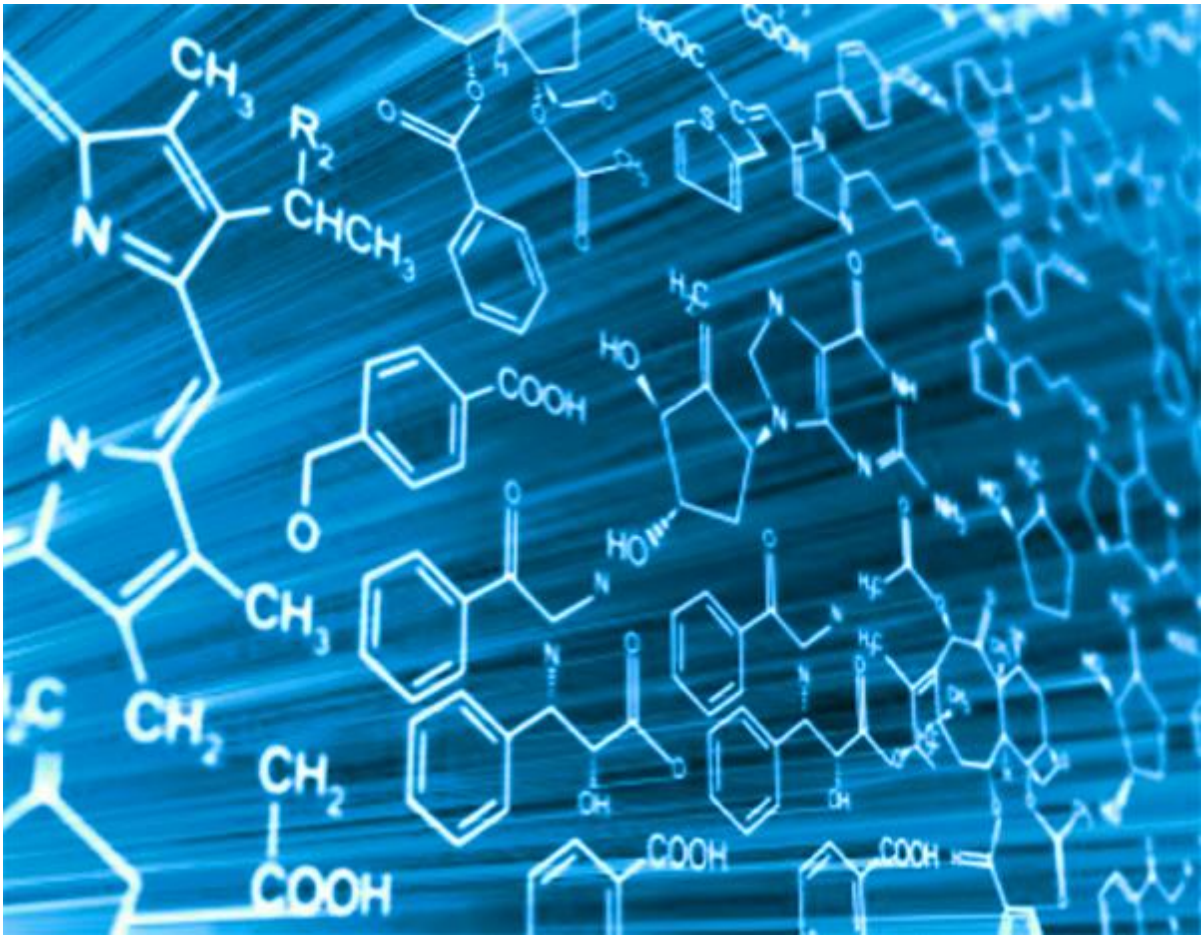
National 5 Chemistry

Unit 2 – Nature's Chemistry
Summary Notes



Success Criteria

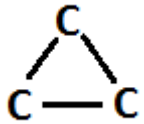
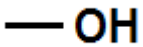
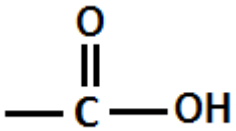
✓	I am confident that I understand this and I can apply this to problems
?	I have some understanding but I need to revise this some more
×	I do not understand this and I need help with it

I will be successful if I can…		Self-Evaluation		
1	Name the elements present in a hydrocarbon	✓	?	x
2	Describe the solubility of hydrocarbons in water	✓	?	x
3	Define a homologous series	✓	?	x
4	Give examples of different homologous series	✓	?	x
5	Write the general formula for the alkanes	✓	?	x
6	Name the alkanes containing up to 8 carbon atoms	✓	?	x
7	Write the molecular formula for the alkanes containing up to 8 carbon atoms	✓	?	x
8	Draw the full structural formula for the alkanes containing up to 8 carbon atoms	✓	?	x
9	Describe the term saturated	✓	?	x
10	Give examples of uses of alkanes and explain the properties of the alkanes that make them suitable for this	✓	?	x
11	Write the general formula for the alkenes	✓	?	x
12	Name the alkenes containing up to 8 carbon atoms	✓	?	x
13	Write the molecular formula for the alkenes containing up to 8 carbon atoms	✓	?	x
14	Draw the full structural formula for the alkenes containing up to 8 carbon atoms	✓	?	x
15	Describe the term unsaturated	✓	?	x
16	Give examples of uses of alkenes and explain the properties of the alkenes that make them suitable for this	✓	?	x
17	Write the general formula for the cycloalkanes	✓	?	x
18	Name the cycloalkanes containing up to 8 carbon atoms	✓	?	x
19	Write the molecular formula for the cycloalkanes containing up to 8 carbon atoms	✓	?	x
20	Draw the full structural formula for the cycloalkanes containing up to 8 carbon atoms	✓	?	x
21	Describe the test for unsaturation/saturation	✓	?	x
22	Systematically name a branched chain alkane	✓	?	x

23	Systematically name a branched chain alkene indicating the position of the double bond	✓	?	x
24	Define an isomer	✓	?	x
25	Identify isomers from given structures	✓	?	x
26	Draw isomers of a given structure	✓	?	x
27	Give examples of addition reactions of alkenes	✓	?	x
28	Identify the products of an addition reaction	✓	?	x
29	Draw the products of an addition reaction	✓	?	x
30	Name the products of an addition reaction	✓	?	x
31	Identify a hydroxyl group	✓	?	x
32	Write the general formula of the alcohols	✓	?	x
33	Name the alcohols containing up to 8 carbon atoms	✓	?	x
34	Systematically name alcohols indicating the position of the hydroxyl group	✓	?	x
35	Write the molecular formula for the alcohols containing up to 8 carbon atoms	✓	?	x
36	Draw the full structural formula for the alcohols containing up to 8 carbon atoms	✓	?	x
37	Give examples of uses of alcohols and explain the properties of the alcohols that make them suitable for this	✓	?	x
38	Describe the relationship between the size of the alcohol and its solubility	✓	?	x
39	Explain the relationship between the size of the alcohol and its melting point and boiling point in terms of the strength of intermolecular forces	✓	?	x
40	Identify a carboxyl group	✓	?	x
4	Write the general formula of the carboxylic acids	✓	?	x
42	Name the carboxylic acids containing up to 8 carbon atoms	✓	?	x
43	Write the molecular formula for the carboxylic acids containing up to 8 carbon atoms	✓	?	x
44	Draw the full structural formula for the carboxylic acids containing up to 8 carbon atoms	✓	?	x
45	Give examples of uses of carboxylic acids and explain the properties of the carboxylic acids that make them suitable for this	✓	?	x
46	Describe the relationship between the size of the alcohol and its solubility	✓	?	x
47	Explain the relationship between the size of the carboxylic acid and its melting point and boiling point in terms of the strength of intermolecular forces	✓	?	x

