

Organic Chemistry

Alkanes and Alkenes



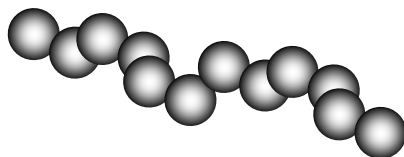
Pure Hydrocarbons

- Because the main use of hydrocarbons is as a fuel there is no point in going to the effort to separate them into individual hydrocarbons.
- It is, however, possible to obtain pure hydrocarbons by very careful distillation.
- This section is about pure hydrocarbons.



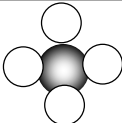
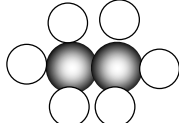
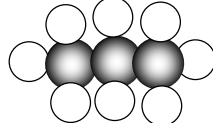
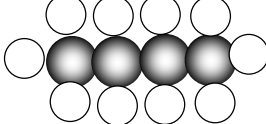
Carbon: Organic Chemistry

- Carbon is an unusual atom in that it is able to form very strong covalent bonds with other carbon atoms.
- When we then include it's ability to also bond with other elements we open up the possibility of the highly diverse and complex molecules (like DNA) that have led to the possibility of life.
- Because of this, the chemistry of carbon containing compounds is often called **organic chemistry**.



Alkanes

- The simplest hydrocarbons form a series of compounds known as alkanes.
- These all consist of carbon and hydrogen only and every carbon has four single covalent bonds.

Hydrocarbon	Formula	Structure
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	

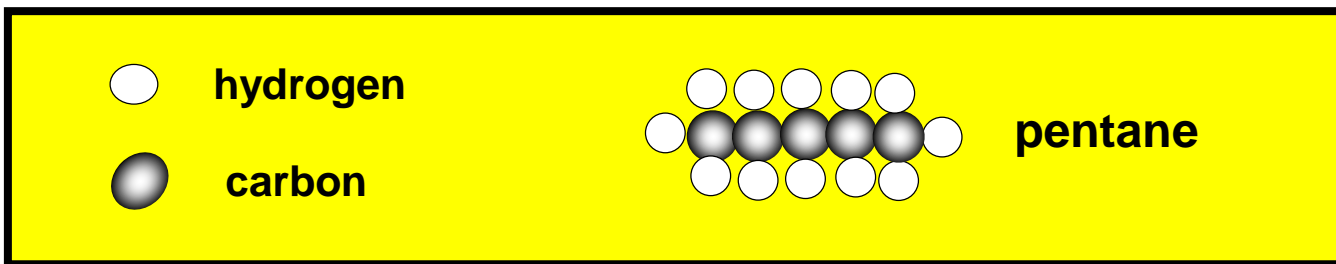
○ hydrogen

● carbon



Names of Alkanes

- The names of the 4 simplest alkanes are methane, ethane, propane and butane.
- After that the names are systematic (like the words used to describe geometric shapes.) E.g.
 - 5 carbons = pentane C_5H_{12}
 - 6 carbons = hexane C_6H_{14}
 - 7 carbons = heptane C_7H_{16}
 - 8 carbons = octane C_8H_{18}
 - 9 carbons = nonane C_9H_{20}
 - 10 carbons = decane $\text{C}_{10}\text{H}_{22}$



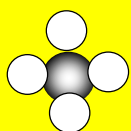
Homologous Series

- Alkanes all have very similar structures.
- They have a CH_3 at each end of the molecule.
- What differs is the number of CH_2 groups between the two ends.
- These all consist of carbon and hydrogen only and every carbon has four single covalent bonds.
- It is possible to build up a series by simply adding an extra CH_2 group
- This leads to a general formula of $\text{C}_n\text{H}_{2n+2}$

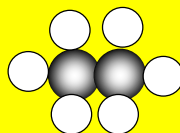
○ hydrogen

● carbon

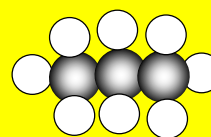
n= 1



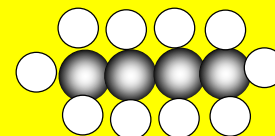
n=2



n=3



n=4



- What will be the formula for alkanes containing the following numbers of carbons?

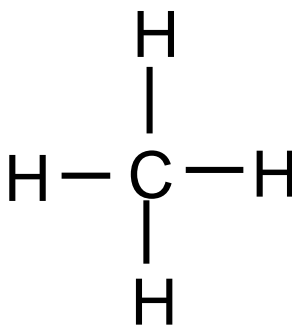
Number of carbons	Formula
12	$\text{C}_{12}\text{H}_{26}$
16	$\text{C}_{16}\text{H}_{34}$
31	$\text{C}_{31}\text{H}_{64}$
19	$\text{C}_{19}\text{H}_{40}$



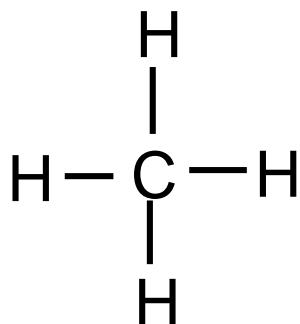
Formulae and Models of Alkanes

- Although normal chemical formula - like **C₅H₁₂** - are used to describe alkanes they do not convey which atom is joined to which other atom.
- To get around this we often used displayed formula to describe organic molecules.
- Displayed formula show which 4 atoms each carbon is bonded to but even these do not show the actual 3D shapes. For that we use models.

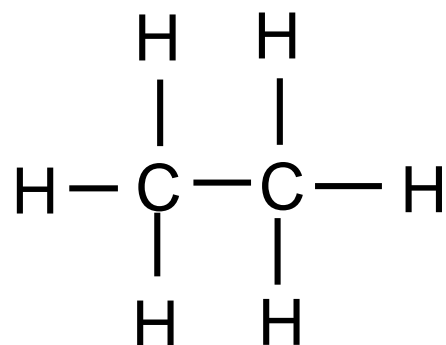
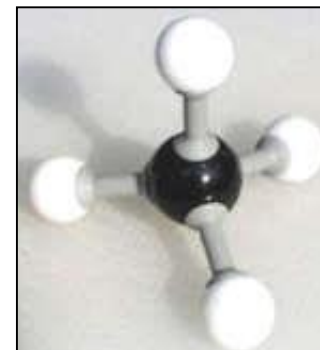
methane, CH₄



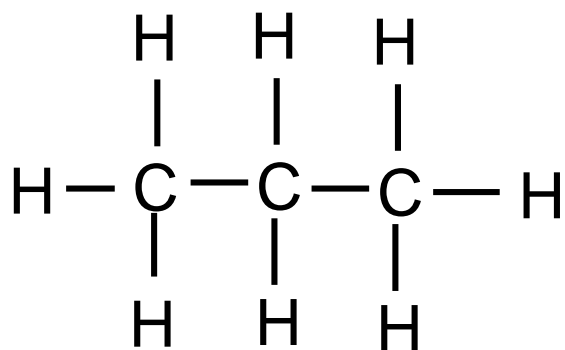
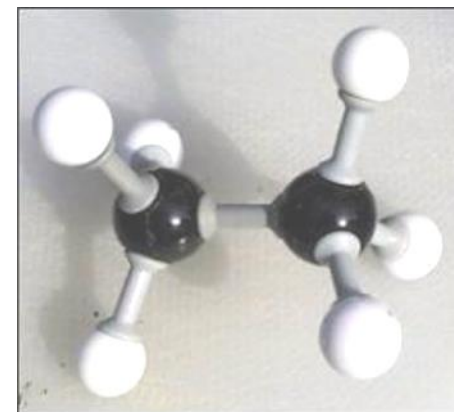
Alkanes



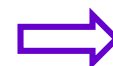
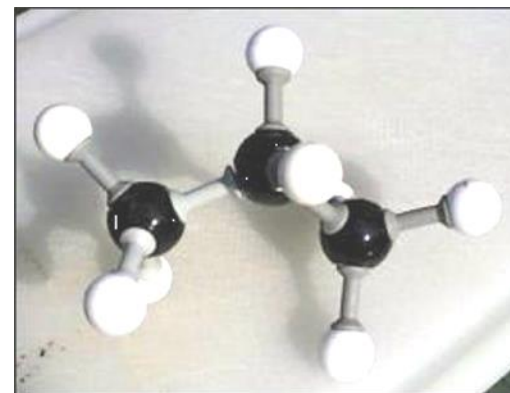
methane, CH_4



