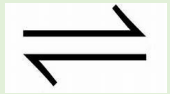
Title – C7 Organic Chemistry Monday, 25 September 2023

Do it now:

What is a catalyst? A substance that **speeds up a reaction** by providing an alternative reaction pathway with a **lower activation energy**.	Describe the effect of increasing temperature on the rate of reaction. At higher temperatures particles have **more kinetic energy**, so there are **more frequent successful collisions** and a **faster rate of reaction**.	What is the symbol for a reversible reaction? How do reversible reactions reach equilibrium? Reversible reactions reach equilibrium when the **rate of the forward reaction** equals the **rate of the backwards reaction**. 
If a reversible reaction gives out 50J of energy in the forward reaction, describe the energy transfer in the backward direction. In the backward direction, it would **TAKE IN 50J.**	What are the effects of nitrogen oxides and sulphur dioxide on human health and on the environment? Both pollutants cause **global dimming** (less sunlight can reach the Earth's surface) and **respiratory problems**.	What is the difference between complete and incomplete combustion? **Complete combustion:** - Occurs when there is a lot of oxygen, forms **carbon dioxide** **Incomplete combustion:** - Occurs when there is **not** a lot of oxygen, forms **carbon monoxide**

Crude oil

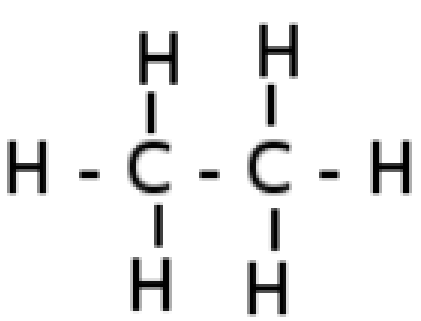
Crude oil is a dark, smelly liquid formed from the remains of **plants** and **animals** that have decayed over **millions** of years.

Key definition:

Crude oil is made up of a mixture of lots of hydrocarbons. It is extracted from the ground and refined to produce fuels that can be burned to release energy.

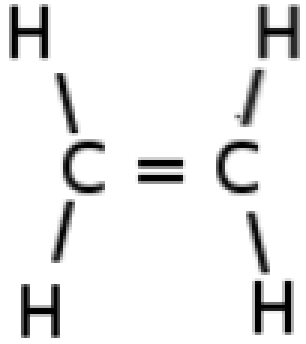
Crude oil

Two ‘families’ of hydrocarbons are **alkanes** and **alkenes.** Both contain covalent bonds between carbon and hydrogen atoms:



ALK**A**NES

ethane



ALK**E**NES

ethene

- Contain ONLY ***single C-H bonds = saturated***
- Name ends in ‘**ane**’

- Contain ***double C-H bonds = unsaturated***
- Name ends in ‘**ene**’

Alkanes

Rule 1: Alkanes will ALWAYS end in –ane.

Rule 2: The start of the name depends on how many carbon atoms the molecule has…

Number of carbon atoms	Beginning of the word	Remember!!
1	Meth-	**M**onkeys
2	Eth-	**E**at
3	Prop-	**P**eanut
4	But-	**B**utter

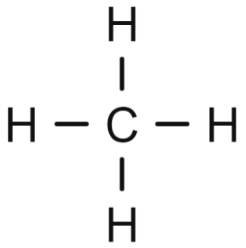
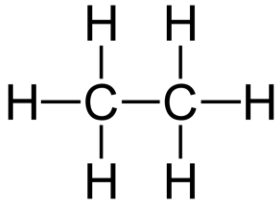
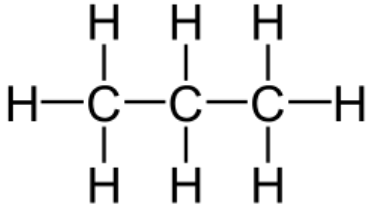
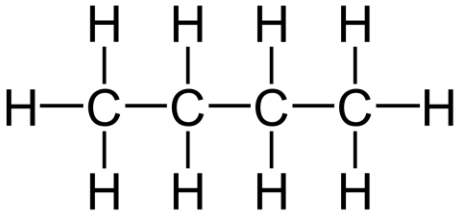
The general formula for alkanes is:

C_nH_{2n+2}

This ‘family’ of hydrocarbons is known as a **homologous series**

Alkanes

Task: *Complete the table...*

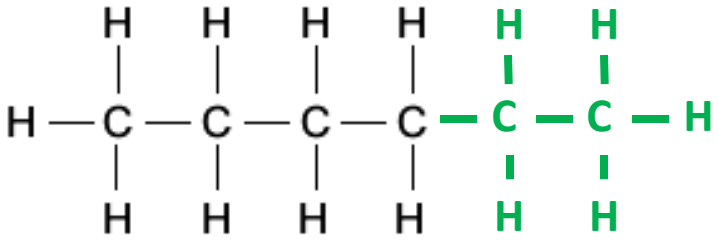
No. of carbon atoms	*Name*	*Molecular formula*	*Structure*
1	Methane	CH_4	
2	Ethane	C_2H_6	
3	Propane	C_3H_8	
4	Butane	C_4H_{10}	

Exam practice

1. Crude oil is a mixture of hydrocarbons. Most of these hydrocarbons are alkanes.

(a) The general formula of an alkane is C_nH_{2n+2}

Complete the structural formula for the alkane that has **six** carbon atoms in its molecules.