48	Describe a combustion reaction	✓	?	x
49	Define the term exothermic	✓	?	x
50	Write balanced chemical equations for combustion reactions	✓	?	x
51	Use E=cmΔT to calculate the energy released when a fuel is burned	✓	?	x
52	Carry out calculations from balanced chemical equations	✓	?	x

Homologous Series Summary Table

	Naming	Features	
Alkanes	-ANE	Only single bonds	
Alkenes	-ENE	Contain double bonds	
Cycloalkanes	CYCLO- -ANE	Chain of carbon atoms join	
Alcohols	-OL	Contain a hydroxyl group	
Carboxylic Acids	-OIC ACID	Contain a carboxyl group	

Key Area 2.1 – Hydrocarbons

Hydrocarbons

- Hydrocarbons are molecules containing only hydrogen and carbon
    - hydrocarbons are insoluble in water
- A homologous series is a family of hydrocarbons with similar chemical properties and the same general formula
- Alkanes and alkenes are examples of homologous series of hydrocarbons

Naming Hydrocarbons

- When we name hydrocarbons, the prefix tells us how many carbon atoms are in the chain

Prefix	Number of Carbon atoms
Meth	1
Eth	2
Prop	3
But	4
Pent	5
Hex	6
Hept	7
Oct	8

Full Structural Formula

- The full structural formula of a molecule shows how the atoms are arranged including the bonds made and elements present
- It is important to remember that carbon atoms have to make 4 bonds and hydrogen atoms can make only one bond

Molecular Formula

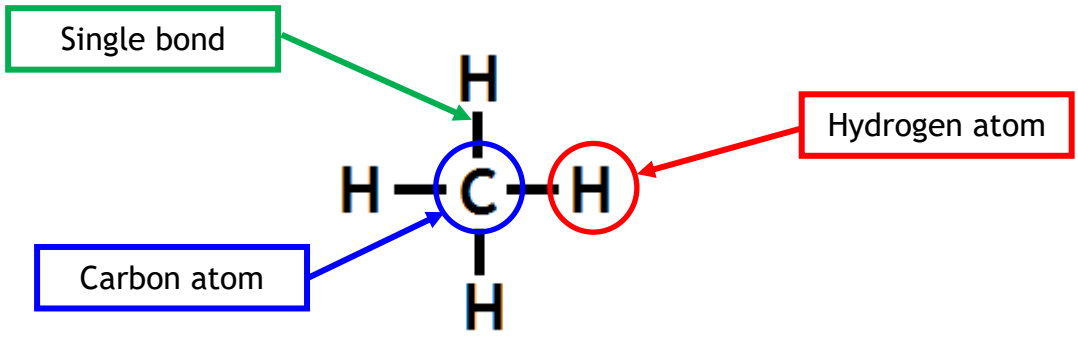
- The molecular formula of a molecule states how many atoms of each element are present in the molecule
- The elements are represented by their elemental symbol

Alkanes

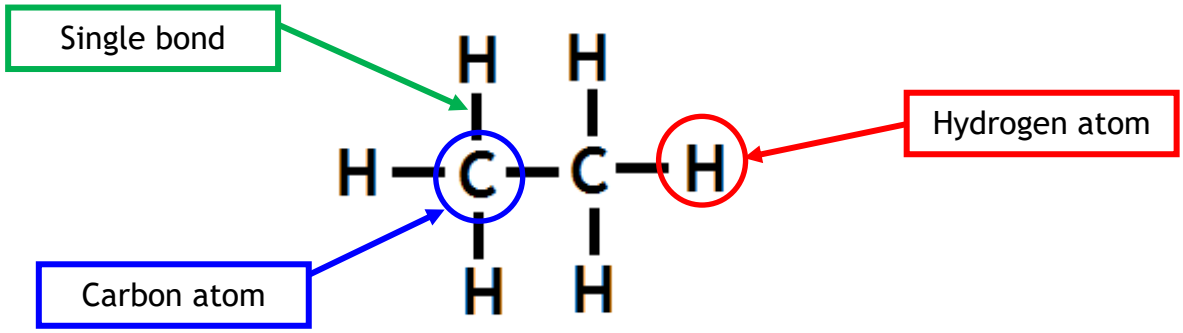
- Have the general formula C_nH_{2n+2}
- Are saturated – they contain only single C-C bonds
- Have no reaction with bromine water (bromine water remains yellow)
- Alkanes are commonly found in fuels, they can be burned to release energy
- The names, number of carbons and molecular formula for the alkanes are shown in the table below

Name	*No. of carbons*	*Molecular formula*
methane	1	CH_4
ethane	2	C_2H_6
propane	3	C_3H_8
butane	4	C_4H_{10}
pentane	5	C_5H_{12}
hexane	6	C_6H_{14}
heptane	7	C_7H_{16}
octane	8	C_8H_{18}

- The diagram below shows the full structural formula of methane



- The diagram below shows the full structural formula of ethane

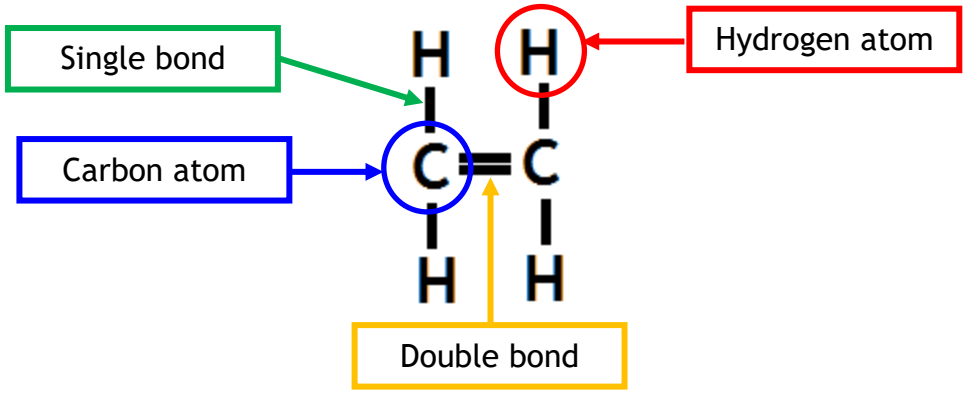


Alkenes

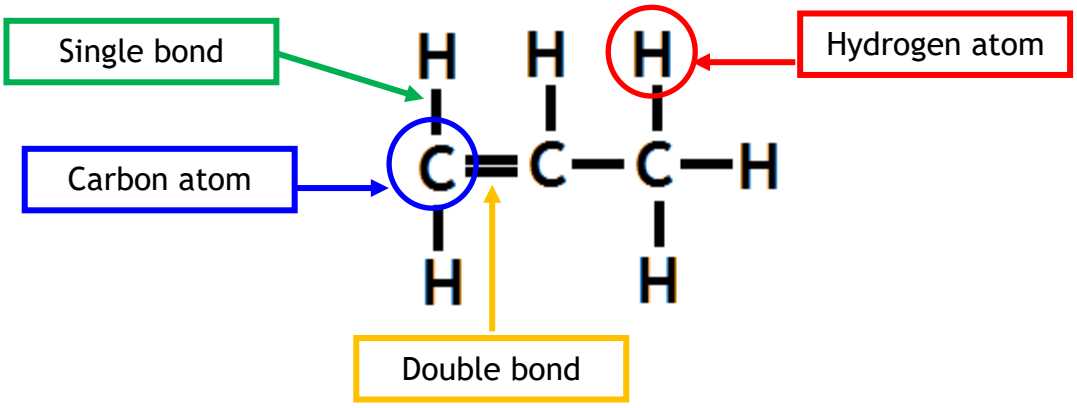
- Have the general formula C_nH_{2n}
- Are unsaturated – they contain C=C double bonds
- Rapidly decolourise bromine water (bromine water changes from yellow to colourless)
- Alkenes can be used in the production of plastics due to the presence of the double bond
- The names, number of carbons and molecular formula for the alkenes are shown in the table below

