Topic(s) –Isomers and Cracking

This set of work is to be done over the week, from Monday 18th May to Thursday 21st May (Friday is another May holiday for you all, as are Monday 25th and Tuesday 26th).

Here is a list of the resources you should be using this week, on the following pages the resources have been screenshotted so you all only need this one document open to work from for the whole week.

Video solutions to homework 10 can be found in the files section now.

1. As a 'starter' for this week please attempt the Microsoft Form on the work you completed last week on Addition reactions and a Summary of what you have learnt so far. The link for it is here:

https://forms.office.com/Pages/ResponsePage.aspx?id=oyzTzM4Wj0KVQTctawUZKeSVSAJoJ4FKoNm9KbBanehUNDEzMk1XQVNSQjNRTUFIWFBDT0JYVFpIWi4u

Please note that you need your glow username and password to access the form.

2. Please watch the video, accessed by the link below (you need to double click on the icon), of the slides on Isomers with a teacher talk over.

   https://glowscotland.sharepoint.com/:v:/r/sites/S2Chemistry2018/Class%20Materials/National%204%20and%205%20Unit%202/Isomers.mp4?csf=1&web=1&e=tnu1y2

3. Notes to copy into notes jotter and learn – Isomers and Cracking. *Instructions/teaching points are in the text boxes down the side, in bold and italic text. There are 8 notes in total.* **If you have the option to do so at home, feel free to print and stick them into your notes jotter.**

4. Self Checks – 13 and 17.

5. Homework – 9 and 12.

6. Videos that should be watched:

Isomers

BBC Bitesize: https://www.bbc.co.uk/bitesize/clips/z2dspbk

YouTube: https://www.youtube.com/watch?v=oxLR1o2gay0

Cracking Crude Oil

https://www.youtube.com/watch?v=bOiYLKX9ZRY

Homologous Series Recap

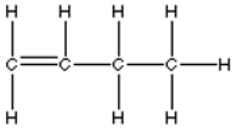
https://www.youtube.com/watch?v=qBNSKXpyvb8&t=

1.

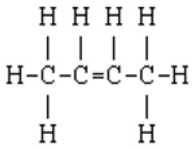
Isomers

Definition: substances with the same molecular formula (the number of each type of atom present), but different a structural formula (the way the atoms are arranged).

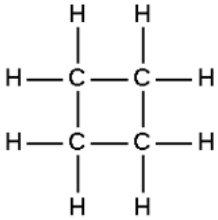
Ex. 1 Isomers with the atomic formula of C_4H_8



But-1-ene



But-2-ene



Cyclobutane

Isomers usually have different physical properties to each other e.g. melting point, boiling point, solubility etc.

You need be able to draw isomers from structural formulae and molecular formulae.

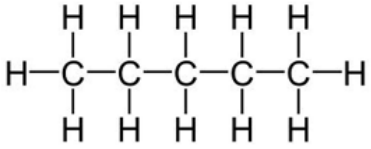
Put simply isomers are just ways to arrange a given number of atoms in different ways.

This first example is the three ways you can arrange atoms with the formula C_4H_8. Therefore all structures have to be Alkenes or Cycloalkanes as they are the only two homologous series which fit that formula.

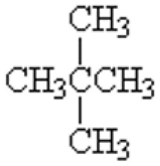
Isomers can therefore belong to two different homologous series.

2.

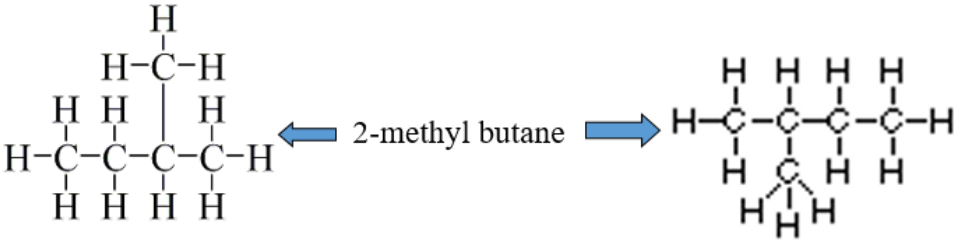
Ex. 2 Isomers with the atomic formula of C_5H_{12}



pentane



2,2-dimethyl propane



2-methyl butane

This second example is the three ways you can arrange atoms with the formula C_5H_{12}. Therefore all the structures have to be ALKANES.