(1)

(b) Give the formula of propane.

C_3H_8

(1)

(c) Circle which of the following is **not** an alkane.

C_7H_{16} C_9H_{18} $C_{11}H_{24}$ $C_{24}H_{50}$

(1)

(d) What is the formula of octane?

C_8H_{18}

(1)

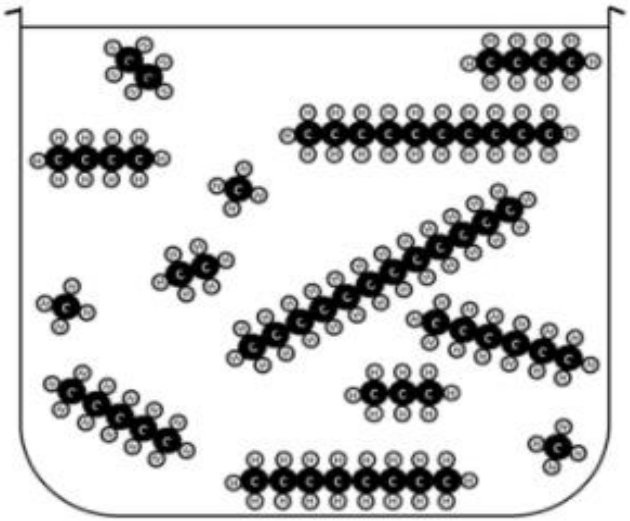
Fractional distillation

AFTER (fractions)

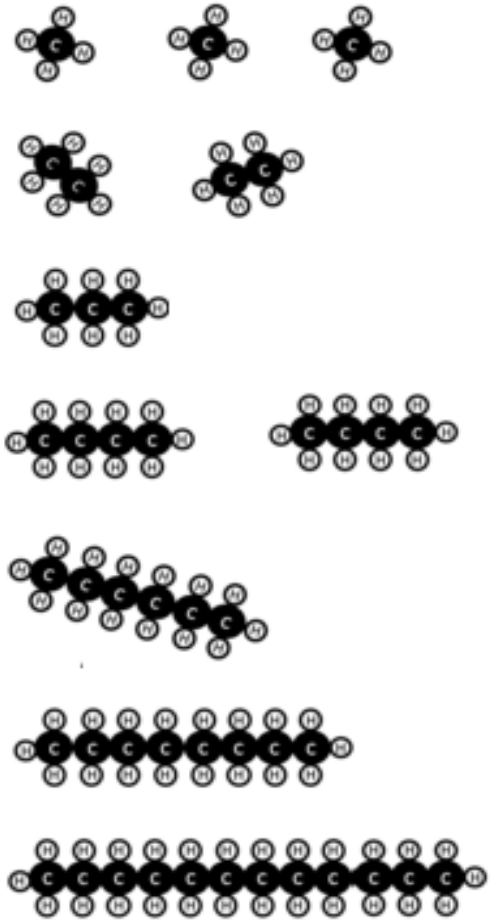
- Hydrocarbons are **separated**
- **Useful** as fuels!

BEFORE (crude oil)