Name	*No. of carbons*	*Molecular formula*
ethene	2	C_2H_4
propene	3	C_3H_6
butene	4	C_4H_8
pentene	5	C_5H_{10}
hexene	6	C_6H_{12}
heptene	7	C_7H_{14}
octene	8	C_8H_{16}

- The diagram below shows the full structural formula of ethene



- The diagram below shows the full structural formula of propene

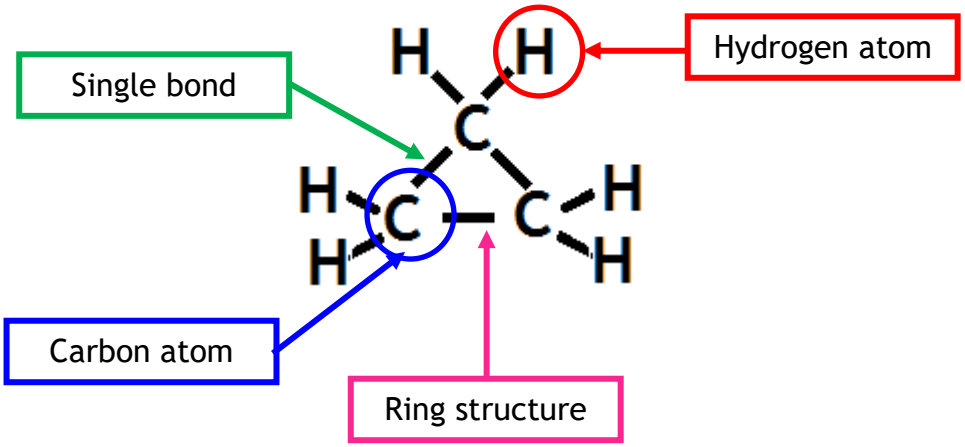


Cycloalkanes

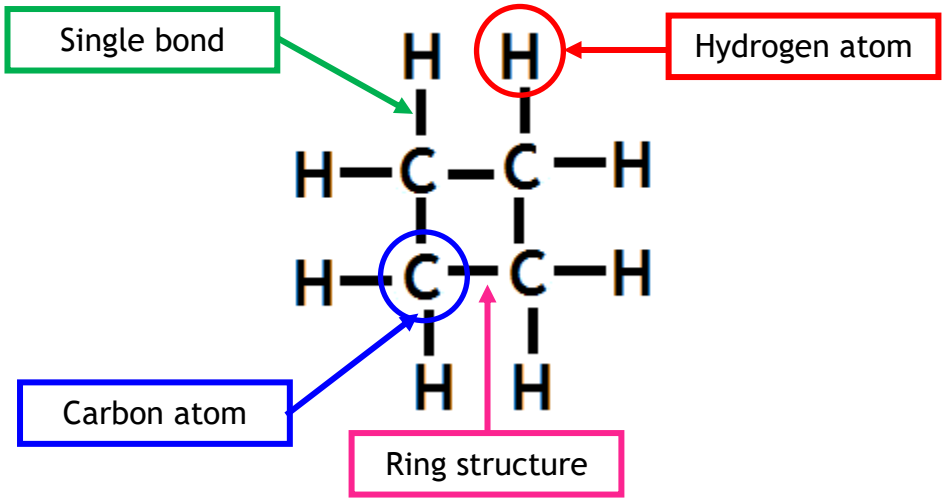
- Have the general formula C_nH_{2n}
- Are saturated – they contain only single C-C bonds
- Have no reaction with bromine water (bromine water remains yellow)
- The names, number of carbons and molecular formula for the cycloalkanes are shown in the table below

Name	*No. of carbons*	*Molecular formula*
cyclopropane	3	C_3H_6
cyclobutane	4	C_4H_8
cyclopentane	5	C_5H_{10}
cyclohexane	6	C_6H_{12}
cycloheptane	7	C_7H_{14}
cyclooctane	8	C_8H_{16}

- The diagram below shows the full structural formula of cyclopropane.



- The diagram below shows the full structural formula of cyclobutane.



Systematic Naming

- Systematic naming is used to give more information about the structure of the molecule
  - It can be used to indicate the position of branches
  - It can be used to indicate the position of a double bond

Naming a branched alkane

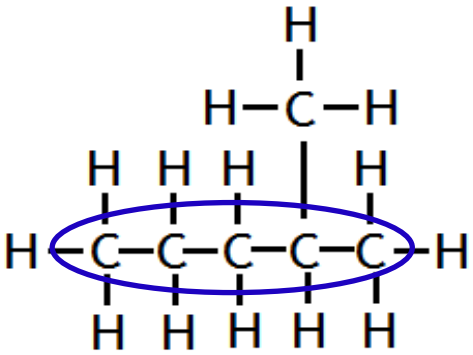
1. Identify the longest chain of carbon atoms and name after the appropriate alkane
2. Number the carbon atoms starting from the end of the chain closest to the branch
3. Name the branch from the number of carbon atoms in the branch

Number of carbon atoms in branch	Name of branch
1	**methyl**
2	**ethyl**
3	**propyl**

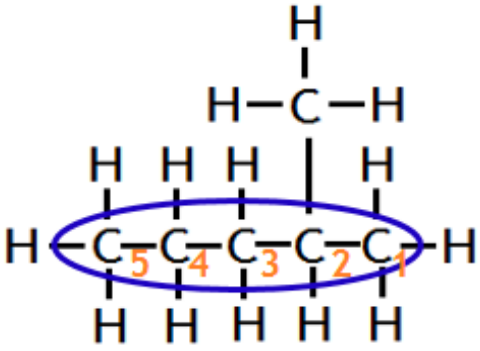
4. Use 'di' and 'tri' as a prefix to the branch name when there are more than one of that branch in the molecule
5. Add position of branch, name of branch and name of longest chain together

- **For example,**

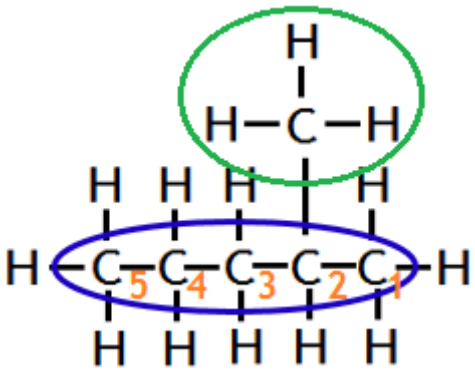
1. Longest chain of 5 carbon atoms, ***PENTANE***



