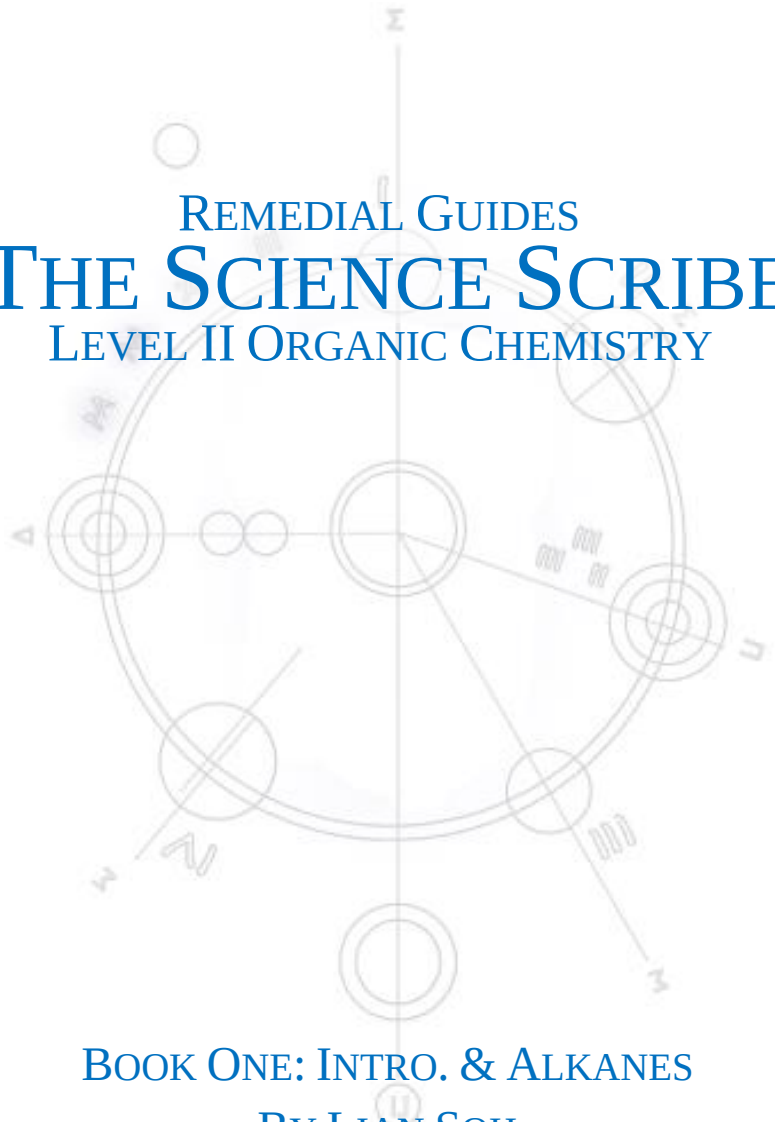
Remedial Guides

The Science Scribe

Level II Organic Chemistry



Book One: Intro. & Alkanes

By Lian Soh

ABOUT

The REMEDIAL GUIDES are a set of notes with practice questions which aims to scaffold gaps in content knowledge. They have been called *remedial* booklets because they have been published with the intention of filling/fixing gaps in content knowledge. For example, you might have been away for 2 days and completely missed out on a small block of work (or maybe you just fell behind) so you might decide to only download the relevant booklet which will catch you up.

Regardless, I hope you find this resource useful to you in some way. I appreciate any feedback (especially corrections to errors).

Lian Soh
The Science Scribe

DOCUMENT PROPERTIES
This document has been created using a *2 page per sheet* format, where each sheet is an *A4 size* in *landscape* format.

INTRODUCTION & ALKANES

LEARN: *"MUST EVERY PREFECT BE PERFECT?"*

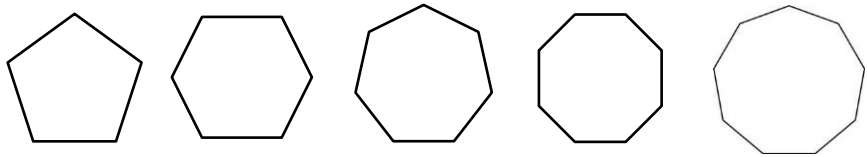
I HAVE MEMORISED THE FIRST 10 PREFIXES ☐

A "prefix" is something which we attach to the front of a word. For example, the prefix "***re***" is used in words such as ***re***attach, ***re***arrange, ***re***do.