- **Mixture** of hydrocarbons
- **Not useful** as a fuel



Fractional distillation

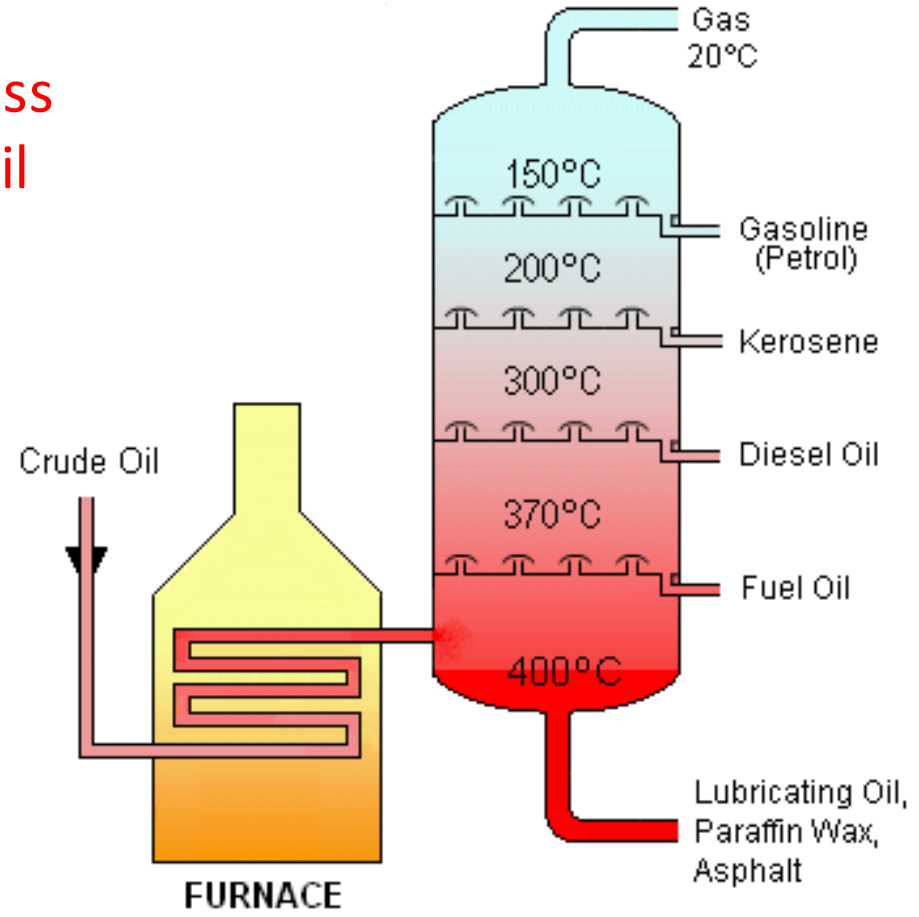


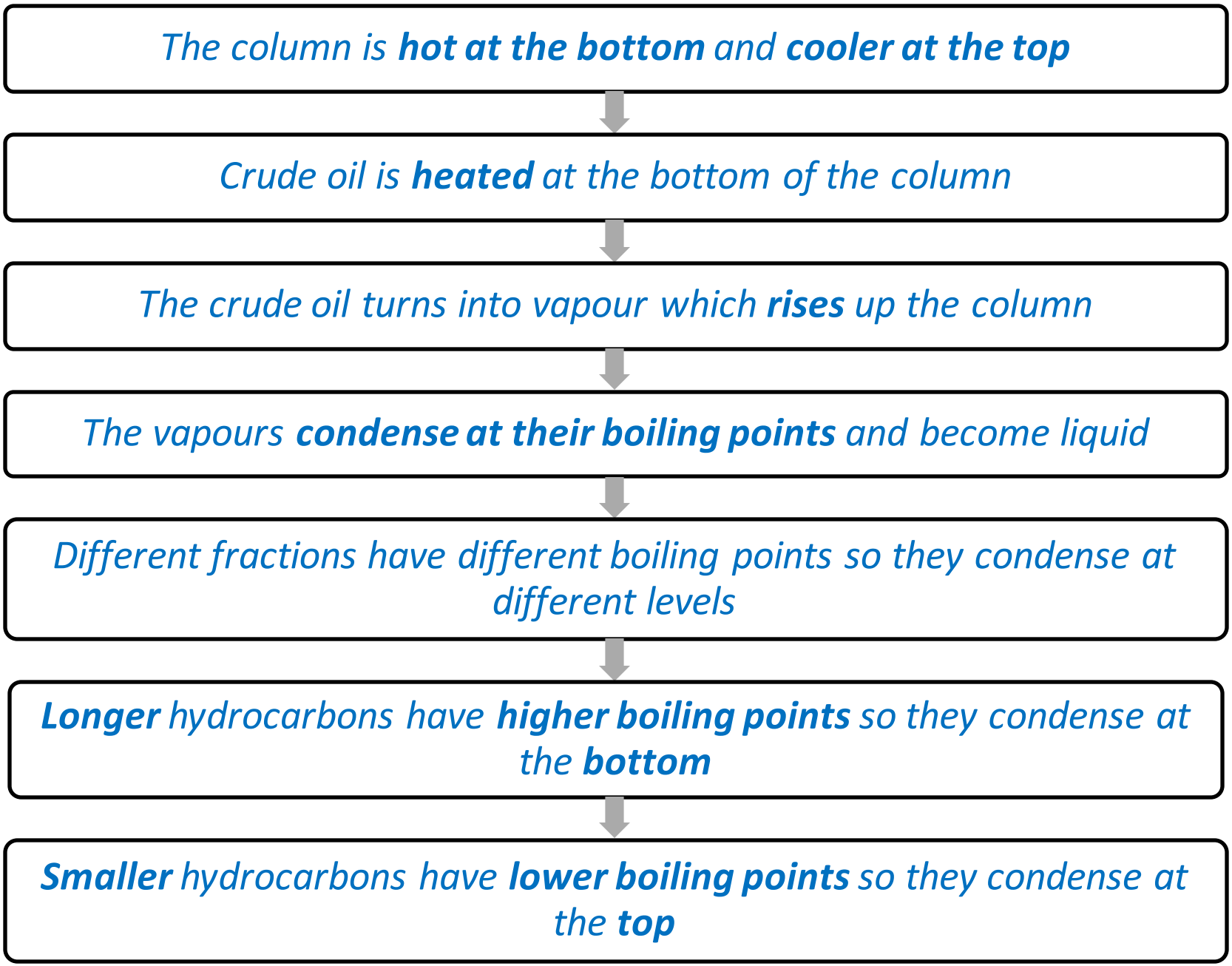
Key definition:

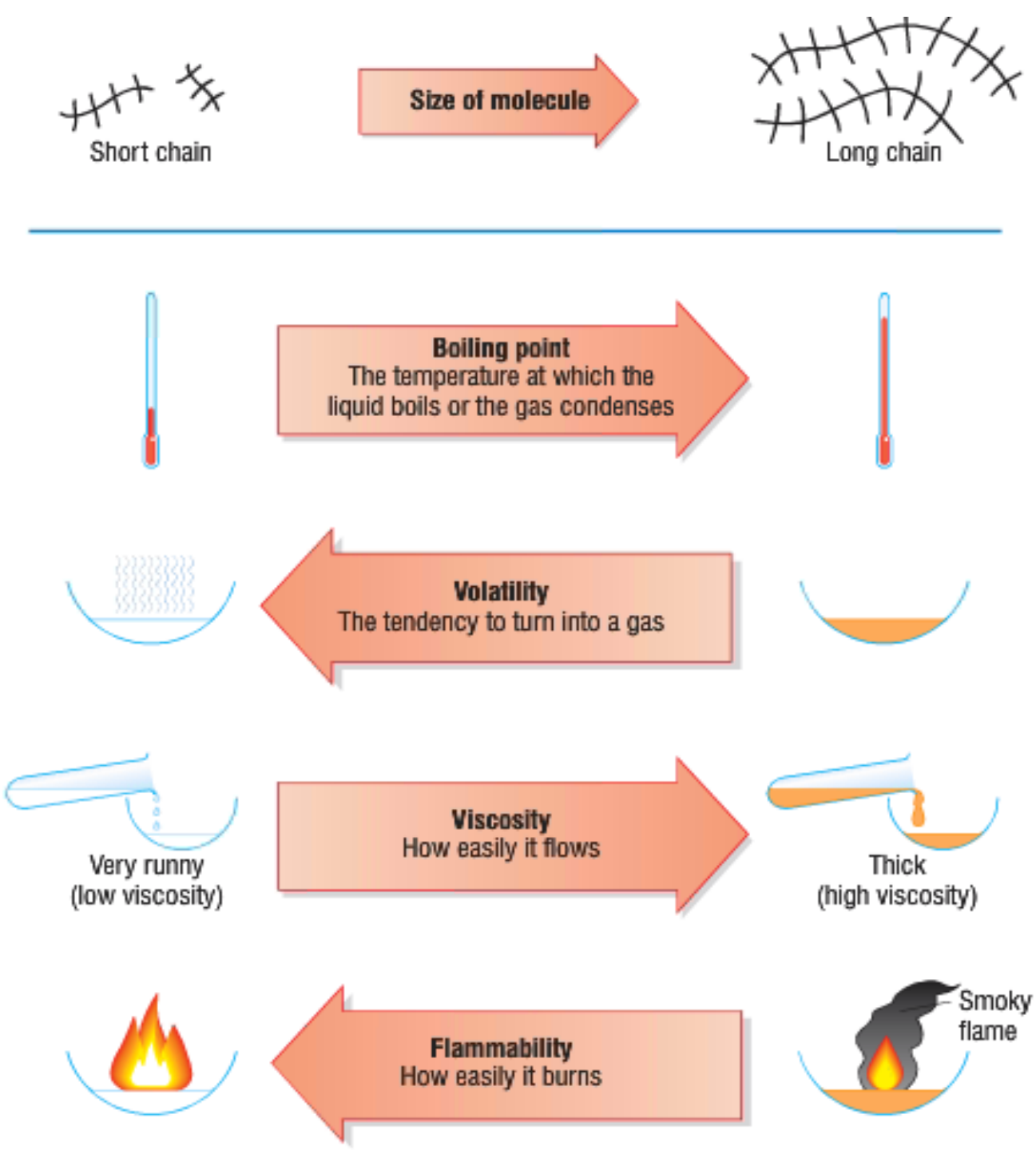
A **fraction** is a set of hydrocarbon molecules of similar size and similar boiling points.