2. ***Number the carbons*** in the longest chain

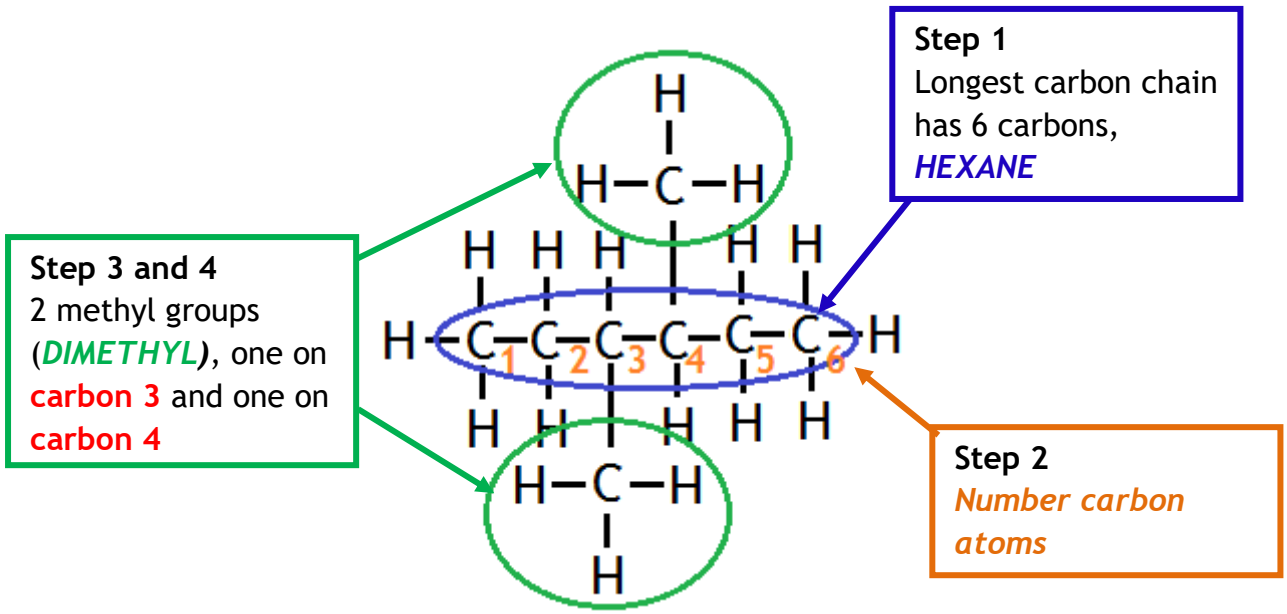


3. Branch on **carbon 2** has 1 carbon atom, ***METHYL***



4. Only one branch so ***does not*** require 'di' or 'tri'
5. The systematic name of this structure is **2-methylpentane**

- **For example,**



Step 5 The systematic name of this structure is **3,4-dimethylhexane**

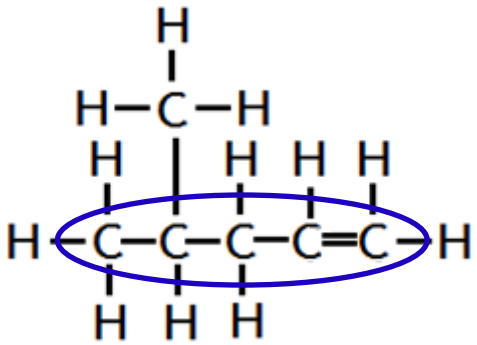
Naming a branched alkene

1. Identify the longest chain of carbon atoms containing the double bond and name after the appropriate alkene
2. Number the carbon atoms starting from the end of the chain closest to the double bond
3. Identify the position of the double bond
4. Name the branch from the number of carbon atoms in the branch

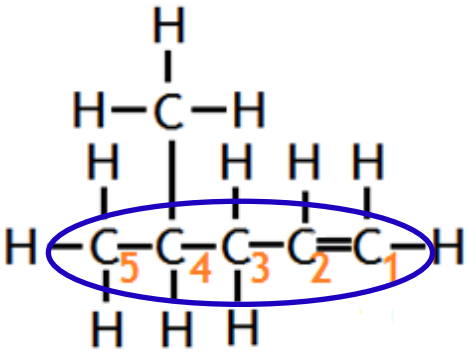
Number of carbon atoms in branch	Name of branch
1	**methyl**
2	**ethyl**
3	**propyl**

5. Use 'di' and 'tri' as a prefix to the branch name when there are more than one of that branch in the molecule
6. Add position of branch, name of branch, position of double bond and name of longest chain together

- **For example,**
  1. Longest chain of 5 carbon atoms, ***PENTENE***

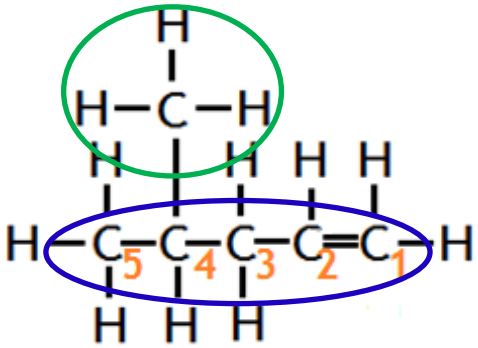


  2. ***Number the carbons*** in the longest chain



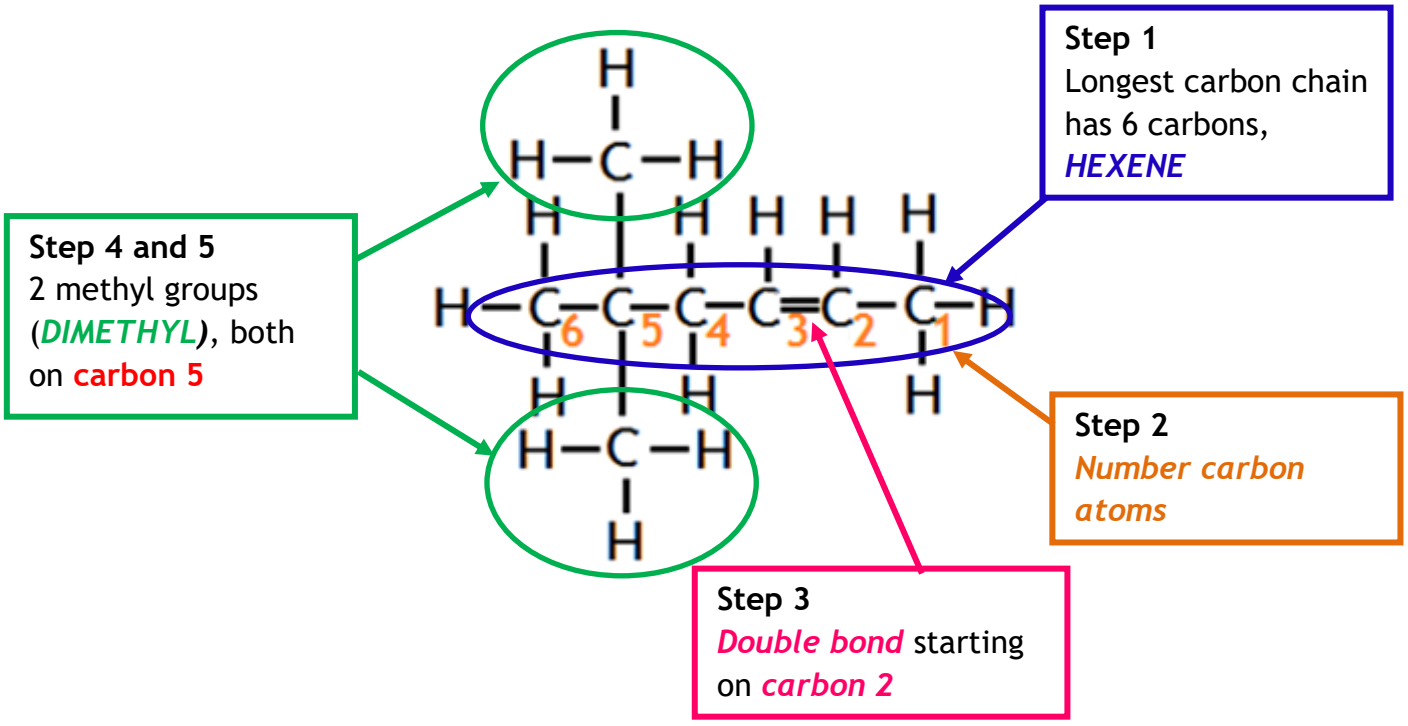
  3. ***Double bond*** starting on ***carbon 1***

