give two safety precautions in this experiment.**

d)
   i. **What solid is used in this experiment?**
   ii. **Describe the precise appearance of this solid**

e) **Explain the white colour that forms as the reaction proceeds**

f) **Explain why the conical flask gets warm as the reaction proceeds**

g) **Name three impurities that could be present in the ethyne gas produced and explain why these impurities may be present**

h) **What substance is the ethyne gas passed through? Explain why ethyne gas is passed through this substance**

i) **Why are the first few test tubes of gas collected discarded?**

j) **Describe the appearance of the ethyne gas collected**

k) **A lighted splinter was placed in a test tube of ethene gas collected**

i. **Describe how the ethyne burned**
ii. **Compare the flame observed when combusting ethyne to combusting ethene**
iii. **Account for the soot produced when combusting ethyne**
iv. **Write a balanced chemical equation for the combustion of ethyne**
v. **Ethyne is an unsaturated compound. Describe two tests that can be performed on the ethyne gas to show this, including what would be observed.**

l) ***The mass of calcium carbide used in the preparation of ethyne was 4.8 g.**
If an 80 % yield of ethyne gas was obtained calculate the volume that could be collected at room temperature

Calculations/Working out answers:

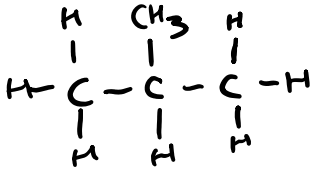
Q2:

h)

i. **Butane**
ii. **Heptane**
iii. **Methylbutane (2-methylbutane)**
iv. **2,2,4-trimethylpentane**
v. **2,2,4-trimethylpentane**
vi. **Methylbutane (2-methylbutane)**
vii. **Dimethylpropane (2,2-dimethylpropane)**

i)

i.



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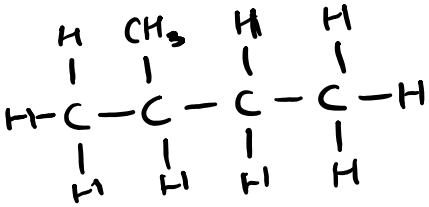

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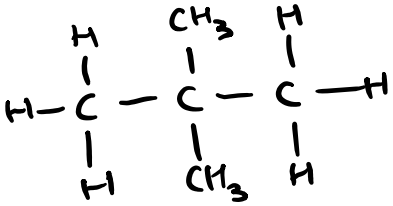

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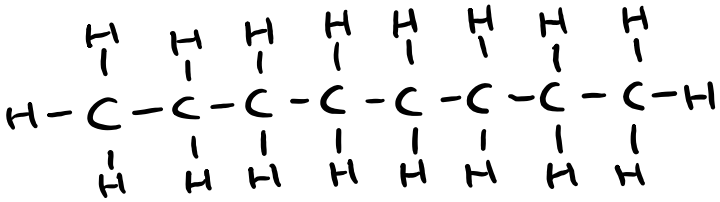

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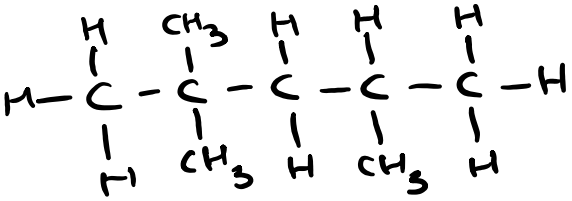
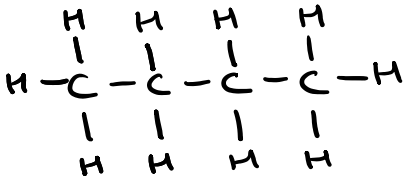


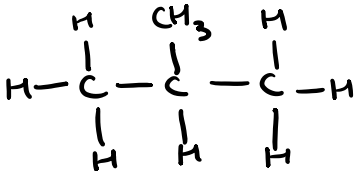
Compounds ii. and iii. are structural isomers

Compounds iv. and v. are also structural isomers

k)

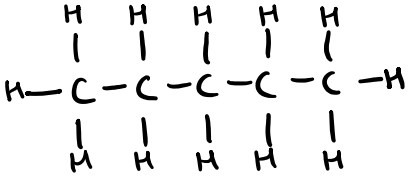


Butane

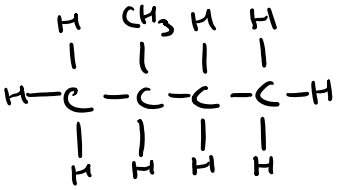


2-methylpropane

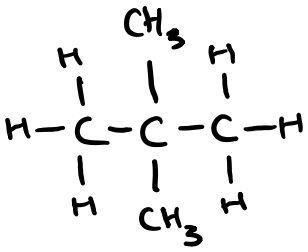
j)



Pentane



2-methylbutane

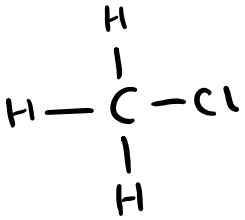


2,2-dimethylpropane

Q3:

b)

i.