Fractional distillation is a process that is used to separate crude oil into it's fractions depending on their boiling points.

Fractional distillation occurs in a **column** that is hot at the bottom and cold at the top:



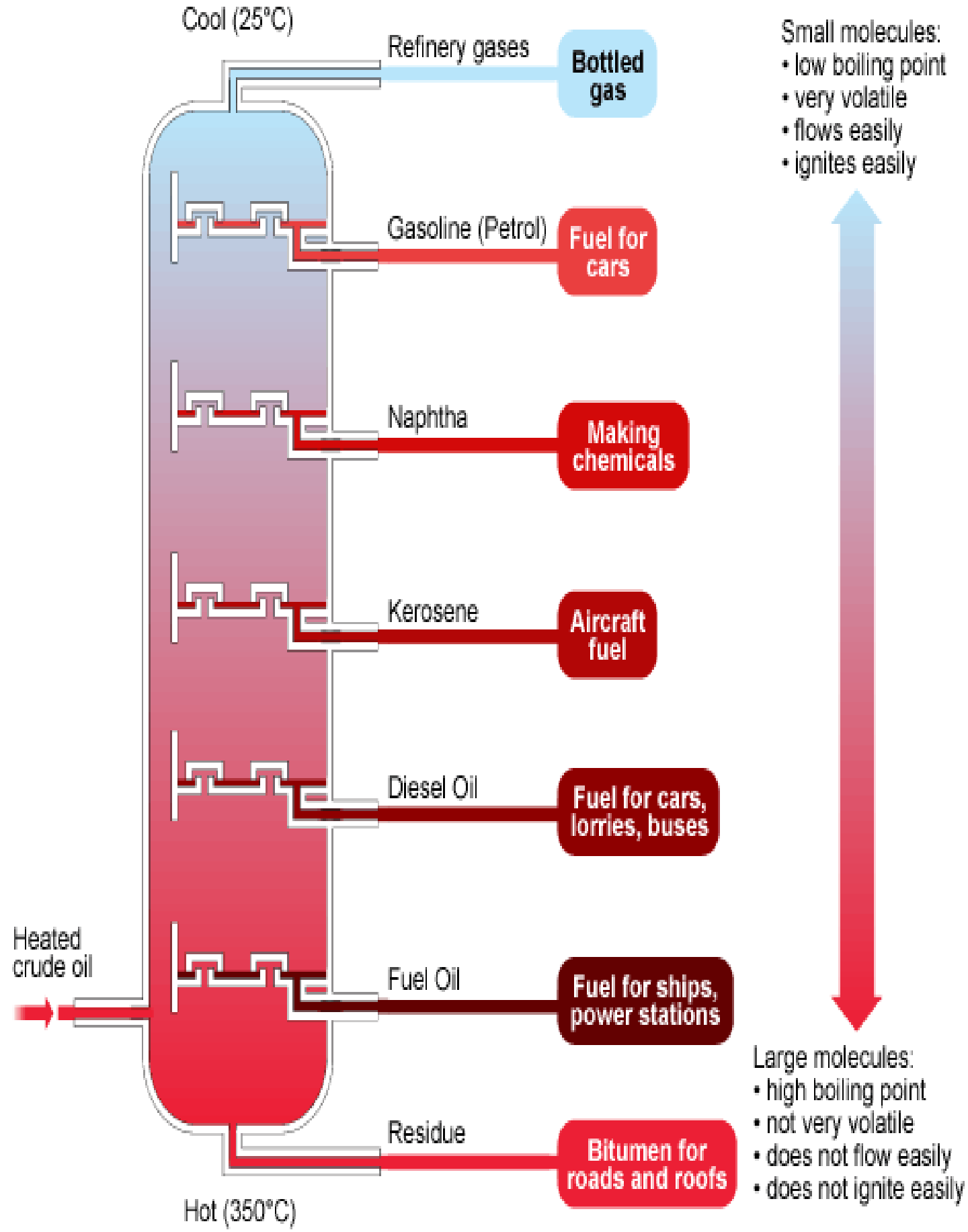

The column is **hot at the bottom** and **cooler at the top**
Crude oil is **heated** at the bottom of the column
The crude oil turns into vapour which **rises** up the column
The vapours **condense at their boiling points** and become liquid
Different fractions have different boiling points so they condense at different levels
Longer hydrocarbons have **higher boiling points** so they condense at the **bottom**
Smaller hydrocarbons have **lower boiling points** so they condense at the **top**