4. Branch on **carbon 4** has 1 carbon atom, ***METHYL***



5. Only one branch so ***does not*** require 'di' or 'tri'
6. The systematic name of this structure is **4-methylpent-1-ene**

- **For example,**

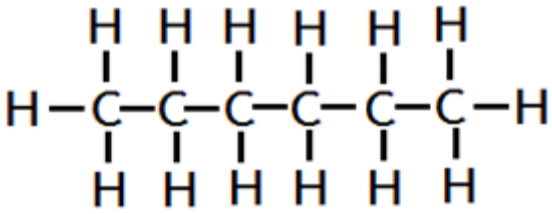


Step 6 The systematic name of this structure is **5,5-dimethylhex-2-ene**

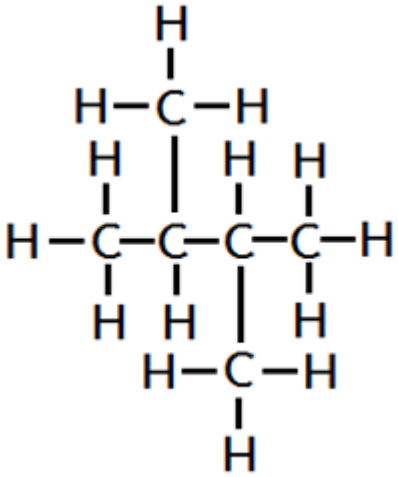
Isomers

- Isomers are molecules with the same molecular formula and different structural formula
- Isomers can have different properties including melting point and boiling point
- To determine if structures are isomers
    1. Write the molecular formula for each structure
    2. Write the systematic name for each structure

- **For example,**



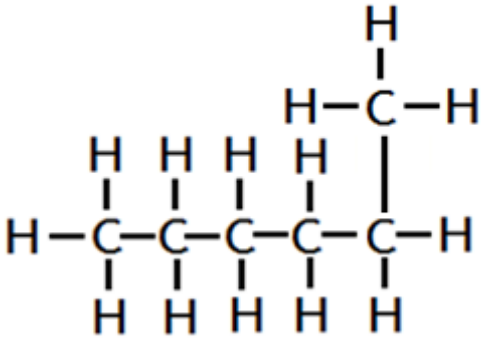
1. C_6H_{14} 2. **hexane**



1. C_6H_{14} 2. 2,3-dimethyl**butane**

This structure has the same molecular formula and a different structural formula

This is an isomer of hexane

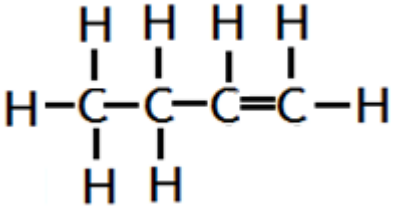


1. C_6H_{14} 2. **hexane**

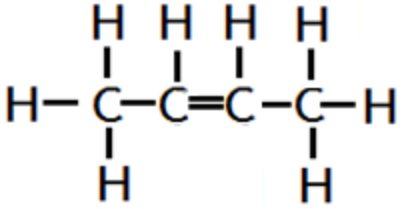
This structure has the same molecular formula and the same structural formula

This is NOT an isomer of hexane

- **For example,**



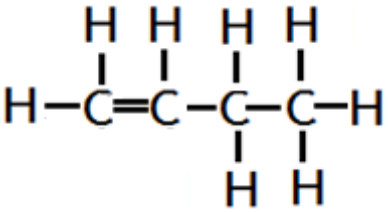
1. C_4H_8 2. **but-1-ene**



1. C_4H_8 2. **but-2-ene**

This structure has the same molecular formula and a different structural formula

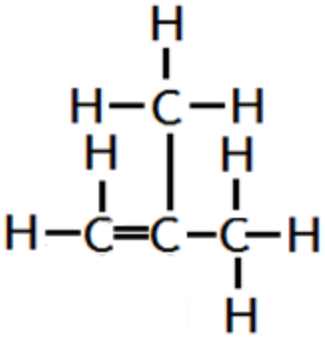
This is an isomer of but-1-ene



1. C_4H_8 2. **but-1-ene**

This structure has the same molecular formula and the same structural formula

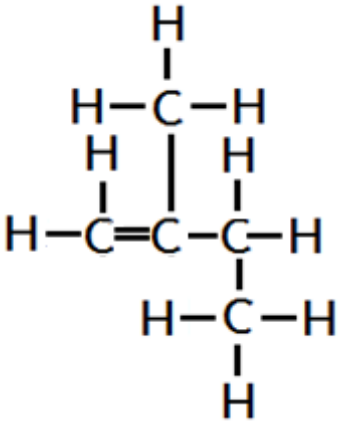
This is NOT an isomer of but-1-ene



1. C_4H_8 2. **2-methylprop-1-ene**

This structure has the same molecular formula and a different structural formula

This is an isomer of but-1-ene



1. C_5H_{10} 2. **2-methylbut-1-ene**

This structure has a different molecular formula and a different structural formula

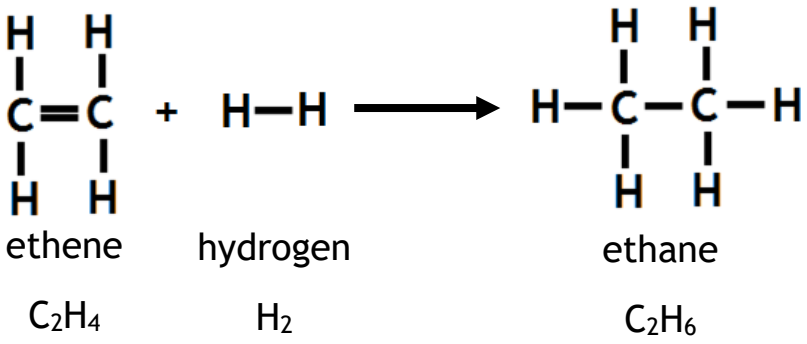
This is NOT an isomer of but-1-ene

Reactions of alkenes

- Alkenes can undergo addition reactions due to the reactive double bond
- There are three addition reactions; hydrogenation, hydration and halogenation