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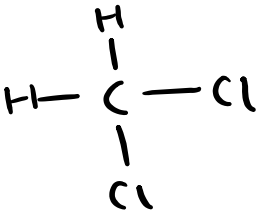

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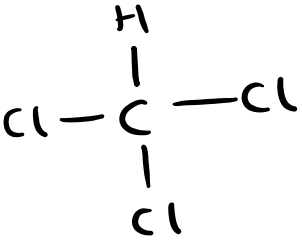

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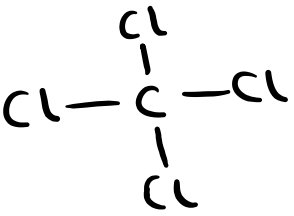

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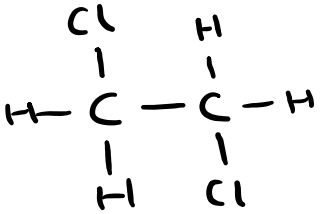

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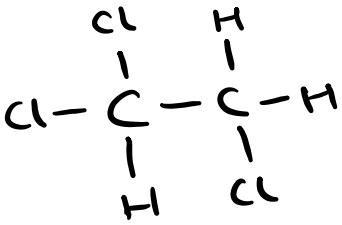

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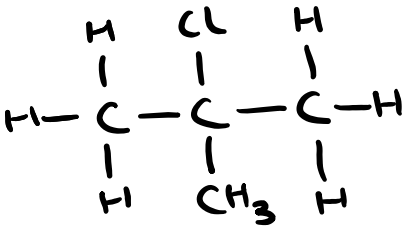
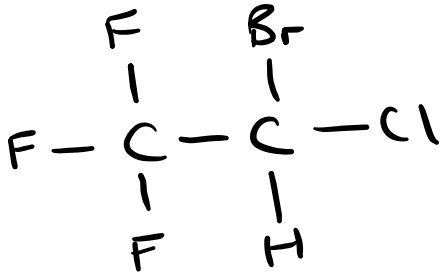


c)



d)

i. Tetrachloromethane
ii. 1,1-dichloroethane
iii. 1,2-duchloroethane
iv. 2-chlorobutane
v. 1,4-dichlorobutane

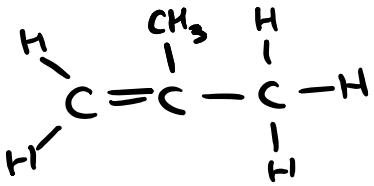
Q4:

d)

i. Propene
ii. Propene
i. But – 1 – ene
ii. But – 2 – ene
iii. But – 1 – ene
iv. Methylpropene
v. Methylpropene

e)

i.



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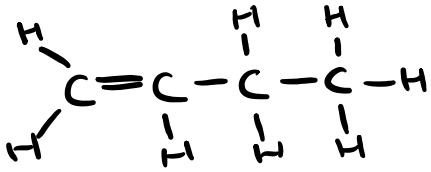
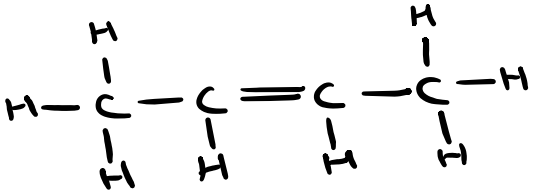
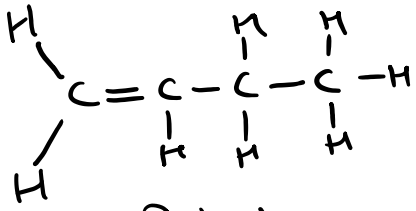


iii.

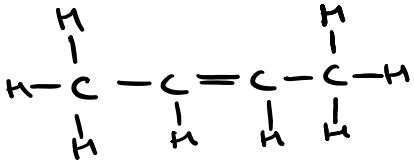


Compounds i. ii. and iii. are structural isomers

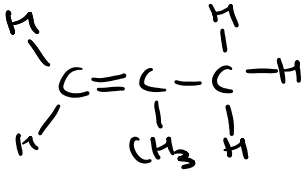
f)



But-1-ene



But-2-ene



2-methylpropene

Q5: **o)** **300 to 315** cm^3 / **0.300 to 0.315** litres

Q7: **l)** **1.44 litres** **or** **1,440** cm^3