These bottom two structures are the same compound, just with the methyl group on the top and bottom

3.

Cracking

Definition: changing large hydrocarbons into smaller more useful hydrocarbons

e.g.

$$C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$$

This process is used to meet the demand for shorter chain alkanes and alkenes.

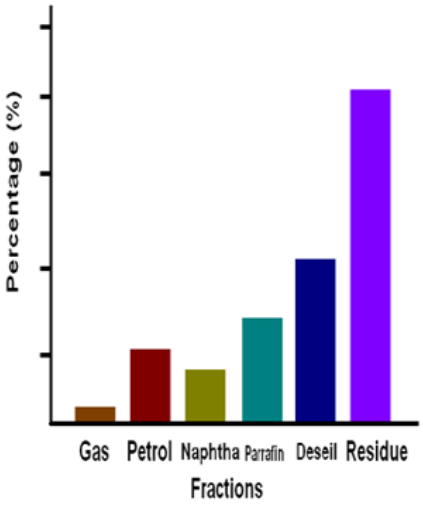
Put very simply, cracking is the name given to the process where we make a long hydrocarbon into smaller ones, which we use more of in everyday life.

For the example here decane is not widely used, but the products are.

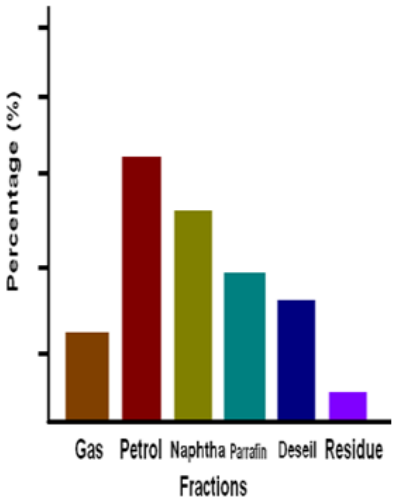
Octane is the main component in petrol and ethene is used to make plastics (you'll learn about this process in detail in Unit 3 in fourth year).

4. Why there is a need for Cracking:

What we get from Crude Oil



What we need for everyday life



These two graphs show you why we need cracking.

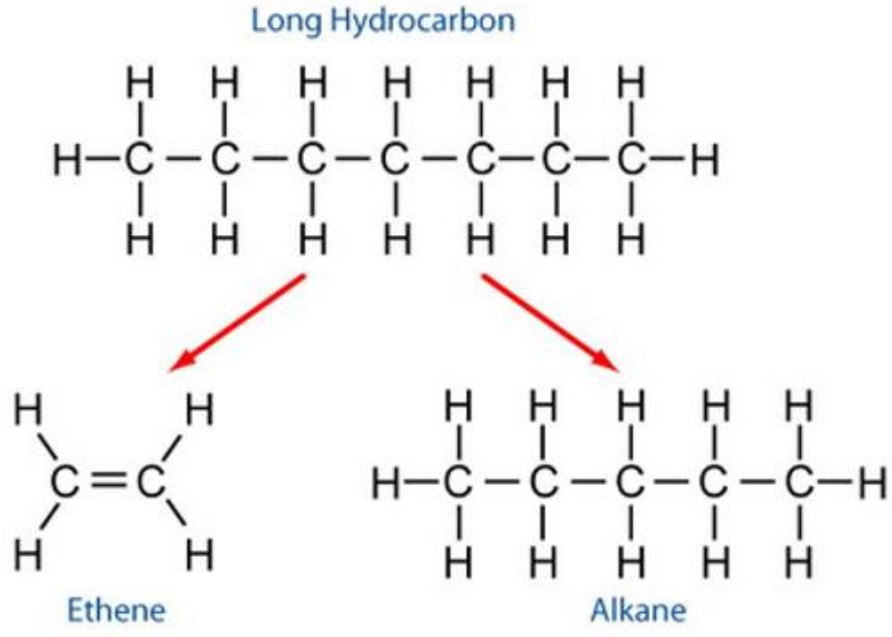
*The **left** graph shows what **we get naturally** from Oil and the **right** graph shows you the **demand** for the compounds we get from Oil.*

As you can see, we need a lot more of gas, petrol, naphtha and paraffin than we get naturally from oil and we need a lot less of residue. So we can crack the residue into the smaller compounds that we use more of in everyday life.

