Crude oil, hydrocarbons and alkanes

4.7.1.1 · Organic chemistry · revision notes

What crude oil is, what hydrocarbons and alkanes are, and how to name, recognise and draw the first four alkanes. Expect short recall questions, formula questions using the general formula C_nH_{2n+2}, and displayed formulae to draw, usually on Paper 2.

Key facts

- Crude oil: finite resource found in rocks; remains of ancient biomass (mainly plankton) buried in mud
- Hydrocarbon = compound made of hydrogen and carbon atoms only
- Methane CH_4, ethane C_2H_6, propane C_3H_8, butane C_4H_{10}
- Each C atom forms 4 bonds; each H atom forms 1 bond
- Crude oil = a mixture of a very large number of compounds, mostly hydrocarbons
- Alkanes: C_nH_{2n+2}, single bonds only (saturated)
- Homologous series: same general formula, differ by CH_2, similar reactions, trend in physical properties
- Grade 7+ only Alkane $M_r = 14n + 2$

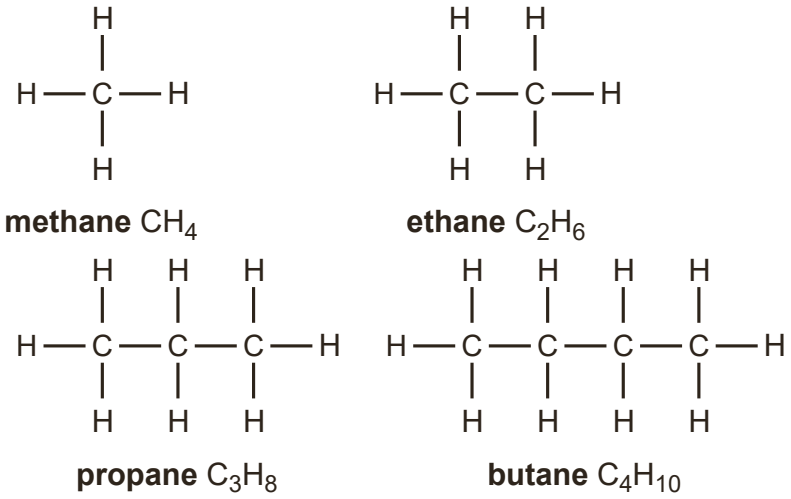
Notes

Crude oil

- **Crude oil** is a **finite** resource found in rocks. It is being used far faster than it forms, so it will run out.
- It is the remains of an ancient **biomass**, consisting mainly of **plankton**, that was buried in mud and compressed over millions of years.
- Crude oil is a **mixture** of a very large number of compounds. They are not chemically joined to each other, so they can be separated by a physical method (fractional distillation).
- Most of the compounds in crude oil are **hydrocarbons**: molecules made up of **hydrogen and carbon atoms only**.
- Most of these hydrocarbons are **alkanes**.

The alkanes

- The alkanes are a **homologous series**: a family of compounds with the same general formula, in which each member differs from the next by CH_2.
- General formula: $\mathbf{C_nH_{2n+2}}$, where n is the number of carbon atoms.
- The first four are **methane** CH_4, **ethane** C_2H_6, **propane** C_3H_8 and **butane** C_4H_{10}. These are the only alkane names you must know.

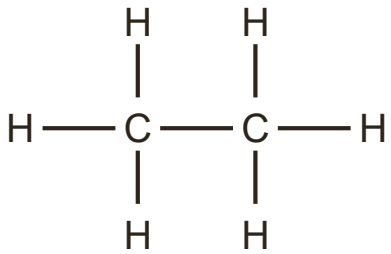


The first four alkanes: every C has 4 bonds, every H has 1.

- Every carbon atom in an alkane forms four single covalent bonds. There are only single bonds, so alkanes are **saturated**.
- Members of a homologous series have similar chemical reactions and show a gradual trend in physical properties, such as boiling point.

Showing alkane molecules

- A **molecular formula** shows the number of atoms of each element in one molecule, e.g. C_3H_8.
- A **displayed formula** shows every atom and every bond as a line. Ethane, C_2H_6:



- Check a displayed formula by counting: 4 bonds on every C, 1 bond on every H.
- You may also see formulae such as $CH_3CH_2CH_3$ (propane), which show how the atoms are grouped along the chain.
- Relative formula mass of an alkane: M_r = 12n + (2n + 2) = 14n + 2. Grade 7+ only

How to answer each type of question

Describe what crude oil is

1 to 4 marks | Grade 3

1. Use the key words: finite, mixture, hydrocarbons, ancient biomass, plankton, buried in mud.
2. For 'hydrocarbon', say hydrogen and carbon atoms **only**: 'only' is often a separate mark.

Example. Describe what crude oil is and how it was formed.

Model answer. Crude oil is a mixture of a very large number of compounds, most of them hydrocarbons (1). It formed from the remains of an ancient biomass, mainly plankton (1), that was buried in mud (1) and compressed over millions of years (1).