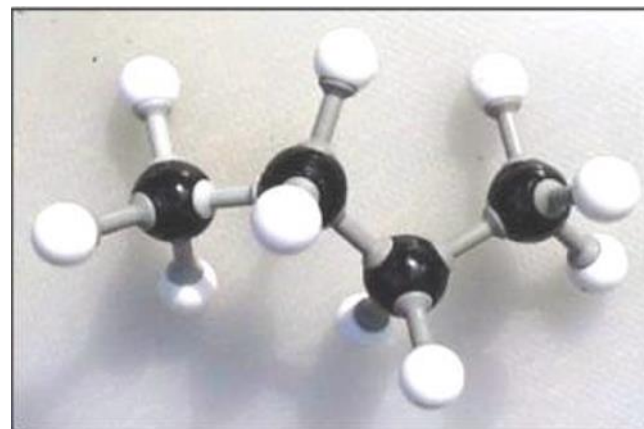
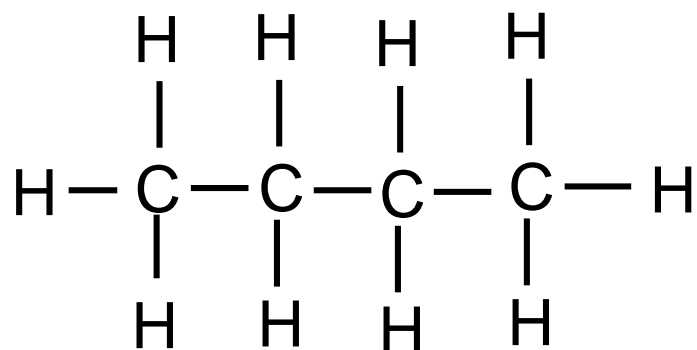
ethane, C_2H_6



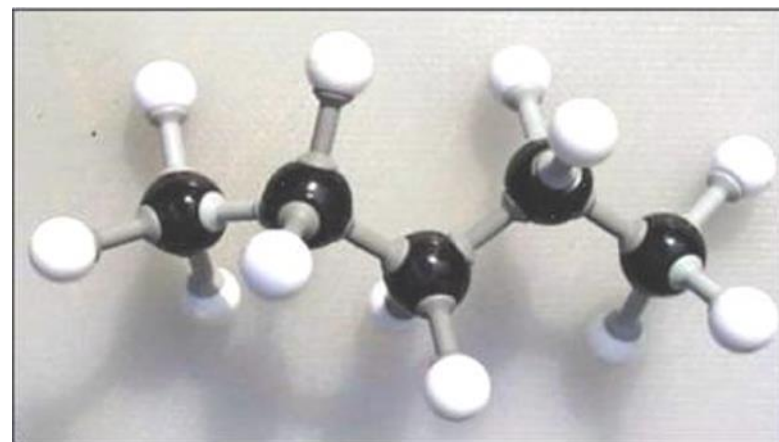
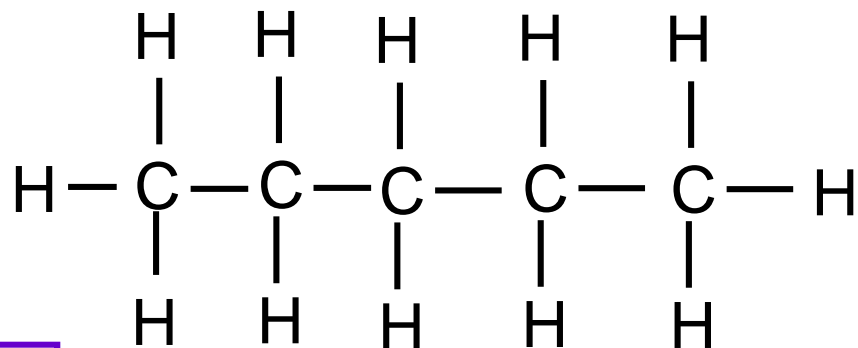
propane, C_3H_8



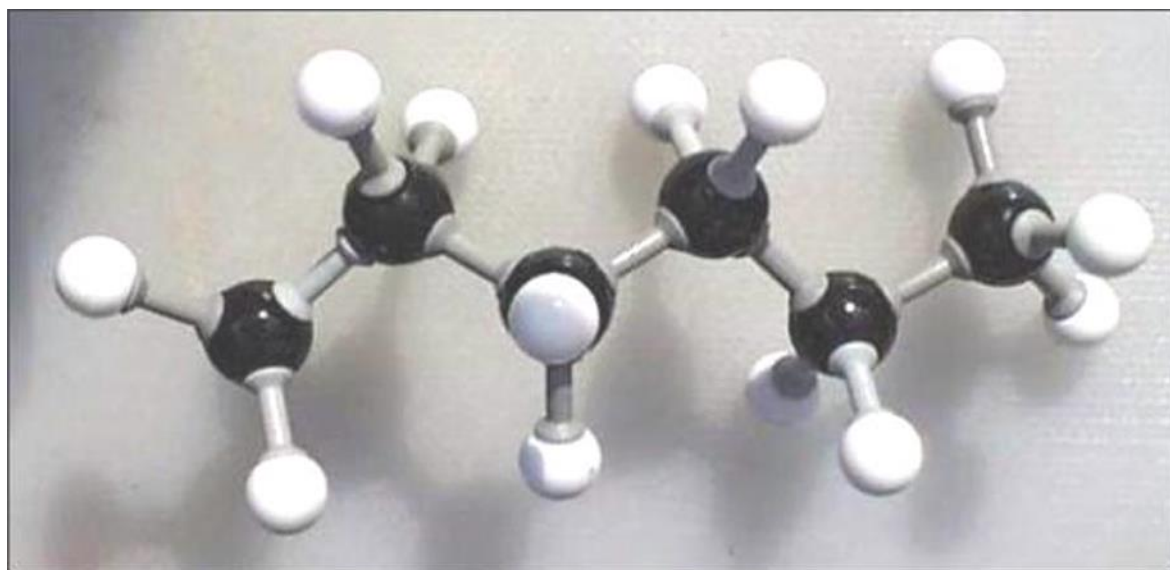
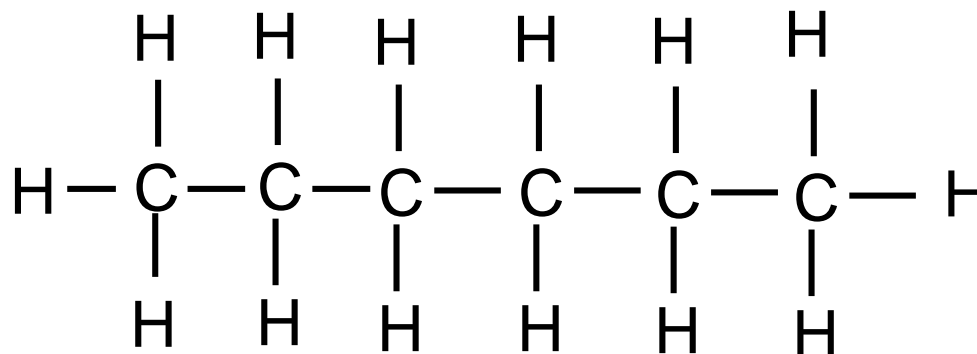
butane, C_4H_{10}



pentane, C_5H_{12}

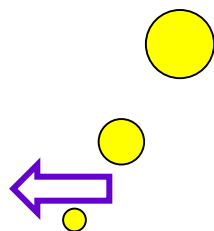


hexane, C_6H_{14}



Notice
the carbon chain
is not really
straight

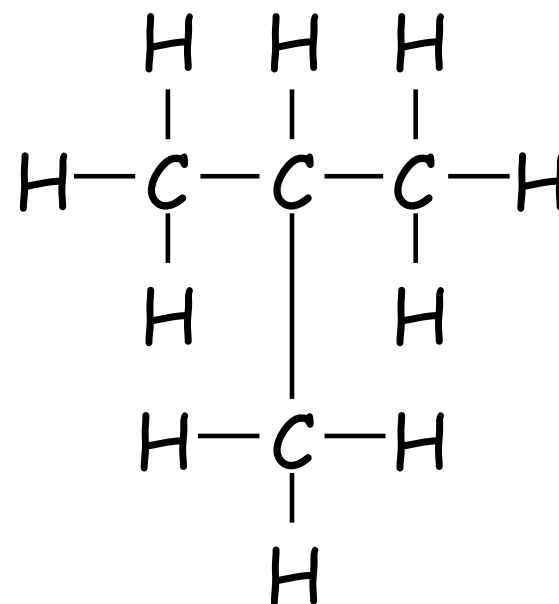
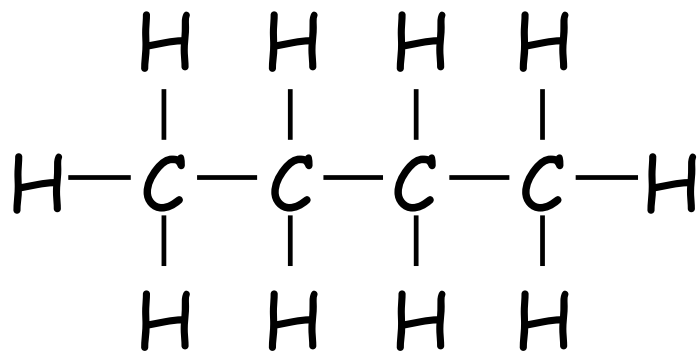
and so on.....