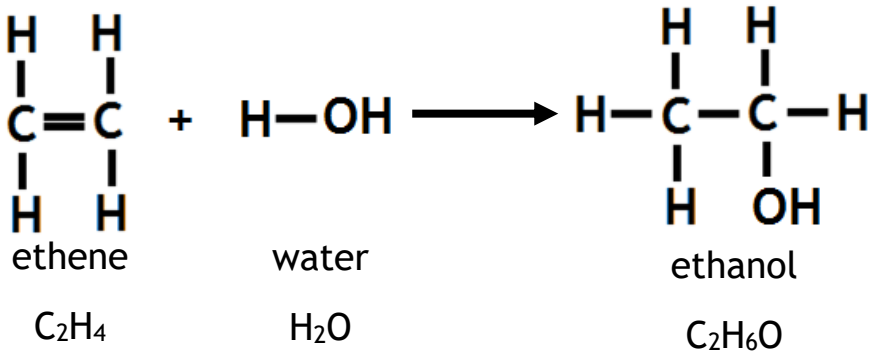
Hydrogenation

- Hydrogenation is the addition of hydrogen across the double bond present in an alkene
- Hydrogenation of an alkene always results in the formation of an alkane
- For example, the reaction of hydrogen with ethene to produce ethane



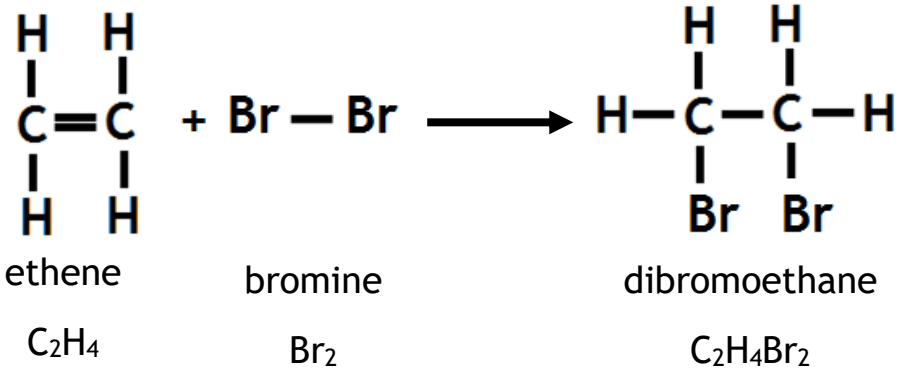
Hydration

- Hydration is the addition of water across the double bond present in an alkene
- Hydration of an alkene always results in the formation of an alcohol
- For example, the reaction of hydrogen with ethene to produce ethanol



Halogenation

- Halogenation is the addition of a halogen molecule across the double bond present in an alkene to produce a dihaloalkane
- For example, the reaction of bromine with ethene to produce dibromoethane



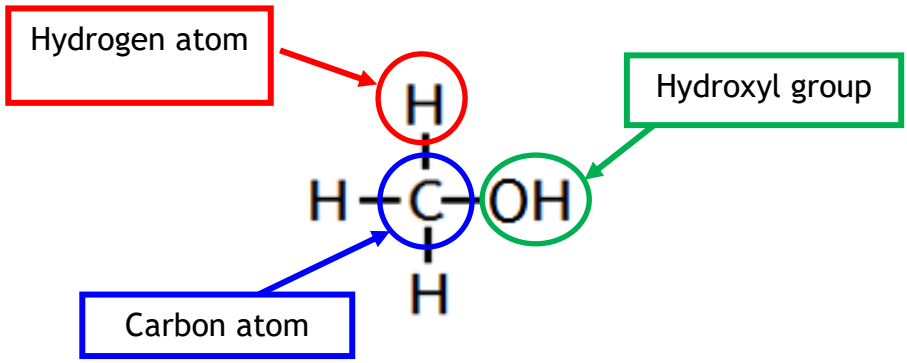
Key Area 2.2 – Everyday Consumer Products

Alcohols

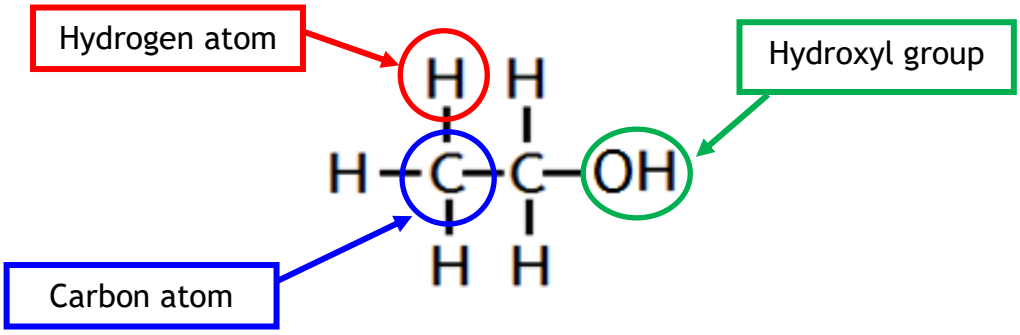
- Have the general formula $C_nH_{2n+1}OH$ ($C_nH_{2n+2}O$)
- Contain a hydroxyl group (-OH) and can be identified by the '-ol' name ending
- The names, number of carbons and molecular formula for the alcohols are shown in the table below

Name	*No. of carbons*	*Molecular formula*
methanol	1	CH_3OH
ethanol	2	C_2H_5OH
propanol	3	C_3H_7OH
butanol	4	C_4H_9OH
pentanol	5	$C_5H_{11}OH$
hexanol	6	$C_6H_{13}OH$
heptanol	7	$C_7H_{15}OH$
octanol	8	$C_8H_{17}OH$

- The diagram below shows the full structural formula of methanol



- The diagram below shows the full structural formula of ethanol



Properties of Alcohols

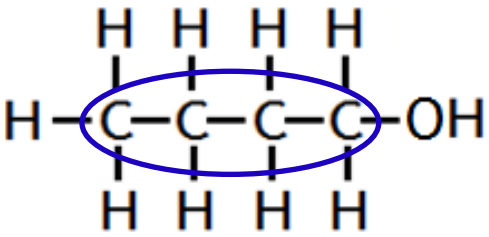
- Alcohols are flammable and can be used as fuels, they can be burned to release energy
- The melting point and boiling point of an alcohol increases as the size increases
  - This is due to an increase in the strength of the intermolecular forces
- The solubility of an alcohol in water decreases as the size increases
  - Methanol, ethanol and propanol are considered miscible in water

Naming Alcohols

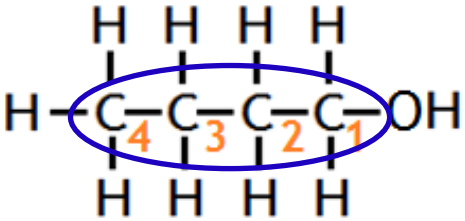
1. Identify the longest chain of carbon atoms containing the hydroxyl group and name after the appropriate alcohol
2. Number the carbon atoms starting from the end of the chain closest to the hydroxyl group
3. Identify the position of the hydroxyl group
4. Add position of hydroxyl group and name of longest chain together