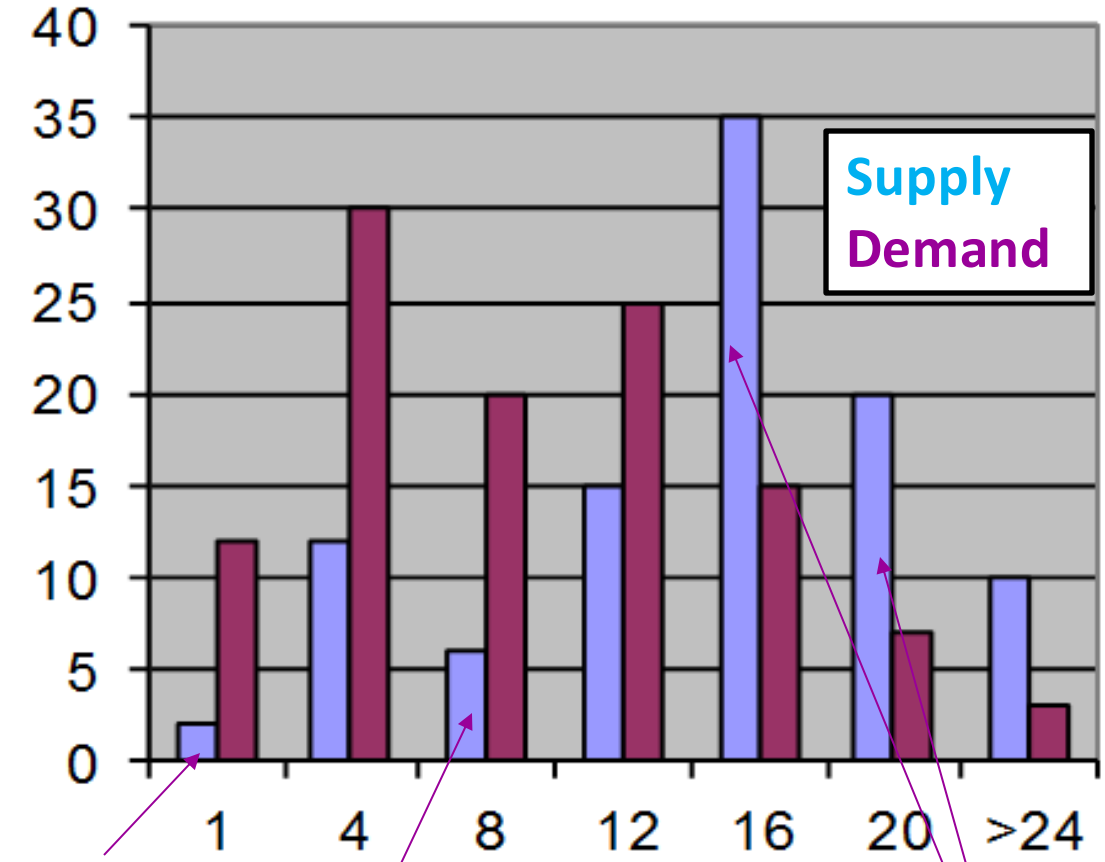
Longer carbon chain:
- *higher* boiling point
- *higher* viscosity
- *lower* flammability
- *lower* volatility

In **larger** molecules, with long chain lengths, there are **more** intermolecular forces.

More energy is required to overcome these forces which is why the **boiling point increases** with chain length.


Cool (25°C)
Refinery gases
Bottled gas
Gasoline (Petrol)
Fuel for cars
Naphtha
Making chemicals
Kerosene
Aircraft fuel
Diesel Oil
Fuel for cars, lorries, buses
Heated crude oil
Fuel Oil
Fuel for ships, power stations
Residue
Bitumen for roads and roofs
Hot (350°C)
Small molecules:
• low boiling point
• very volatile
• flows easily
• ignites easily
Large molecules:
• high boiling point
• not very volatile
• does not flow easily
• does not ignite easily

Cracking



Methane gas

Octane – found in the petrol fraction

Long chains – found in the residue fraction

Key definition:

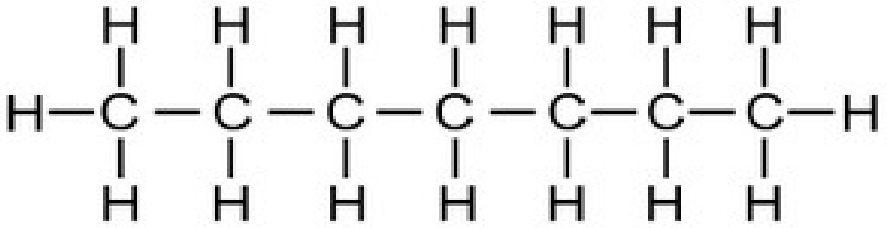
Cracking is a process in which long chain hydrocarbons can be broken down into **shorter (and more useful) hydrocarbons.**

Cracking always produces **shorter alkanes** (which can be used for fuel) and **shorter alkenes** (which are used to make **polymers**).