Isomerism

Alkanes of the same formula can have different arrangements of atoms. Such different arrangements are known as **isomers**.

Two isomers of C_4H_{10} are shown



Isomers of butane

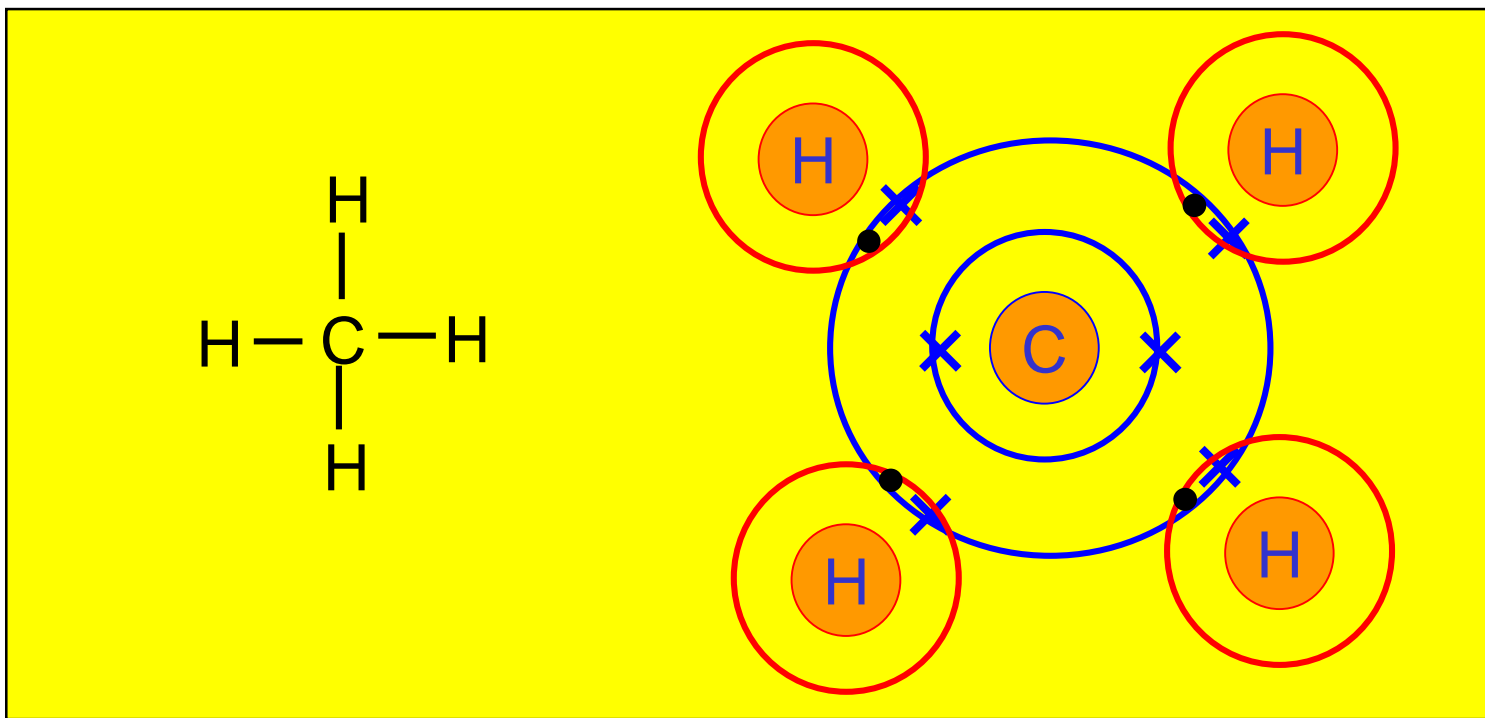


Bonding in Alkanes: Methane, CH₄

Alkanes contain atoms held together by single covalent bonds.

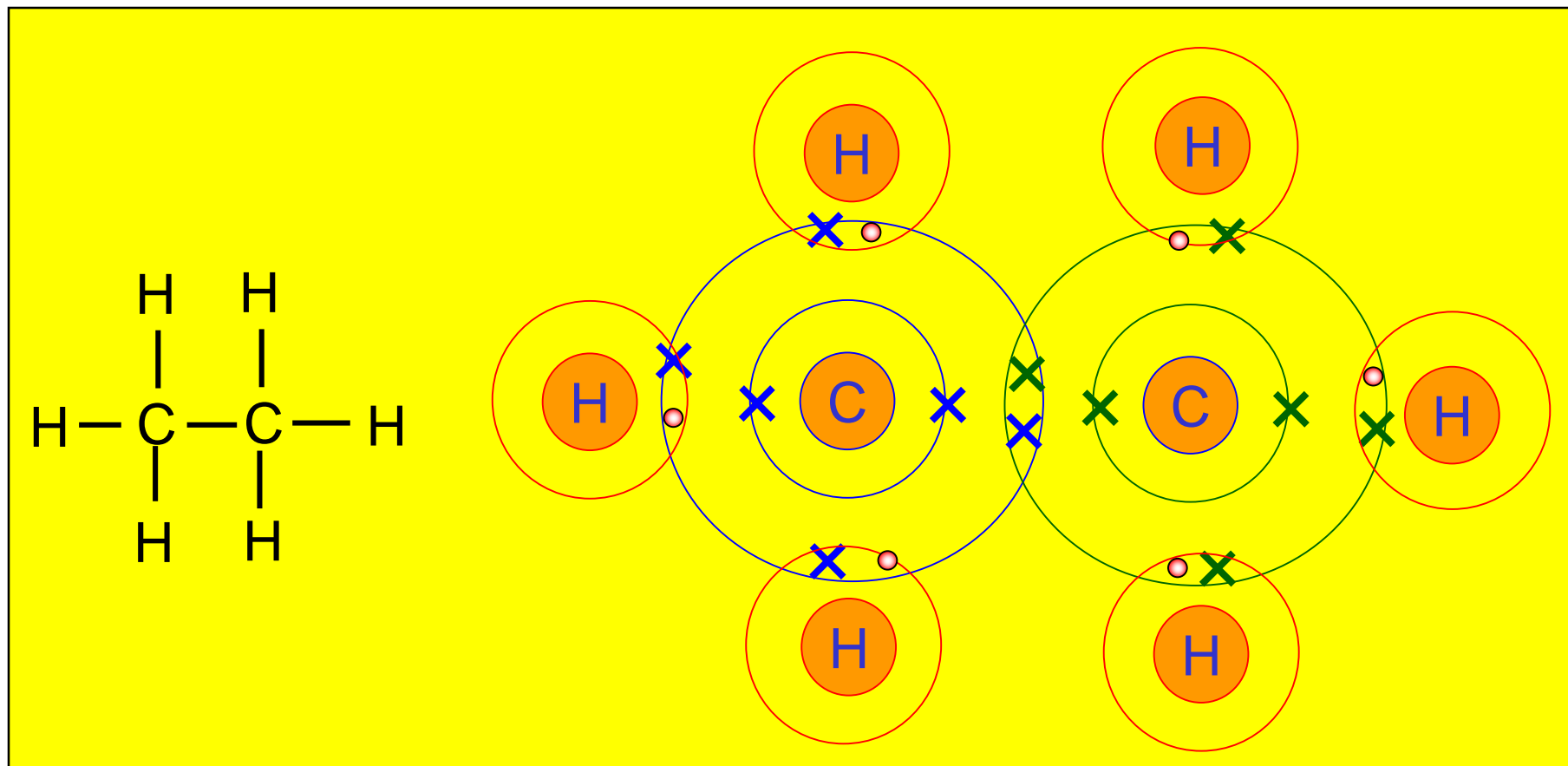
In the formula displayed we show these bonds as a single line.