5.

Ex1. C_7H_{16} → C_2H_4 + C_5H_{12}

(Long Hydrocarbon) (Alkene) (Alkane)



This is a written example of a cracking reaction. You need to be able to write these out and fill in a missing compound.

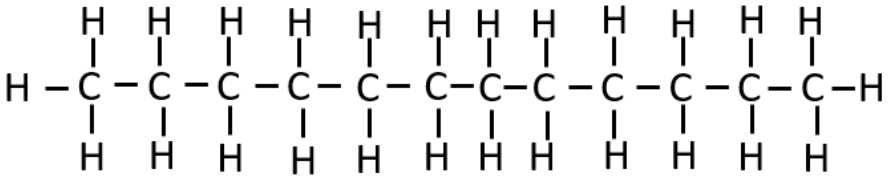
For example you could be given the long hydrocarbon and the alkene formulae and be asked to work out the name and formula of the alkane.

When doing this you should make sure that the number of Carbon atoms and Hydrogen atoms is always EXACTLY the SAME on both side of the arrow.

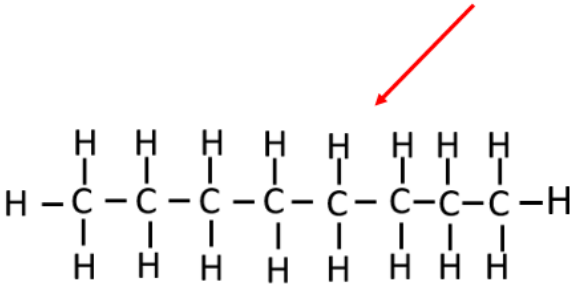
6.

Ex2. $C_{12}H_{26}$ → C_8H_{18} + C_4H_8

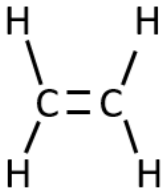
(Long Hydrocarbon) (Alkane) (Alkene)



Long Hydrocarbon



Alkane



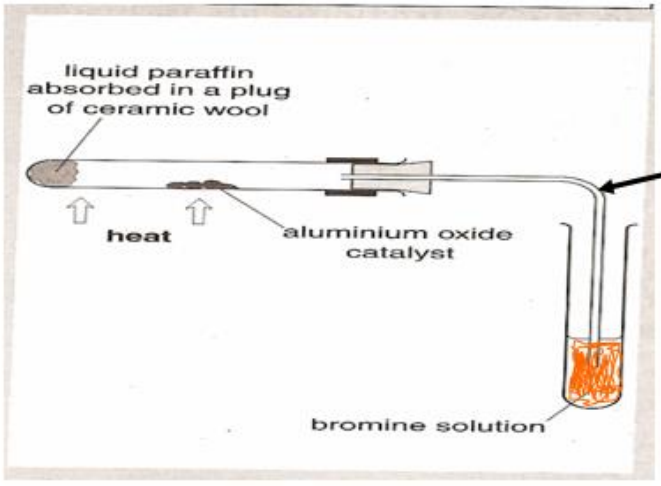
Alkene

7.

Cracking experiment in the Lab

Aim: To crack liquid paraffin (a long chain hydrocarbon) and show that one of the products is unsaturated

Procedure:



This is an experiment you would be doing in school if we were all there.

We heat paraffin with a catalyst in a boiling tube and produce an alkene.

We test to see what we have made using Bromine water, when it rapidly changes from Orange/Brown to colourless, we know we have made a shorter chain alkene.

8.

Suck-back:

• Is when some of the bromine water is sucked into the hot boiling tube containing the reactants, this will result in the glass cracking.

• to avoid this we must always ensure that the delivery tube is removed from the bromine solution before we stop heating the boiling tube.

Results: The bromine solution is rapidly decolourised

Conclusion: Cracking produces smaller and unsaturated hydrocarbons

'Suck back' is a safety consideration you should we aware of for this experiment.

The results and conclusion are along the lines of what you would write down in your class jotters after you have completed the experiment.

Self Check 13

1. C_4H_{10} can exists as two isomers.

   (a) Define isomers.
   (b) Name and give the entended and shortened structural formula of each isomer.