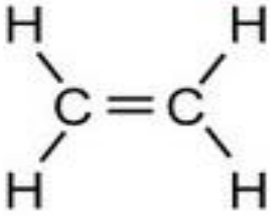
Smaller **alkanes** and **alkenes** are always formed during cracking. The alkane is used for fuels like petrol and the alkenes are used to make polymers.

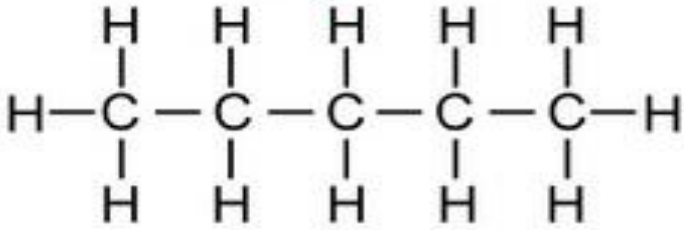
Note, there are the same number of C and H atoms before and after!

Heptane, C_7H_{16}



Ethene
C_2H_4





Pentane
C_5H_{12}

ALKENE
Used for fuels

ALKANE
Used to make polymers

There are **two types** of cracking

1. CATALYTIC CRACKING

= temperature of approximately 550°C and a catalyst.

2. STEAM CRACKING

= higher temperature of approximately 800°C, no catalyst.

Catalytic cracking is usually used in industry because it can happen at **lower temperatures** which **saves energy** and therefore **saves money**!

Alkenes will react with **orange-brown bromine water** to turn it **colourless (NOT CLEAR!).**

Alkanes will not react and will remain orange/brown.

Orange/brown bromine water

→

Turns **colourless** when **alkene** is added

Remember! The number of carbons and hydrogens is the same on both sides of the arrow.

Complete the following equations:

1. $C_{12}H_{26} \rightarrow C_8H_{18} + \mathbf{C_4H_8}$

2. $C_{16}H_{34} \rightarrow C_3H_6 + \mathbf{C_{13}H_{28}}$

3. $C_{20}H_{42} \rightarrow C_5H_{10} + C_9H_{20} + \mathbf{C_6H_{12}}$

4. $C_{14}H_{30} \rightarrow C_7H_{16} + \mathbf{C_5H_{10}} + C_2H_4$

Challenge – *Identify which products are alkanes and which products are alkenes!*

Exam practice

Q1. (a) The hydrocarbon $C_{16}H_{34}$ can be cracked. Balance the equation below:

$$C_{16}H_{34} \rightarrow \underline{\quad C_6H_{12} \quad} + C_2H_4 + C_8H_{18}$$

(1)

(b) Describe the differences between cracking and fractional distillation.

(2)

Cracking uses a catalyst, distillation doesn't. Cracking is a chemical process that breaks up molecules, distillation is a physical process that separates molecules.

(c) What type of reaction is cracking?

Combustion Decomposition Neutralisation Precipitation

(1)

Q2. This question is about hydrocarbons. Most of the hydrocarbons in crude oil are alkanes. Large alkane molecules can be cracked to produce more useful molecules.

The equation shows the cracking of dodecane.

$$C_{10}H_{22} \rightarrow \underline{\quad C_3H_6 \quad} C_2H_4 + C_5H_{12}$$

(a) Complete the equation above. **(1)**

(b) Give two conditions used to crack large alkane molecules. High temperature, catalyst. **(2)**

1. Complete combustion

Complete combustion occurs when there is lots of oxygen available to burn the fuel in:

'fuel' + oxygen → carbon dioxide + water

Task: Write a **word equation** to represent the two reactions below. Identify the reactants and products.

1. Complete combustion of methane (CH_4):

2. Complete combustion of ethane (C_2H_6):

Challenge!: Write a ***balanced*** symbol equation for the two reactions.

2. Incomplete Combustion

Incomplete combustion occurs when there is not very much oxygen available to burn the fuel in.

There are two products that can be made in incomplete combustion:

'fuel' + oxygen → carbon monoxide + water

(CO)

= a poisonous gas that stops oxygen bonding to red blood cells

'fuel' + oxygen → carbon + water

(C)

= soot

5.7.1.1 Crude oil, hydrocarbons and alkanes

Content

Crude oil is a finite resource found in rocks. Crude oil is the remains of an ancient biomass consisting mainly of plankton that was buried in mud.

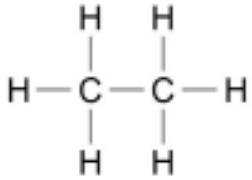
Crude oil is a mixture of a very large number of compounds. Most of the compounds in crude oil are hydrocarbons, which are molecules made up of hydrogen and carbon atoms only.