Each line is really a pair of shared electrons



Alkanes: Ethane, C₂H₆

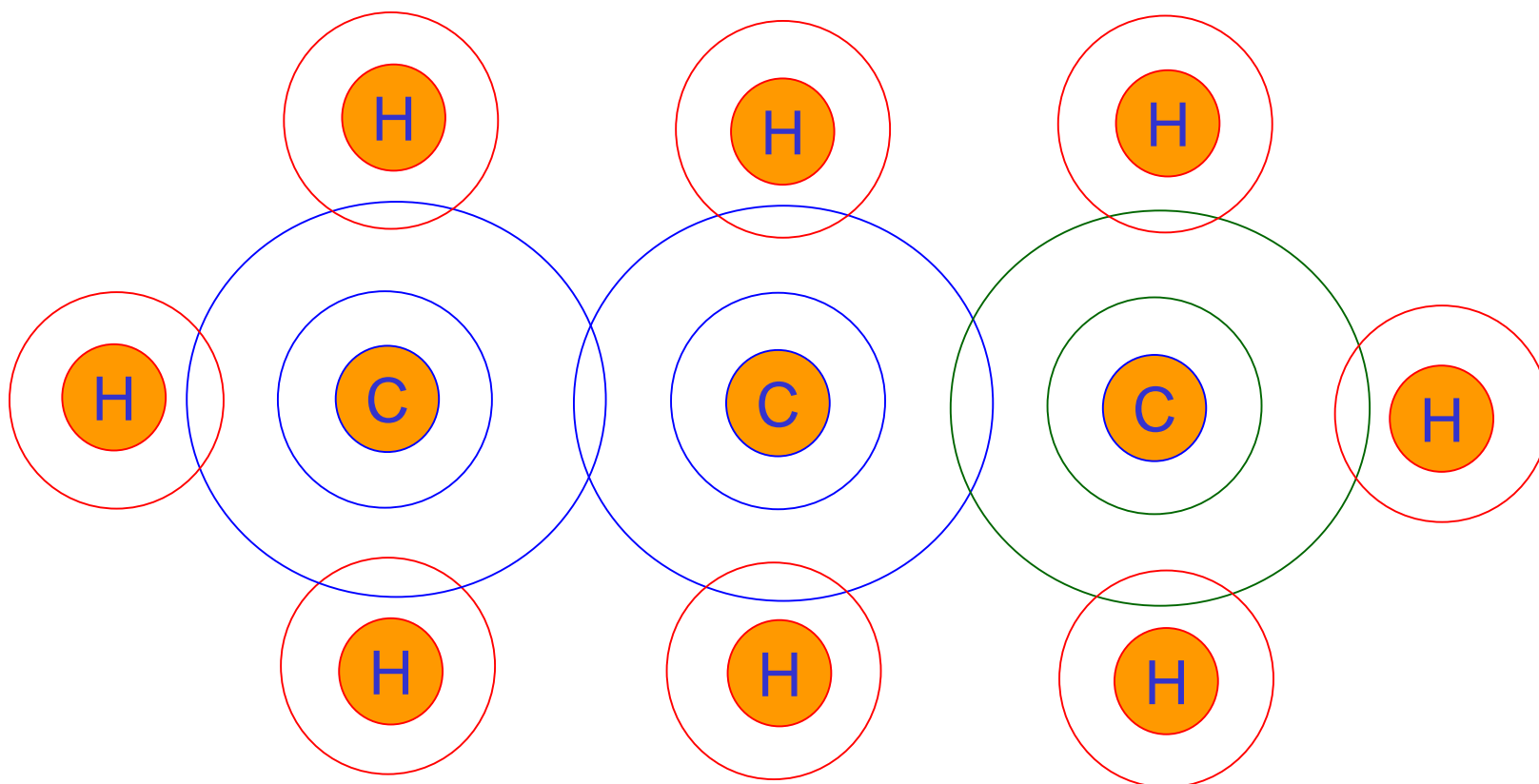
- Ethane is the simplest alkane containing a C-C single covalent bond.



- Complete the diagram below including it's electrons.

✕ Carbon electron

● Hydrogen electron



Combustion of Alkanes

- Alkanes are not especially reactive but they do have one very important reaction: combustion.
- With an adequate supply of air they react to form carbon dioxide and water.

Methane + oxygen → water + carbon dioxide



Incomplete Combustion of Alkanes

- In the absence of an adequate supply of air, alkanes may react to form carbon monoxide and water.
- Carbon monoxide is highly poisonous and this is one reason why gas boilers must be serviced regularly.



A carbon monoxide detector

Methane + oxygen → water + carbon monoxide



- Complete the equations below assuming an adequate supply of oxygen for complete combustion. *(These are quite tricky!)*



Alkenes

- When carbon forms compounds each carbon atom always forms four bonds.
- This does not, however, mean that each carbon is joined to four other atoms.
- It is possible to have bonds grouped into pairs. These are called double bonds.
- Alkenes contain carbon atoms joined by double covalent bonds.

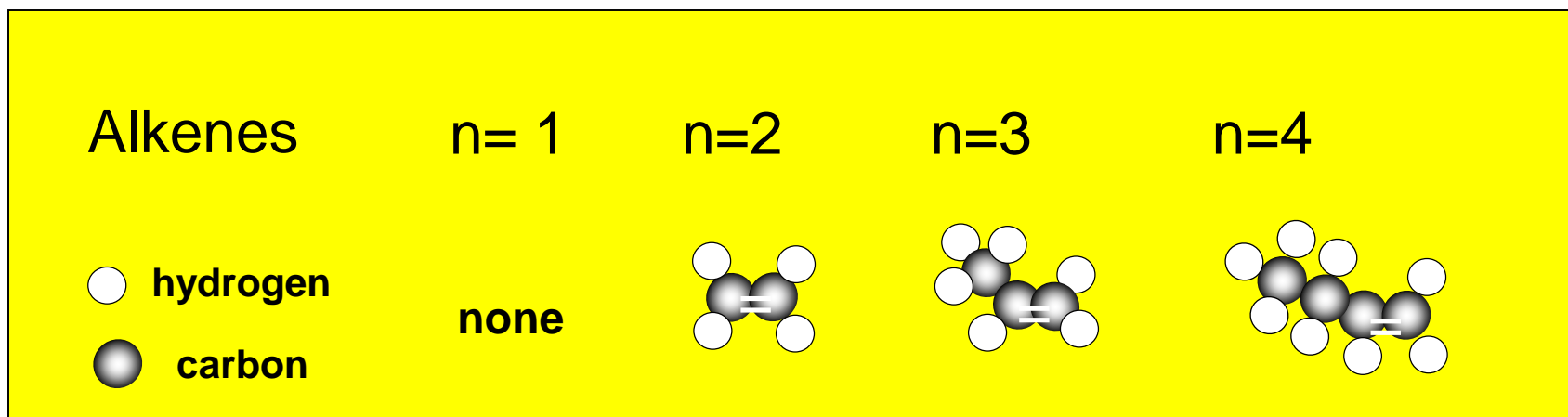
Single covalent bond $\text{C} - \text{C}$

Double covalent bond $\text{C} = \text{C}$



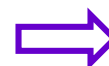
Alkenes - homologous series

- A series of alkenes exist differing only in the number of CH_2 groups.
- The same is true for alkenes.
- This leads to a homologous series with the general formula $\text{C}_n \text{H}_{2n}$



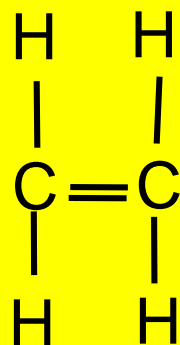
- What will be the formula for alkenes containing the following numbers of carbons?