2. C_4H_8 can exist as isomers.

   (a) Give the name and entended structural formula of the three **unsaturated** isomers whose molecular formula is C_4H_8.
   (b) Give the name and extended structural formula of a **saturated** isomer whose molecular formula is C_4H_8.

Self Check 17

1. America possesses large hydrocarbon reserves in the form of a viscous liquid called Kerogen. Although not useful as a fuel the Kerogen can be catalytically cracked to yield useful fuels such as octane.

   (a) Explain the meaning of the underlined words.
   (b) Kerogen is said to be viscous; what does this tell us about

      (i) The chain length of the hydrocarbons in kerogen?
      (ii) The ease of ignition of kerogen?

   (c) Why is catalytic cracking such an important reaction on the oil industry.
   (d) Cracking reactions involve the use of catalysts. What is a catalyst?

2. When a sample of a hydrocarbon is heated it breaks down as follows

   $$C_8H_{18} \longrightarrow C_5H_{12} + X$$

   (a) What is the molecular formula of the hydrocarbon X?
   (b) Name the hydrocarbons C_8H_{18} & C_5H_{12} and give the formula mass of each.

3. Cracking is an important industrial process.

   (a) Draw a labeled diagram of the apparatus used in the laboratory to crack long-chain hydrocarbons.
   (b) How did you show that alkenes are always formed in the process ?

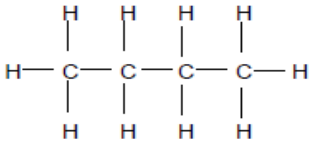
Answers to the Self check are shown on the next page

Self Check Answers 13

1. (a) Isomers are compounds with the same molecular formula but different structural formulae.

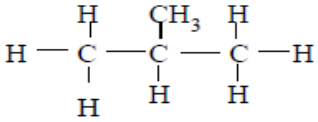
(b) Butane

$CH_3CH_2CH_2CH_3$



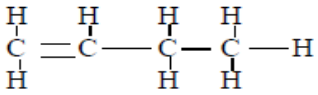
2methyl propane

$CH_3CH(CH_3)CH_3$

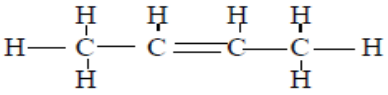


2. (a) The isomers are

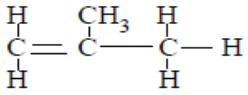
but-1-ene



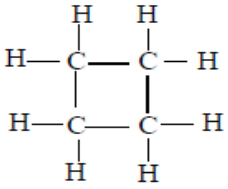
but-2-ene



methyl propene



(b) Cyclobutane is a saturated isomer.



Self Check Answers 17

1. (a) *hydrocarbon* : a compound containing the elements hydrogen and carbon only.
viscous : thick, difficult to pour.

(b) (i) The chains are long
(ii) It does not burn easily.

(c) It converts fractions for which there is little demand (bitumen) into those for which the demand is great (petrol.)

(d) A catalyst is a substance which speeds up a chemical reaction.

2. (a) C_3H_6

(b) C_8H_{18} is octane ; formula mass 114

C_5H_{12} is pentane ; formula mass 72

3. (a) Show diagram to your teacher.
(b) T he gases decolourise bromine water.

Your homework is shown on the next page

Isomers 9

1. C_5H_{12} can exist as three isomers.

(a) Define isomers.

