Topic 8a – Alkanes
Revision Notes

1) General

Alkanes are saturated hydrocarbons with general formula C_nH_{2n+2}

- Saturated = only single C-C bonds
- Hydrocarbon = contains C and H only

C-H bonds are non-polar (C and H have similar electronegativities) so:

- The only intermolecular forces in alkanes are Van der Waal's forces
- Alkanes do not attract charged species (nucleophiles and electrophiles)

In alkanes, the bonds round each carbon are tetrahedral in shape. Each C has 4 bond pairs in its outer shell which repel each other and get as far apart as possible.

2) Boiling points

- Boiling point increases with chain length – more electrons, more Van der Waal's forces
- Boiling point decreases as branching increases – branched alkanes have less surface area in contact so intermolecular forces are weaker (or straighter chains can pack closer, more Van der Waal's forces)

3) Reactions

a) Combustion

- Reaction with oxygen producing CO_2 and H_2O
- Exothermic (produces heat)
- Gas volume increases (used to drive pistons in engines)
- Alkanes are used as fuels in industry, in the home and in transport

b) Substitution

- H replaced by Cl or Br e.g.

$$\mathbf{CH_4 + Br_2 \rightarrow CH_3Br + HBr}$$

- Requires u/v light to break Br-Br bond
- The bond breaking is homolytic fission because two radicals are produced, each having an unpaired electron
- A mechanism shows the detailed steps by which the reactants turn into the products
- The mechanism here is called radical substitution

Initiation step	e.g.	$Br_2 \rightarrow 2Br\bullet$		
Propagation	e.g.	$CH_4 + Br\bullet \rightarrow \bullet CH_3 + HBr$	}	as a
		$\bullet CH_3 + Br_2 \rightarrow CH_3Br + Br\bullet$	}	pair
Termination step	e.g.	$2\bullet CH_3 \rightarrow CH_3CH_3$		

- Further substitution can occur with more H's being replaced by Br's

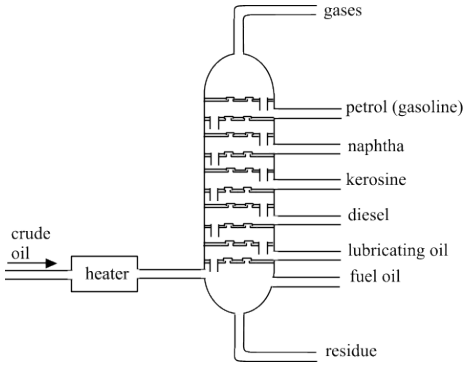
$$\mathbf{CH_3Br + Br_2 \rightarrow CH_2Br_2 + HBr \text{ etc}}$$

- The reaction produces a mixture of products (CH_3Br, CH_2Br_2, $CHBr_3$ and CBr_4). This means that radical substitution is not a good way of making a particular product (the reaction has limited use in synthesis – which means making a desired product in a number of steps)

Topic 8b – Fuels
Revision Notes

1) Fractional Distillation

- Crude oil is a mixture of many compounds, most of which are alkanes.
- Crude oil is separated into fractions, many of which can be used directly as fuels.
- The separation process is called fractional distillation. This involves:
    - Vaporising the crude oil
    - Passing the vapour into a column that is hot at the bottom and cool at the top
    - The vapour rising and condensing at the appropriate level
    - Separation is based on the different boiling points of alkanes



2) Processing of fractions

a) Cracking

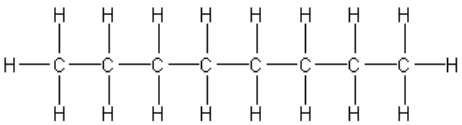
- Crude oil contains no alkenes and more long chain alkanes than are needed.
- Cracking converts long chain alkanes into shorter chain alkanes and an alkene e.g.

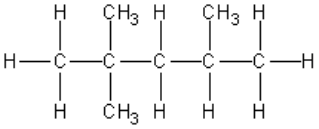
$$C_{11}H_{24} \rightarrow C_8H_{18} + C_3H_6$$

- Cracking requires heat and a catalyst. It is a thermal decomposition reaction.
- The alkenes from cracking are used to make polymers and alcohols

b) Isomerisation

- Isomerisation turns straight chain alkanes into branched chain alkanes e.g. Octane → 2,2,4-trimethylpentane





- Branched chain hydrocarbons make better fuels as their lower boiling points mean they burn more efficiently
- Isomerisation increases the octane number of the hydrocarbon
- It needs a catalyst and heat

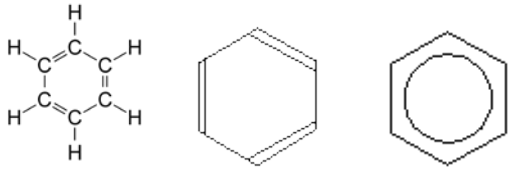
c) Reforming

- Reforming turns straight chain alkanes into cyclic alkanes and arenes (and hydrogen) e.g.

$C_6H_{14} \rightarrow C_6H_{12} + H_2$
Hexane → cyclohexane

$C_6H_{14} \rightarrow C_6H_6 + 4H_2$
Hexane → benzene

- Arenes contain a benzene ring (see A2 - Topic 1). Benzene can be represented in several ways. The third one will make more sense next year:



- Arenes make better fuels than straight chain alkanes as they have higher octane numbers and burn more efficiently
- Reforming needs heat and a catalyst

3) <u>Fossil fuels and biofuels</u>

- Fossil fuels (coal, gas and oil) are very useful to us as sources of energy and as a feedstock for making petrochemicals
- However, they are non-renewable as they take millions of years to form and increased CO_2 levels from burning fossil fuels are leading to global warming and climate change
- We will eventually need to replace fossil fuels with renewable energy sources such as biofuels e.g. alcohol made from sugar cane and biodiesel made from grain
- Biofuels are renewable as plant material takes only a short time to grow