Number of carbons	Formula
11	$\text{C}_{11}\text{H}_{22}$
13	$\text{C}_{13}\text{H}_{26}$
32	$\text{C}_{32}\text{H}_{64}$
21	$\text{C}_{21}\text{H}_{42}$

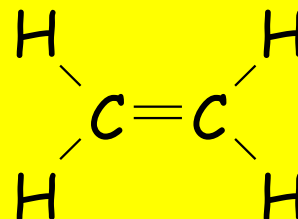


Ethene - formula

- The simplest alkene is ethene.
- It has the formula C_2H_4
- The carbon atoms are joined together by a double bond.
- Its displayed formula may be drawn in slightly different forms but should always clearly show the double bond.

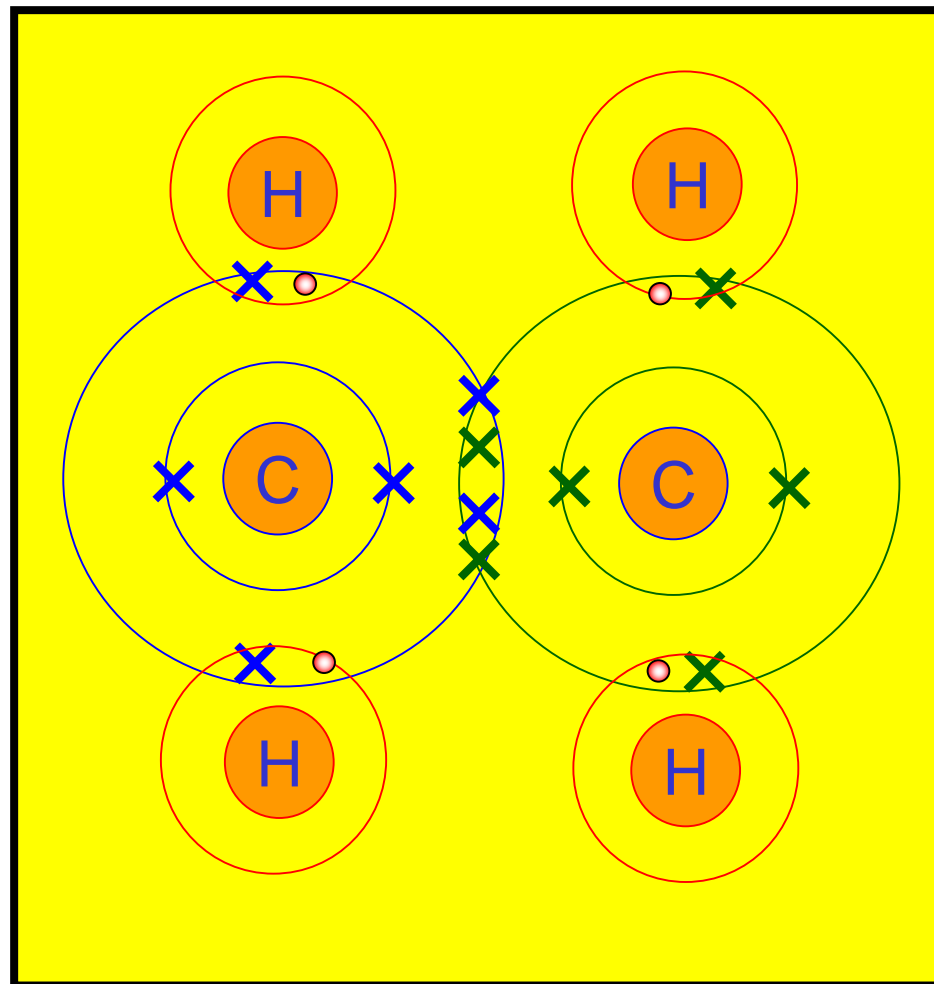
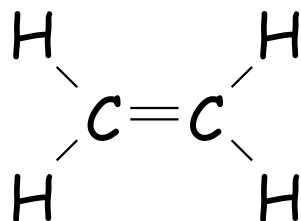


or

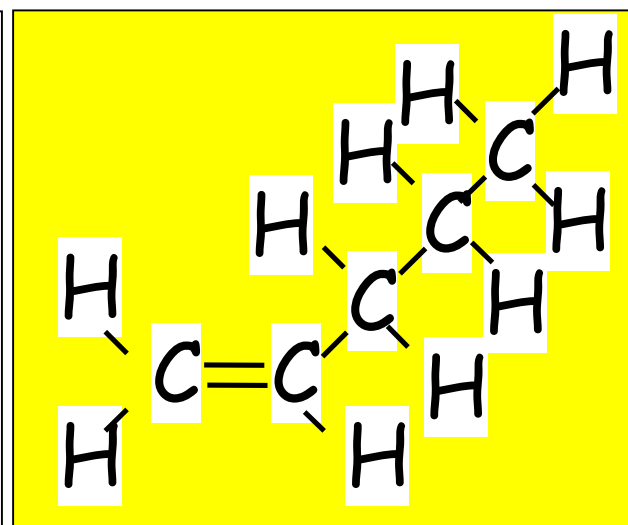
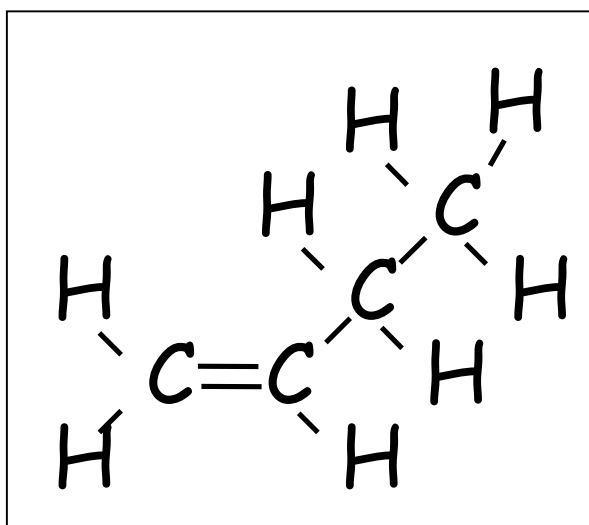
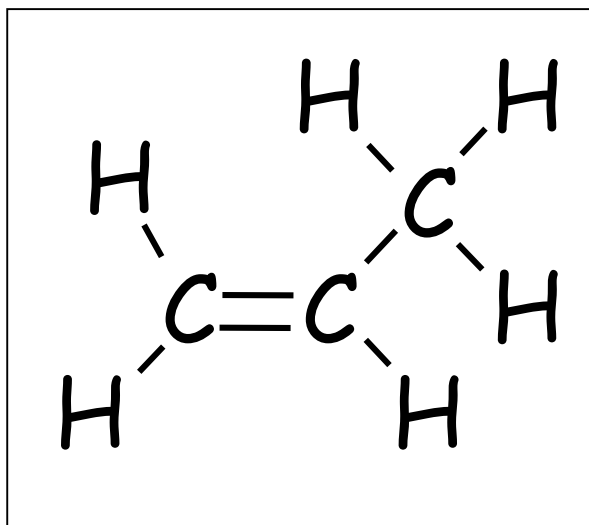


Ethene – electron structure

- In all alkenes there are two carbon atoms that are joined by **two** pairs of electrons.
- This is the double bond.



- Displayed formula for propene and butene are shown.
- Draw a displayed structure for pentane.



Saturated or Unsaturated?

- Saturated means “full up”.

- Alkanes are ***saturated***.

- Every carbon atom has already used all four of its bonds to join to four other atoms. No other atoms can be added.

- Alkenes are ***unsaturated***.

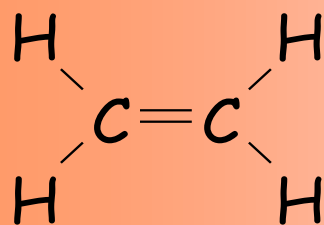
- They have a double bond that could instead become two single bonds. This means that other atoms can be added. It is not “full up”.



- Alkenes are unsaturated and so extra atoms can be added to alkene molecules.
- This forms the basis of a test to distinguish between alkanes and alkenes.
- When bromine water is added to an alkane nothing happens but when bromine is added to an alkene the red colour of the bromine disappears.



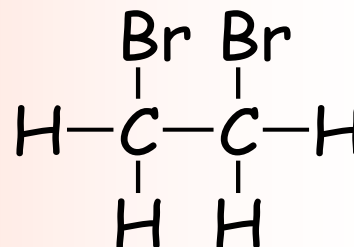
Bromine
loses this
red colour



Gas



red



colourless



- Copy the Table and complete the empty boxes.