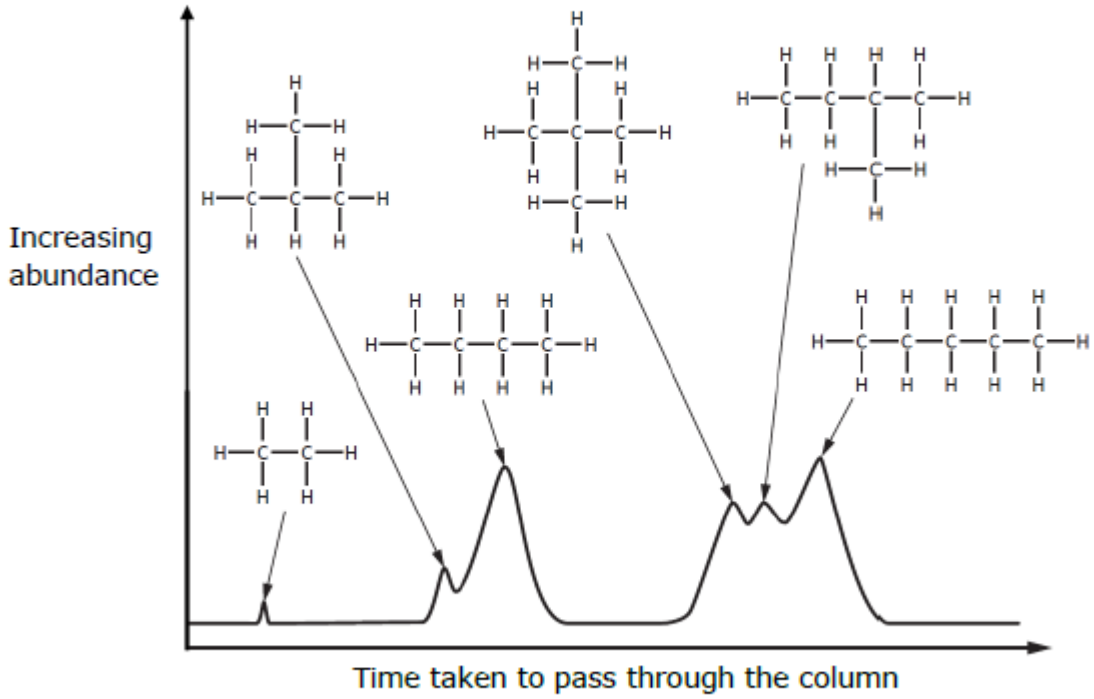
(b) Draw the extended structural formula of each isomer.

2. C_4H_8 can exist as isomers.

(a) Give the name and extended structural formula of two unsaturated isomers whose molecular formula is C_4H_8.

(b) Give the name and extended structural formula of a saturated isomer whose molecular formula is C_4H_8.

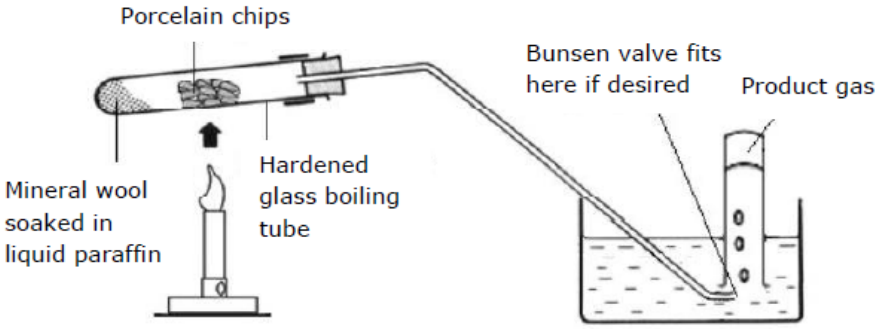
3. A mixture of gas hydrocarbons can be separated by a method called gas chromatography.
The gas mixture is passed through a special column packed with a powder.
Different hydrocarbons move through the column at different speeds.
The following result was obtained from a mixture of hydrocarbons.



Make **two** general statements linking the structure of a hydrocarbon with the length of time taken to pass through the column.

Cracking 12

1. The diagram below shows the laboratory set up used to crack hydrocarbons.



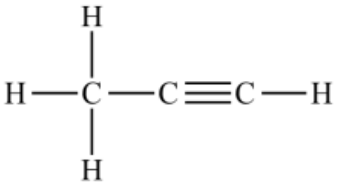
(a) What is the function of the porcelain chips in the above experiment?
(b) How would you show that the gas collected in the test tube contained alkenes?

2. When a sample of a hydrocarbon is heated it breaks down as follows

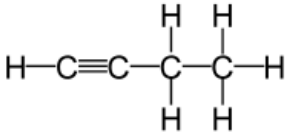
$$C_8H_{18} \rightarrow C_6H_{14} + \mathbf{X}$$

(a) What is the molecular formula of the hydrocarbon **X**?
(b) Name the hydrocarbons C_8H_{18} & C_6H_{14}.

3. The alkynes are a family of hydrocarbons which contain a carbon to carbon triple bond.



propyne



butyne

(a) Suggest a general formula for the alkynes.
(b) Draw the structural formula of pentyne.