- **For example,**

1. Longest chain of 4 carbon atoms, ***BUTANOL***



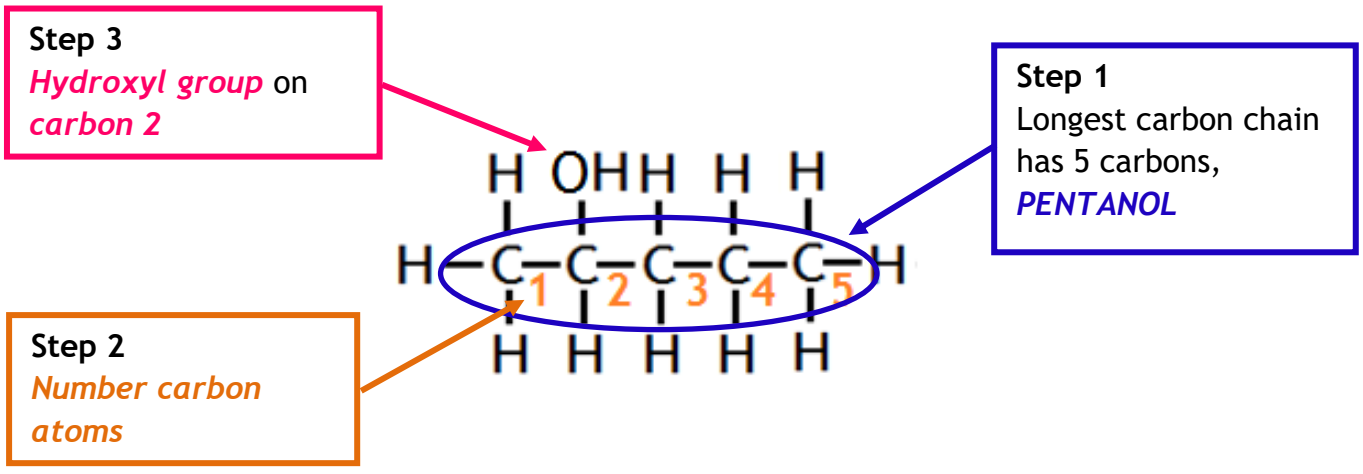
2. ***Number the carbons*** in the longest chain



3. ***Hydroxyl group*** on ***carbon 1***

4. The systematic name of this structure is **butan-1-ol**

- **For example,**



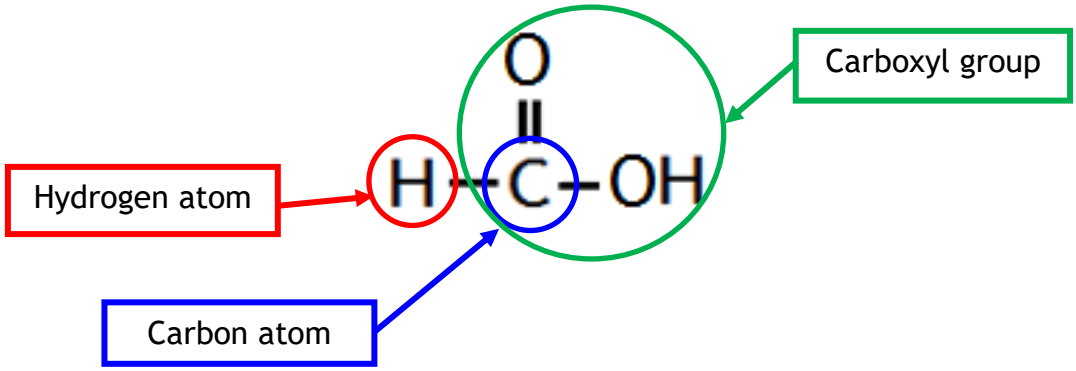
Step 4 The systematic name of this structure is **pentan-2-ol**

Carboxylic Acids

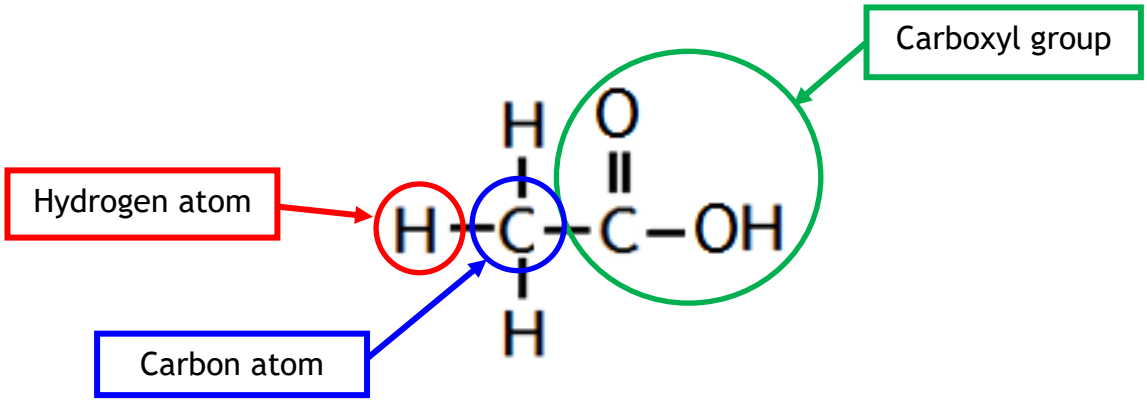
- Have the general formula $C_nH_{2n+1}COOH$ ($C_nH_{2n}O_2$)
- Contain a carboxyl group (-COOH) and can be identified by the '-oic acid' name ending
- Carboxylic acids can be used as solvents or reacted with alcohols to form esters
- Carboxylic acids have a low pH
- The names, number of carbons and molecular formula for the carboxylic acids are shown in the table below

Name	*No. of carbons*	*Molecular formula*
methanoic acid	1	CH_2O_2
ethanoic acid	2	$C_2H_3O_2$
propanoic acid	3	$C_3H_6O_2$
butanoic acid	4	$C_4H_8O_2$
pentanoic acid	5	$C_5H_{10}O_2$
hexanoic acid	6	$C_6H_{12}O_2$
heptanoic acid	7	$C_7H_{14}O_2$
octanoic acid	8	$C_8H_{16}O_2$

- The diagram below shows the full structural formula of methanoic acid



- The diagram below shows the full structural formula of ethanoic acid



  - Ethanoic acid is also known as vinegar
  - Vinegar can be used as a food preservative or used in cleaners to remove lime scale

Properties of Carboxylic Acids

- The melting point and boiling point of a carboxylic acid increases as the size increases
    - This is due to an increase in the strength of the intermolecular forces
- The solubility of a carboxylic acid in water decreases as the size increases
    - Methanoic acid, ethanoic acid and propanoic acid and butanoic acid are considered miscible in water

Key Area 2.3 – Energy from fuels

- Fuels can be burned to release energy
    - This is known as a combustion reaction
    - Combustion reactions are exothermic (give out energy)
    - The fuel reacts with oxygen in the air to produce carbon dioxide and water

Writing combustion equations

- The fuel reacts with oxygen to produce carbon dioxide and water

- For example, the combustion of ethane

    Word equation: ethane + oxygen $\longrightarrow$ carbon dioxide + water

    Chemical equation: $C_2H_6 + O_2 \longrightarrow CO_2 + H_2O$

    Balanced equation: $\mathbf{2}C_2H_6 + \mathbf{7}O_2 \longrightarrow \mathbf{4}CO_2 + \mathbf{6}H_2O$