Number of carbons	Name	Alkane or alkene	Formula
5	pentene	alkene	C_5H_{10}
8	octane	alkane	C_8H_{18}
4	butene	alkene	C_4H_8
10	decane	alkane	$C_{10}H_{22}$

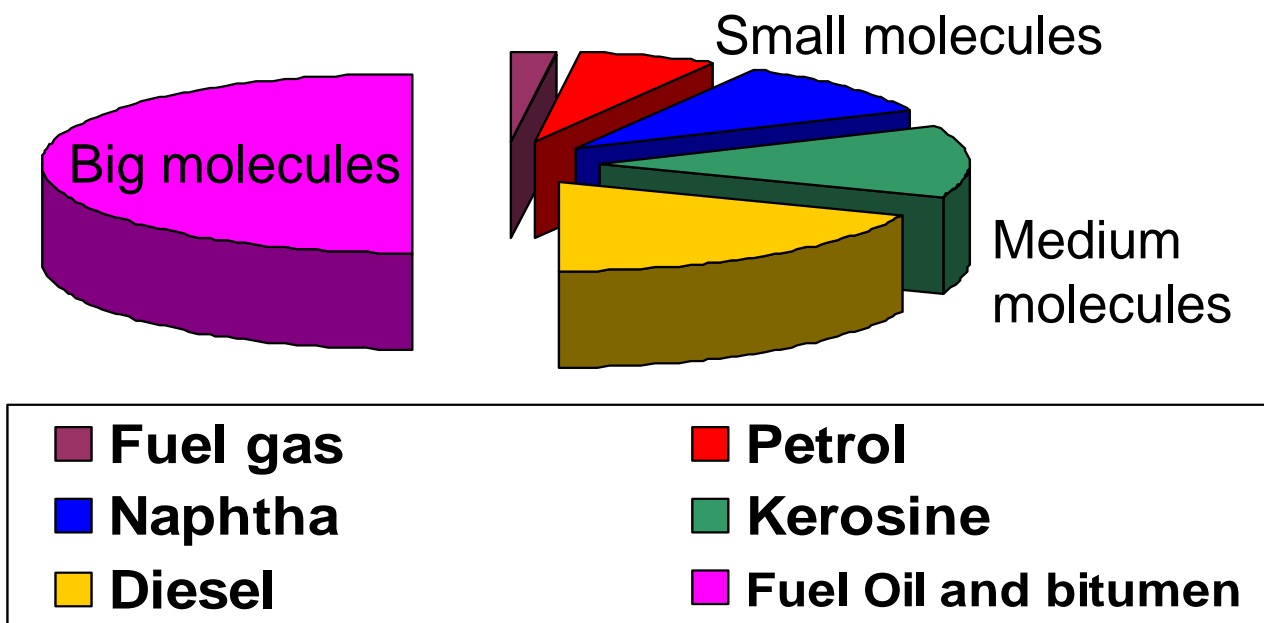


Industrial manufacture and uses of Alkenes



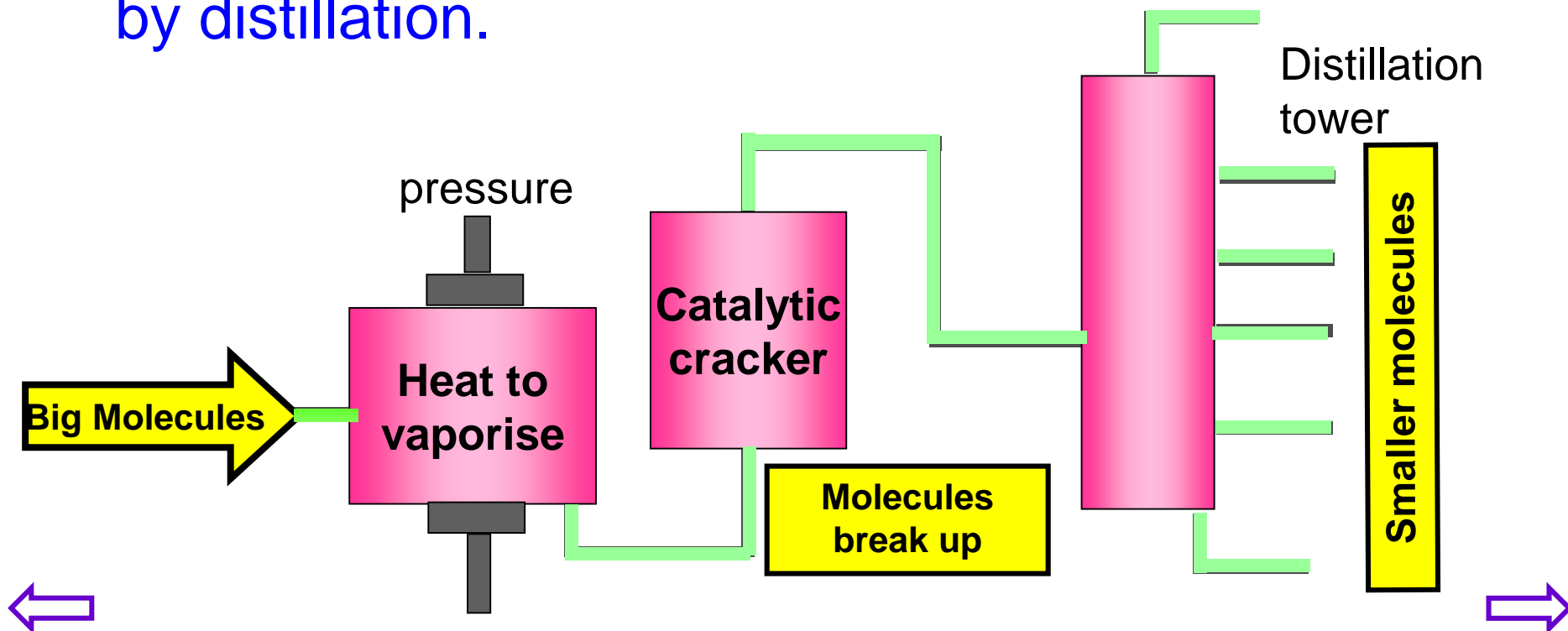
Alkenes Sources

- Crude oil contains many large molecules.
- If these are to be used as fuels or feedstock for the chemical industry then they have to be broken down (or cracked) into smaller molecules.



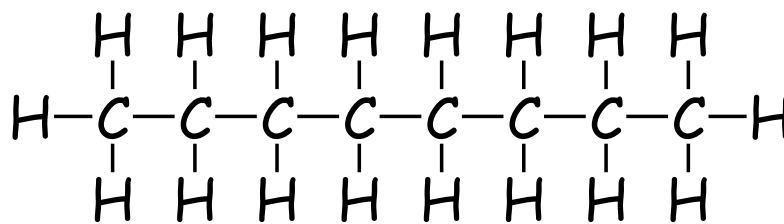
Catalytic Cracking

- Large hydrocarbons are broken into smaller molecules using heat and a catalyst.
- This process is known as catalytic cracking.
- The small molecules produced are then separated by distillation.