Give the formula or name of an alkane

1 mark each | Grade 4

1. Use C_nH_{2n+2}: double the number of carbon atoms and add 2 to get the hydrogens.
2. To recognise an alkane, check that the formula fits: H = 2 × C + 2.
3. Write formulae with capital letters and subscripts, e.g. C_3H_8, not C3h8.

Example. (a) Give the molecular formula of the alkane with 9 carbon atoms.
(b) Which of these is an alkane: C_6H_{12}, C_6H_{14} or C_6H_6?
(c) Name the alkane C_2H_6.

Model answer.

(a) C_9H_{20} (1)

(b) C_6H_{14}, because 2 × 6 + 2 = 14 (1)

(c) Ethane (1)

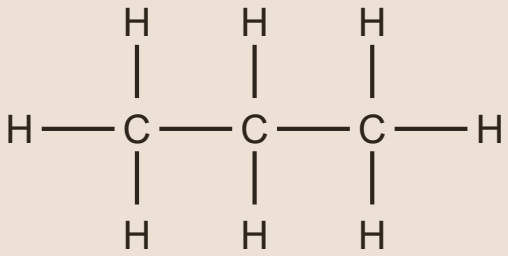
Draw a displayed formula

1 to 2 marks | Grade 5

1. Draw the carbon atoms in a line, joined by single bonds.
2. Add hydrogen atoms until every carbon atom has four bonds.
3. Count the hydrogens: there should be 2n + 2.

Example. Draw the displayed formula of propane, C_3H_8.

Model answer.



Three carbon atoms joined by single bonds (1). Eight hydrogen atoms, with every bond drawn (1).

Calculate: find an alkane from its relative formula mass

2 to 3 marks | Grade 7

1. Write M_r in terms of n: 12n + (2n + 2) = 14n + 2.
2. Set this equal to the M_r you are given and solve for n.
3. Write the formula, and name the alkane if it is one of the first four.

Example. An alkane has a relative formula mass (M_r) of 58.

Relative atomic masses (A_r): H = 1, C = 12

Determine the molecular formula of the alkane and name it.

Model answer.

14n + 2 = 58 (1)

n = 4, so the formula is C_4H_{10} (1)

Butane (1)

(Finding C_4H_{10} by checking, 48 + 10 = 58, also scores the marks.)

Don't lose marks

- Writing that a hydrocarbon is 'a mixture of hydrogen and carbon'. It is a compound, and the key word is 'only'.
- Saying crude oil formed from dinosaurs or trees. The answer examiners want is plankton buried in mud.
- Calling crude oil a compound. It is a mixture of many compounds.

- Drawing a carbon atom with only three bonds (a missing hydrogen), or a bond line with no atom at the end.
- Using superscripts or lower-case letters in formulae, e.g. C^4H^{10} or c4h10.

More tips

Memory tricks

- First four alkanes in order: 'My Elephant Plays Bass' = methane (1 C), ethane (2 C), propane (3 C), butane (4 C).
- Alkane hydrogens: double the carbons and add two. C_5 gives H_{12}; C_8 gives H_{18}.
- Hydro-carbon means hydrogen + carbon and nothing else. If there is O, N or Cl in the formula, it is not a hydrocarbon.
- The ending tells you the family: '-ane' means an alkane, with single bonds only.
- Quick check on any displayed formula: 4 lines on every C, 1 line on every H.

Exam technique

- 'Displayed formula' means every bond drawn. CH_3CH_3 will not score the mark.
- If you are asked for a 'molecular formula', give the numbers of each atom (e.g. C_3H_8), not a drawing.
- In 'which of these is an alkane' questions, test every option with H = 2C + 2 before you choose.
- Show the 14n + 2 step in M_r questions so that you can pick up method marks even if you slip later.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State what crude oil is**
A finite resource found in rocks: the remains of an ancient biomass, mainly plankton, that was buried in mud.

Grade 3 — **Define a hydrocarbon**
A compound whose molecules are made of hydrogen and carbon atoms only.

Grade 4 — **Name the first four alkanes and their formulae**
Methane CH_4, ethane C_2H_6, propane C_3H_8 and butane C_4H_{10}.

Grade 5 — **Use the general formula of the alkanes**
Recognise an alkane from its formula, and write the formula for any number of carbon atoms: 10 carbon atoms gives $C_{10}H_{22}$.

Grade 5 — **Draw the displayed formula of an alkane**
Show every atom and every bond: each carbon atom forms four single bonds and each hydrogen atom forms one.

Grade 6 — **Describe the features of a homologous series**
Same general formula, each member differs from the next by CH_2, similar chemical reactions and a gradual trend in physical properties.

Grade 7 — **Work out an alkane's formula from its Mr**
M_r = 14n + 2, so solve for n: an M_r of 72 gives n = 5, which is C_5H_{12}.

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