Most of the hydrocarbons in crude oil are hydrocarbons called alkanes. The general formula for the homologous series of alkanes is C_nH_{2n+2}

The first four members of the alkanes are methane, ethane, propane and butane.

Alkane molecules can be represented in the following forms:

C_2H_6 or



Students should be able to recognise substances as alkanes given their formulae in these forms.

Students do not need to know the names of specific alkanes other than methane, ethane, propane and butane.

Red	Amber	Green

5.7.1.2 Fractional distillation and petrochemicals

Content

The many hydrocarbons in crude oil may be separated into fractions, each of which contains molecules with a similar number of carbon atoms, by fractional distillation.

The fractions can be processed to produce fuels and feedstock for the petrochemical industry.

Many of the fuels on which we depend for our modern lifestyle, such as petrol, diesel oil, kerosene, heavy fuel oil and liquefied petroleum gases, are produced from crude oil.

Many useful materials on which modern life depends are produced by the petrochemical industry, such as solvents, lubricants, polymers, detergents.

The vast array of natural and synthetic carbon compounds occur due to the ability of carbon atoms to form families of similar compounds.

Students should be able to explain how fractional distillation works in terms of evaporation and condensation.

Knowledge of the names of other specific fractions or fuels is not required.

Red	Amber	Green

5.7.1.3 Properties of hydrocarbons

Content

Some properties of hydrocarbons depend on the size of their molecules, including boiling point, viscosity and flammability. These properties influence how hydrocarbons are used as fuels.

Students should be able to recall how boiling point, viscosity and flammability change with increasing molecular size.

The combustion of hydrocarbon fuels releases energy. During combustion, the carbon and hydrogen in the fuels are oxidised. The complete combustion of a hydrocarbon produces carbon dioxide and water.

Students should be able to write balanced equations for the complete combustion of hydrocarbons with a given formula.

Knowledge of trends in properties of hydrocarbons is limited to:

- boiling points
- viscosity
- flammability.

Red	Amber	Green

5.7.1.4 Cracking and alkenes

Content
Hydrocarbons can be broken down (cracked) to produce smaller, more useful molecules.
Cracking can be done by various methods including catalytic cracking and steam cracking.
Students should be able to describe in general terms the conditions used for catalytic cracking and steam cracking.
The products of cracking include alkanes and another type of hydrocarbon called alkenes.
Alkenes are more reactive than alkanes and react with bromine water, which is used as a test for alkenes.
Students should be able to recall the colour change when bromine water reacts with an alkene.
There is a high demand for fuels with small molecules and so some of the products of cracking are useful as fuels.
Alkenes are used to produce polymers and as starting materials for the production of many other chemicals.
Students should be able to balance chemical equations as examples of cracking given the formulae of the reactants and products.
Students should be able to give examples to illustrate the usefulness of cracking. They should also be able to explain how modern life depends on the uses of hydrocarbons.
(Students do not need to know the formulae or names of individual alkenes.)

Red	Amber	Green

Complete the practice paper questions!

Revision lesson link:

https://www.youtube.com/watch?v=CX2IYWggEBc&list=PL9IouNCPbCxVDcgWiviYYWj0xKMPXTd8s

https://www.youtube.com/watch?v=ykIFTtTjoso&list=PLidqqIGKox7WeOKVGHxcd69kKqtwrKl8W&index=43&t=123s

https://www.bbc.co.uk/bitesize/guides/zshvw6f/revision/1
- Google 'BBC Bitesize Organic Chemistry GCSE'.

15 Minute ILT Task:

5.7.1.1 Crude oil, hydrocarbons and alkanes	1. What is a hydrocarbon? 2. What are alkanes? 3. Why are alkanes said to be saturated? 4. List the names of the first 4 alkanes and draw their displayed structures. 5. What is the general formula of alkanes? 6. State the chemical formula of an alkane with five carbons. 7. What is crude oil, what is it made from and how does it form? 8. Which compounds are crude oils predominantly made from?
5.7.1.2 Fractional distillation and petrochemicals	1. What is fractional distillation? 2. Describe how fractional distillation works.
5.7.1.3 Properties of hydrocarbons	1. State four properties of hydrocarbons as the carbon chain length gets shorter. 2. State the equation for the complete combustion of hydrocarbons. 3. Write the symbol equation for the complete combustion of propane. 4. Write the symbol equation for the complete combustion of butane.
5.7.1.4 Cracking and alkenes	1. What are the fractions of crude oil processed to provide? 2. What is cracking? 3. What kind of a reaction is cracking? 4. Name two methods of cracking. 5. Describe how catalytic cracking works. 6. Describe how steam cracking works. 7. What are the main products of cracking?