Catalytic Cracking

- In the catalytic cracker long chain molecules are split apart or 'cracked'. An example of such a reaction is:



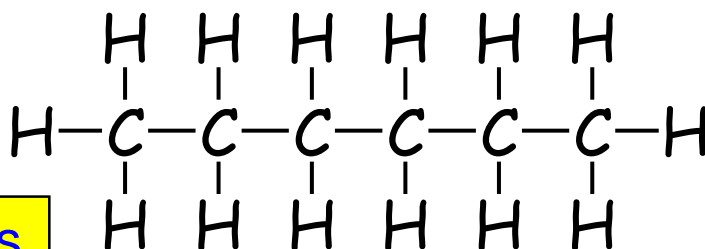
Octane

Heat
pressure

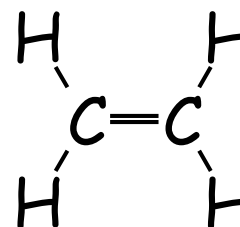


catalyst

hexane



+



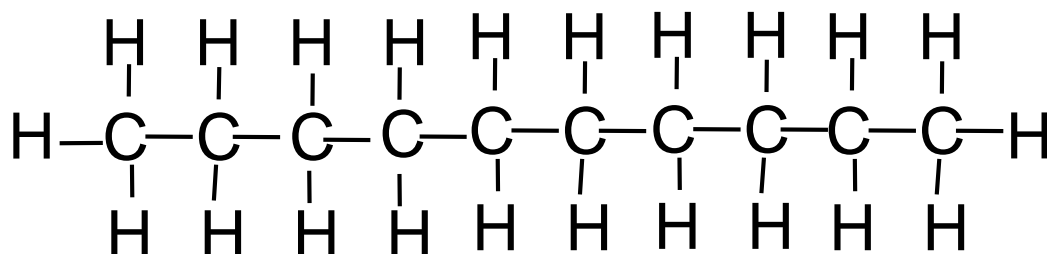
ethene

Used as
a fuel

Ethene
is used
to make
plastics

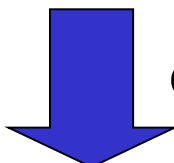


- Draw out displayed formulae of a pair of products formed by cracking decane

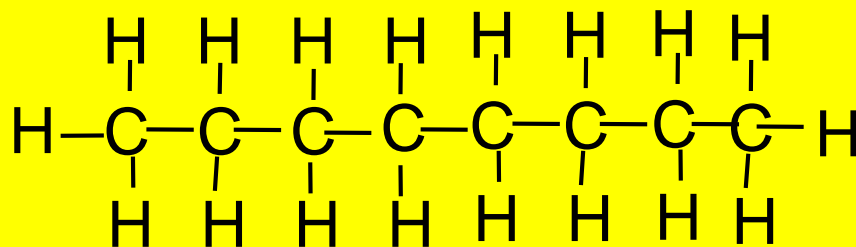


decane

Heat
pressure

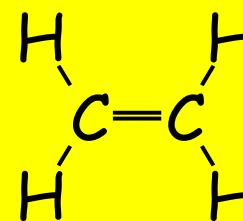


catalyst



octane

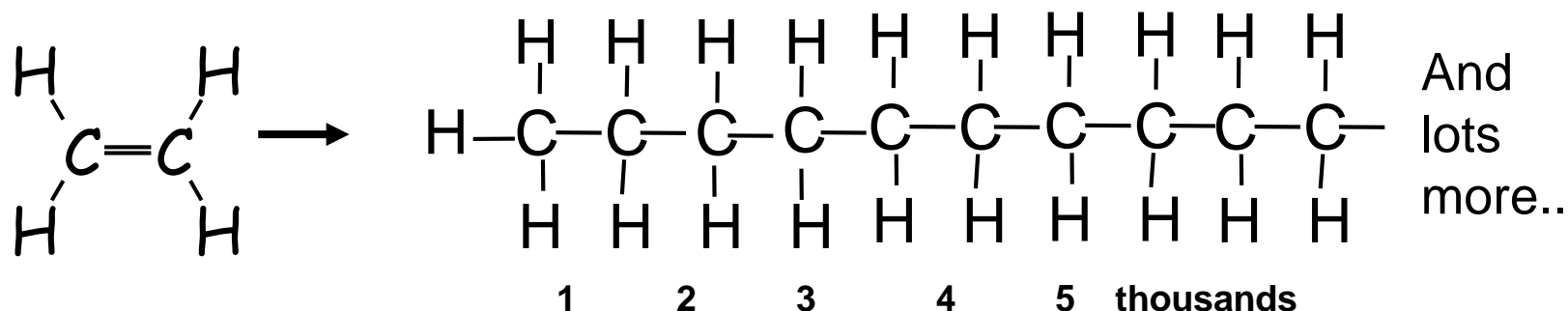
+



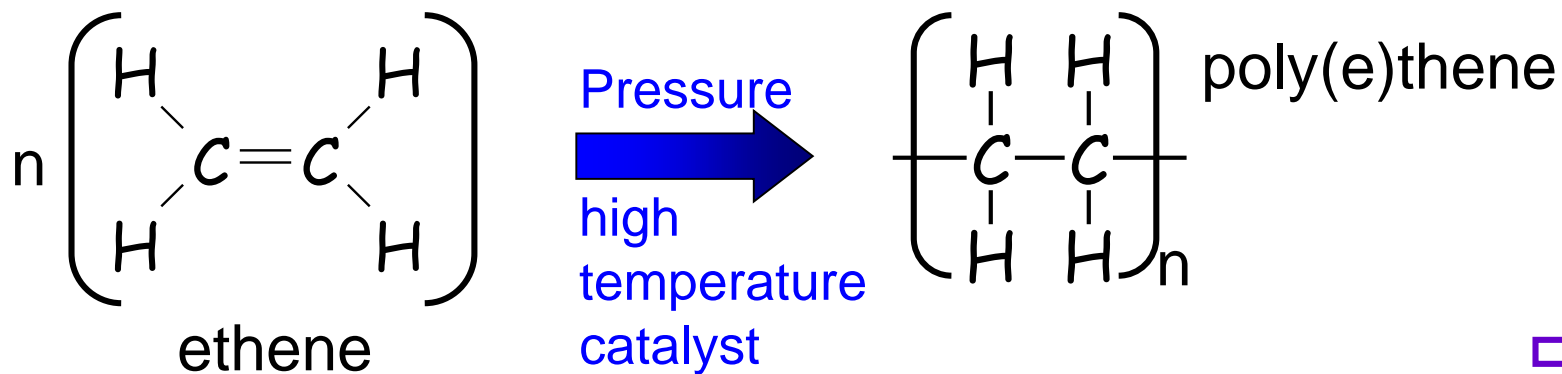
ethene

Poly(e)thene

- One important reaction of alkenes involves the joining together of alkene molecules.

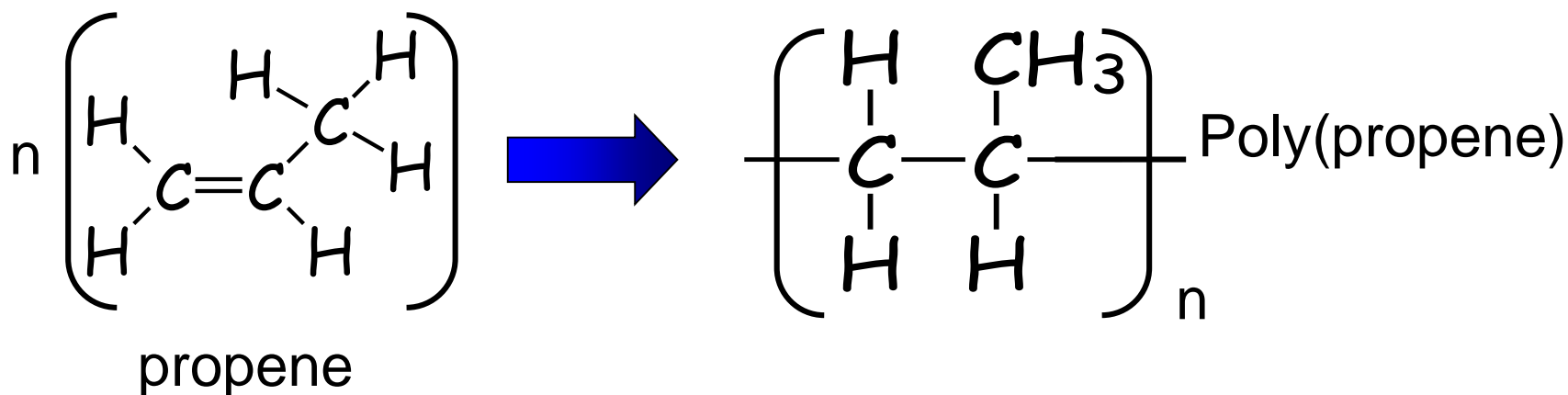


This is called ***addition polymerisation*** and is written as:



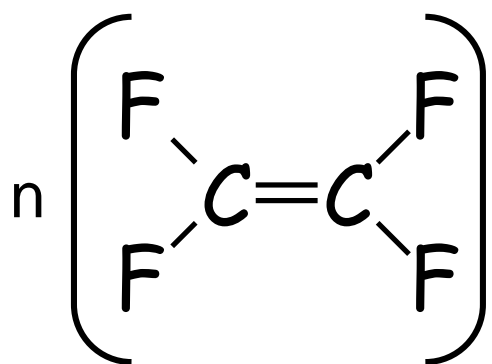
Polypropene

- Ethene is only one alkene. Other unsaturated molecules such as propene, vinyl chloride and styrene can also be **polymerised** to produce a range of plastics. E.g. propene

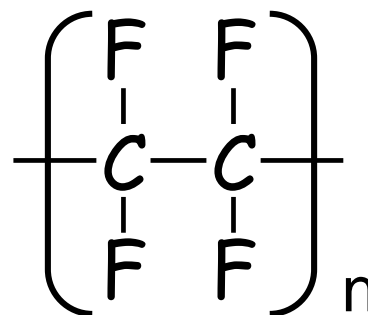


PTFE

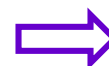
- Tetrafluoroethane is another alkene that is made into an important plastic used to coat non-stick pans: polytetrafluoroethane or PTFE.



