18 The first six members of the alkanes occur as gases and liquids at normal temperatures.
Alkanes are currently our most important fuels, but the use of alcohols as renewable energy source is becoming more and more important. Alcohols are liquids that might be a solution to the energy crisis.

18.1 Which chemical property of alkanes and alcohols make them suitable to be used as fuels? (2)
18.2 Briefly explain why ethanol is a renewable energy source, while the alkanes are non-renewable. (2)

19 Write down the structural formula of an isomer of the following compound that has only FOUR carbon atoms in the longest chain:

$CH_3CH_2CH_2CH_2CH_2CH_3$ (2)

20 Write down the structural formula of 2,3-dimethylbutane, which is an isomer of hexane. (2)

21 Write down a balanced equation for the combustion reaction of C_3H_8 with excess oxygen.
(Structural formulae are not required.) (3)

22 Cracking is a process that is generally used in the oil industry.

22.1 What is meant by cracking? (2)
22.2 Why is cracking used in the fuel industry? (2)

Alkenes

The alkenes are **unsaturated hydrocarbons**.

Functional group: Alkenes are characterised by one or more **double bonds** between two carbon atoms. Therefore its functional group is – **C = C** –

General formula is $\mathbf{C_nH_{2n}}$

IUPAC (systematic) name: Similar to naming the alkanes.
Count the number of C-atoms in the longest chain and select the corresponding prefix from the table on p 64, then add –ene, which indicates the presence of a double bond. Number the C atoms from end closest to the double bond. Indicate the position of the double bond by specifying the number of the double bond, e.g. – C – C – C = C – is but-1-ene and – C – C = C – C – is but-2-ene. (it is often written as 1-butene and 2-butene, but it is preferably written as but-1-ene, etc.) The presence of two double bonds is indicated by -**di**ene. Everything except H attached to the chain is now written in alphabetical order, preceded by the number of the carbon atom it is attached to, **plus a hyphen**.
If the compound is a ring structure, write "cyclo" followed by the prefix from the table, indicating the number of carbon atoms in the ring, then add "–ene" as a suffix, e.g. C_6H_{10} is cyclohexene.

Everything except H attached to the chain is now written in alphabetical order, preceded by the number of the carbon atom it is attached to, plus a hyphen.
The **dienes** (substances containing **two** double bonds) can be classified as follows:
- **Conjugated dienes**, consisting of alternating double and single bonds, e.g. – C = C – C = C –.
- **Isolated dienes** which consist of one or more saturated carbon atoms (single bonds only) between two double bonds, e.g. – C = C – C – C = C –.
- **Cumulated dienes** where two double bonds formed to one carbon atom, e.g. – C = C = C –.

Chemical properties:
- Alkenes burn in the same way as alkanes, producing more energy.
- **Addition reactions**: When a double bond breaks, other atoms are added to the chain.
  Addition reactions, which occur at unsaturated hydrocarbons, happen **faster than substitution reactions**, which occur at saturated hydrocarbons and this difference in rate can be used to test whether a hydrocarbon is saturated or unsaturated.
  There are different kinds of addition reactions:
  - **Hydrohalogenation**, which is the addition of HX (X = Cℓ, Br, I), in the absence of water, e.g.

    $CH_2 = CH_2 + HC\ell \rightarrow CH_3 - CH_2C\ell$

During addition of HX to unsaturated hydrocarbons, the H atom attaches, according to **Markovnikov's rule**, to the C atom which already bears the greater number of H atoms.
The X atom attaches to the C atom bearing the smaller number of H atoms, e.g.

$$CH_3CH = CH_2 + HX \rightarrow \underset{\text{Br}}{CH_3CH} - \underset{\text{H}}{CH_2}$$

The C on the left of the = has only one H atom, while the C on the right of the = has 2 H atoms, therefore it will take the H.

- **Halogenation**, which is the addition of X_2 (X = Cℓ, Br, I) to alkenes, e.g.

  $CH_2 = CH_2 + C\ell_2 \rightarrow CH_2C\ell - CH_2C\ell$

- **Hydration**, which is the addition of H_2O (or H – OH) to alkenes (excess water and a small amount of HX or other strong acid as catalyst), e.g.

  $CH_2 = CH_2 + H_2O \rightarrow CH_3 - CH_2OH$

  During addition of H-OH to unsaturated hydrocarbons, the H atom attaches to the C which already bears the greater number of H atoms.
  The OH group attaches to the C atom bearing the smaller number of H atoms, e.g.

$$CH_3CH = CH_2 + H_2O \rightarrow \underset{\text{OH}}{CH_3CH} - \underset{\text{H}}{CH_2}$$

- **Hydrogenation**, which is the addition of hydrogen to alkenes (dissolved in a non-polar solvent with catalyst Pt, Pd or Ni in a hydrogen atmosphere), is used in producing **margarine**.
  E.g.

  $CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$

Exercise 29:

1 Give ONE word/term for

1.1 a group of compounds that can undergo addition reactions. (1)

2 When margarine is manufactured from unsaturated vegetable oil, the reaction which occurs when the fats are hardened can be described as

I addition II hydrogenation III polymerisation.(3)

A I only B II only C III only D I and II only

3 Consider the following chemical reaction: $C_5H_{10} + HC\ell \rightarrow C_5H_{11}C\ell$
This type of reaction can best be described as

A an addition reaction. B an acid-base reaction.
C a substitution reaction. D a hydrogenation reaction. (3)

4 Saturating an alkene by treating it with hydrogen is known as

A hydrogenation B substitution
C hydrolysis D protolysis (3)

5 An alkene compound having the formula C_4H_8 has .... structural isomers.

A 1 B 2
C 3 D 4 (3)

6 The organic chemistry experiment to illustrate **addition** to unsaturated compounds is conducted by adding bromine water to cyclohexene.