- For example, the combustion of propane

    Word equation: propane + oxygen $\longrightarrow$ carbon dioxide + water

    Chemical equation: $C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$

    Balanced equation: $C_3H_8 + \mathbf{5}O_2 \longrightarrow \mathbf{3}CO_2 + \mathbf{4}H_2O$

- For example, the combustion of butanol

    Word equation: butanol + oxygen $\longrightarrow$ carbon dioxide + water

    Chemical equation: $C_4H_{10}O + O_2 \longrightarrow CO_2 + H_2O$

    Balanced equation: $C_4H_{10}O + \mathbf{6}O_2 \longrightarrow \mathbf{4}CO_2 + \mathbf{5}H_2O$

- For example, the combustion of pentane

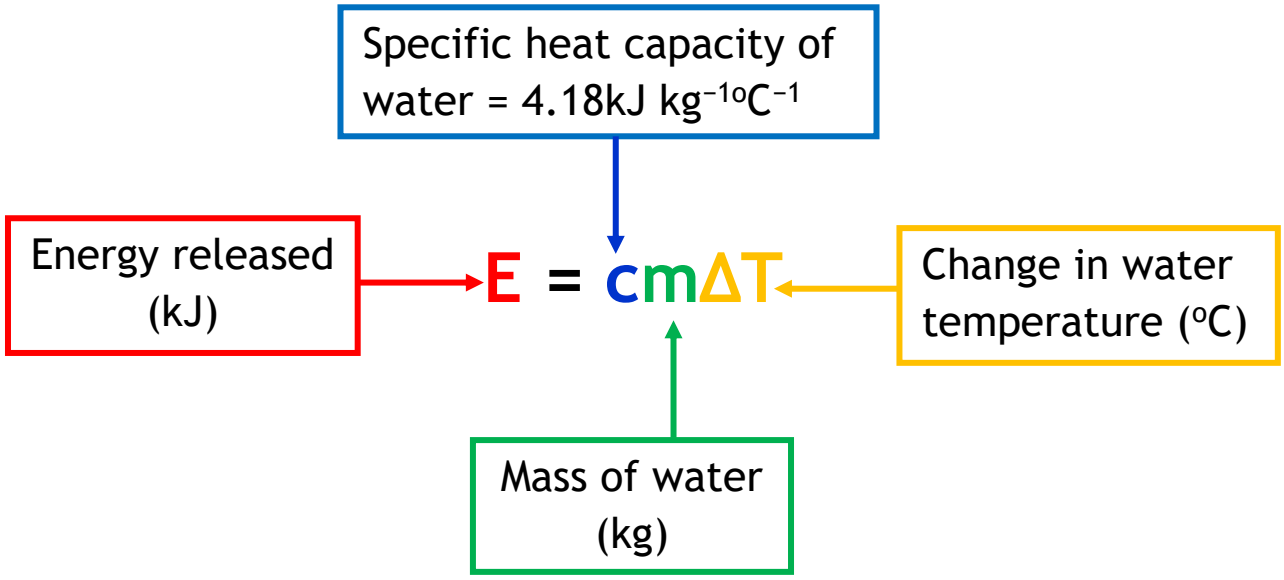
    Word equation: pentane + oxygen $\longrightarrow$ carbon dioxide + water

    Chemical equation: $C_5H_{12} + O_2 \longrightarrow CO_2 + H_2O$

    Balanced equation: $C_5H_{12} + \mathbf{8}O_2 \longrightarrow \mathbf{5}CO_2 + \mathbf{6}H_2O$

Energy released

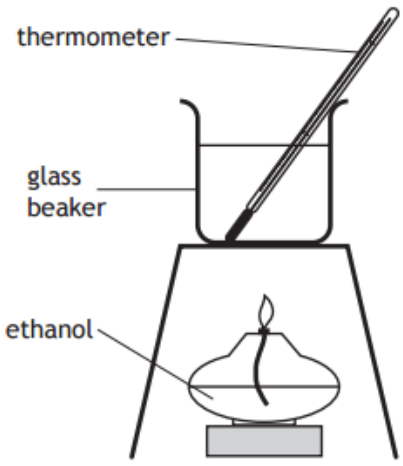
- The energy released from burning a fuel can be calculated using the following equation



- An example is shown below

A student calculated the energy absorbed by water when ethanol is burned. The data below was recorded.

Mass of ethanol burned (kg)	0.5
Volume of water heated (cm^3)	100
Initial temperature of water (°C)	24
Fend temperature of water (°C)	32



Calculate the energy released during this experiment

Conversion
$1cm^3$= 1ml= 1g
1000g = 1kg

E= ?
c = 4.18 $kJkg^{-1}°C^{-1}$
m = 100g = 0.1kg
ΔT = 32-24 = 8°C

E= cmΔT
= 4.18 x 0.1 x 8
= 3.3kJ

Calculations from combustion equations

- It is possible to calculate the concentration/ volume/ mass of a reactant or product required in a reaction
    - A balanced chemical equation is required
    - The mole calculations
- The following steps are used

1. Write a balanced chemical equation
2. Circle the two compounds mentioned in the question
3. Write the molar ratio
4. Calculate the number of moles of the substance you have been given information about
5. Use the molar ratio to state the number of moles of the compound you are trying to find
6. Calculate what you are being asked in the question

- An example is shown below

Question: The equation below shows the complete combustion of methane in oxygen.

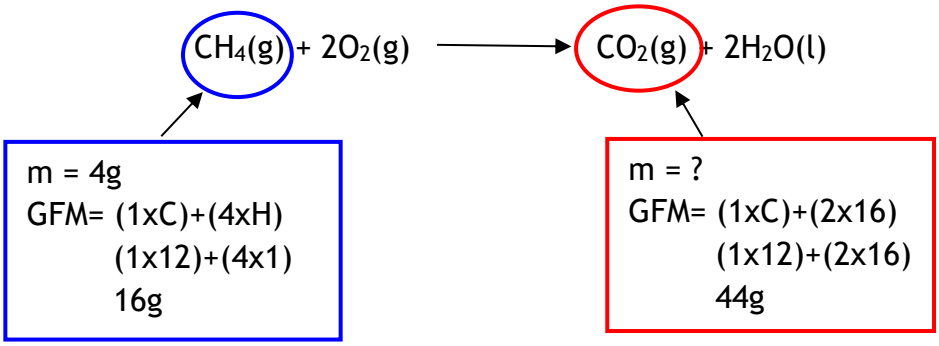
$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

Calculate the mass of carbon dioxide produce when 4g of methane is burned.

1. Balanced chemical equation

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

2. Circle the two compounds mentioned in the question
    - methane and carbon dioxide are mentioned in the question



3. Write the molar ratio

$$CH_4 : CO_2$$
1 mole : 1 mole

4. Calculate the number of moles of the substance you have been given information about

   n = m/GFM
   n = 4/16
   n = 0.025 moles of CH_4

5. Use the molar ratio to state the number of moles of the compound you are trying to find

   CH_4 : CO_2
   1 mole : 1 mole
   0.25 moles : 0.25 moles of CO_2

6. Calculate the mass
   n = m/GFM
   m = n x GFM
   m = 0.25 x 44
   m = <u>11g</u>