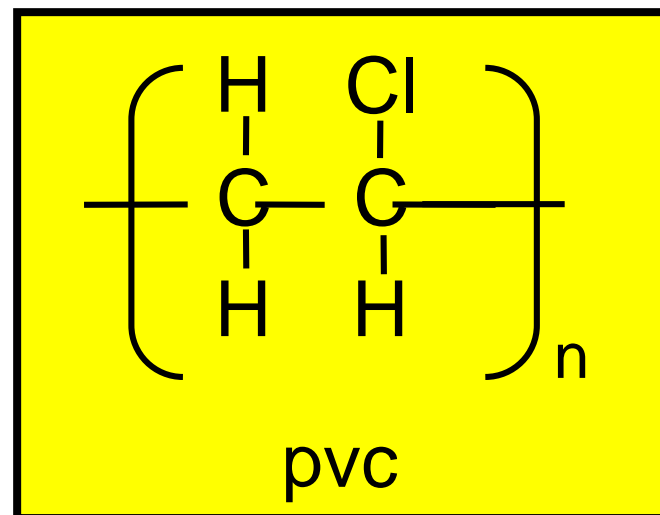
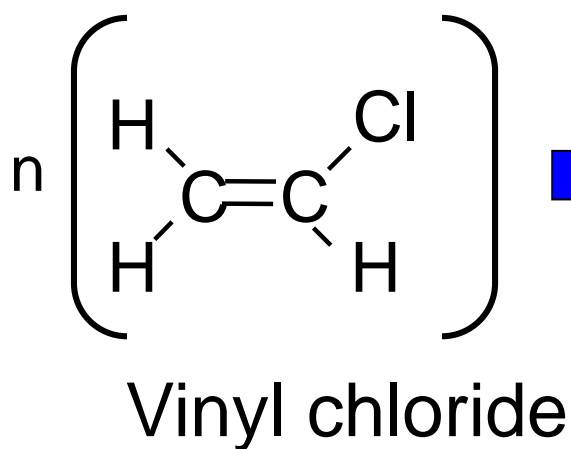
tetrafluoroethene



Poly(tetrafluoroethane)
or PTFE



- Fill in the products that will be obtained from vinyl chloride



Some uses of plastics

Poly(e)thene

Shopping bags

Bottles

Buckets

Washing up
bowls



Polypropene

Milk crates

Rope

Carpet fibres

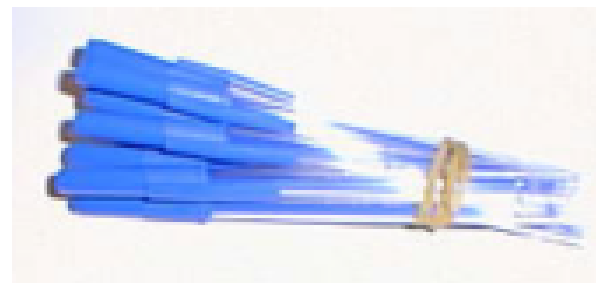


Polystyrene

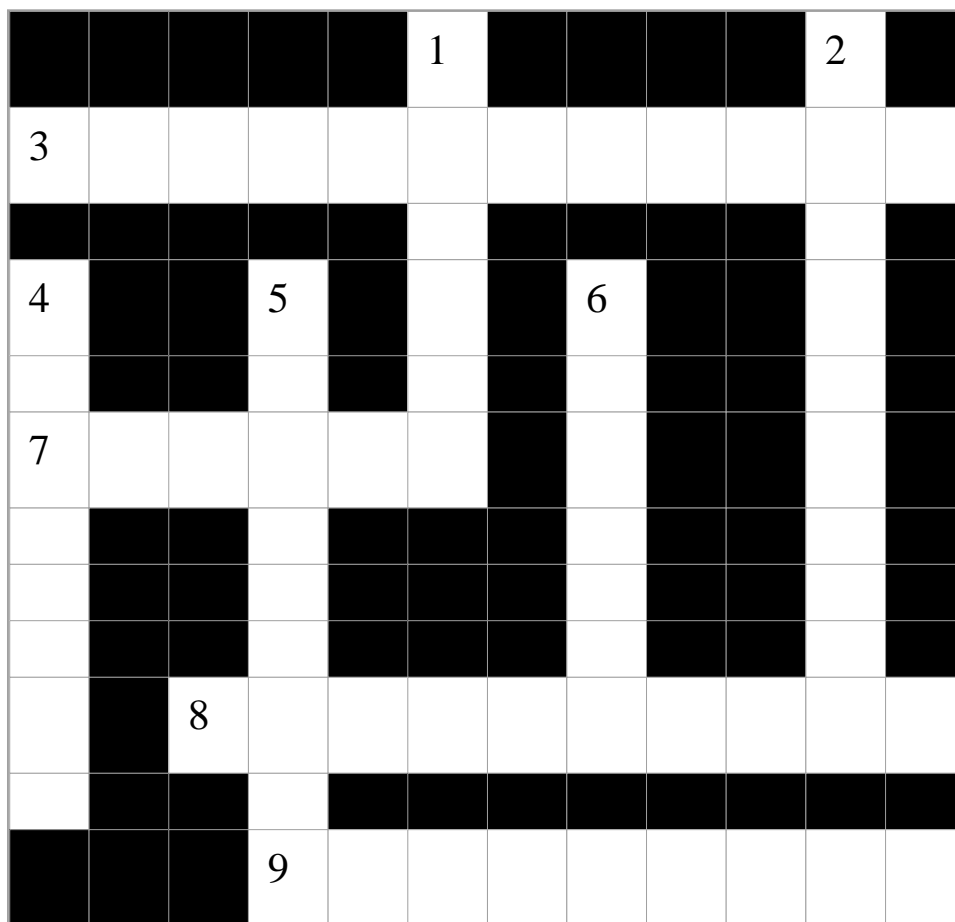
packing

insulation

Ball pens



Across	Down
3) separate substances with different boiling points	1) Contain a double bond
7) saturated hydrocarbon	2) a series of molecules differing by a CH ₂
8) joining of many small molecules	4) breaking up a large molecules
9) full up: unable to add more atoms	5) the different substances collected from distillation
	6) used to test for unsaturated molecules.



Answers

Across	Down
3) separate substances with different boiling points DISTILLATION	1) Contain a double bond ALKENE
7) saturated hydrocarbon ALKANE	2) a series of molecules differing by a CH_2 HOMOLOGOUS
8) joining of many small molecules POLYMERISE	4) breaking up a large molecules CRACKING
9) full up: unable to add more atoms SATURATED	5) the different substances collected from distillation FRACTIONS
	6) used to test for unsaturated molecules. BROMINE



Which of these is an alkane?



Which of these is a true statement about alkenes?

A. They turn bromine water from colourless to red

B. They contain a double bond

C. The smallest alkene has 1 carbon atom

D. They have names that end in “ane.”



Which of these is a true statement about cracking?

- A. it is the separation of molecules into fractions of different sizes.
- B. it is carried out at low temperatures
- C. it uses a catalyst.
- D. It produces polymers



Which of these is a true statement about polymerisation?

A.it is the joining together of many small molecules.

B. it is the thermal decomposition of plastics

C.it is carried out using saturated molecules

D.it is a multiplication reaction



Which of these is an addition polymer?

A. styrene

B. ethene

C. p.v.c.

D. propane



How might you test to see if polystyrene still contained some unsaturated monomer (styrene)?

- A. Crush it up and burn it.
- B. Crush it up and add it to bromine water
- C. Crush it up and dissolve it in petrol
- D. Crush it up and add hydrochloric acid