In organic chemistry, prefixes can tell us how many carbon atoms there are.

PREFIX	NUMBER OF CARBON ATOMS PRESENT	
Meth-	1	**M**ust
Eth-	2	**E**very
Prop-	3	**P**refect
But-	4	**B**e
Pent-	5	**P**erfect?
hex-	6	
hept-	7	
oct-	8	
non-	9	
dec-	10	

Notice that from prefix 5 onward, we use *Greek* names. You would have seen these in math for the number of sides in a shape.



pentagon **hex**agon **hept**agon **oct**agon **non**agon

You can remember "dec" as in ***dec****agon* (10 sided shape), ***dec****imal* (base 10 in math) or ***Dec****ember* (when we used to only have 10 months a year)

USE: *"HOW DO I LOVE ORGANIC? LET ME COUNT THE WAYS"*

I CAN USE PREFIXES TO DETERMINE THE NUMBER OF CARBON ATOMS PRESENT ☐

Write the number of carbon atoms present in each of the following molecules. **Four have been completed for you**. Try these without looking at the previous page.

Methane	**1**		**Hept**ene	**7**
Decane			Butane	
Nonane			Hexene	
Ethane			**Prop**anol	**3**
Butene			Propyne	
Methanamine	**1**		Butanoic Acid	
Butanol			Decene	
Octanol			Octane	
Ethanamine			Propane	
Heptane			Hexanamine	
Ethene			Ethyne	
Hexanoic Acid			Hexane	
Butyne			Propanamine	
Octanol			Pentyne	
Hexyne			Butanamine	
Octane			Hexanol	
Pentane			Ethanoic Acid	
Pentanamine			Nonanamine	
Pentene			Nonanol	
Decanamine			Propene	
Pentanol			Propanoic Acid	
Butanoic Acid			Heptanamine	
Decanol			Butane	

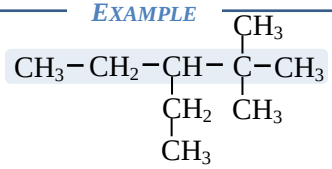
LEARN: *"NAMING ALKANES"*

I CAN SYSTEMATICALLY NAME ALKANES ☐

STEP ONE: Find and name the longest chain.

The ending for an alkane is *"ane"*

EXAMPLE



Longest chain is **5 carbons**.

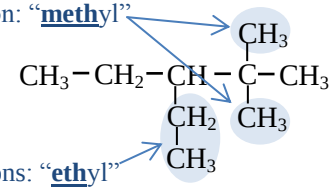
Name: **pent*ane***

STEP TWO: Name any side chains.

Side chains end with ***"yl"***

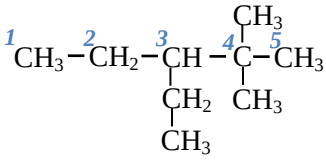
1 carbon: "**meth**yl"

2 carbons: "**eth**yl"



STEP THREE: Number the longest chain.

You identified the longest chain in Step One.

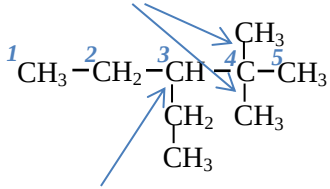


STEP FOUR: Use the numbers to assign where the side groups are located.

Note we have **two** identical methyl groups so we add "**di**". **Both** of the methyl groups occur at **position 4**.

"***4,4-di***methyl"

"***3***-ethyl"



STEP FIVE: Put it together.

no spaces, ever.

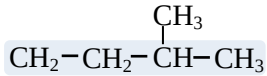
"***3***-ethyl-4,4-dimethylpentane"

dashes separate numbers and letters

commas *between* clusters of numbers

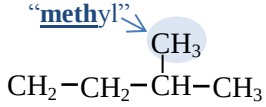
aim for alphabetical order of side chains. ethyl comes before *methyl* but we **ignore** *modifiers like "di"* or *"tri"*

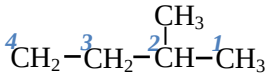
EXAMPLE



but*ane*

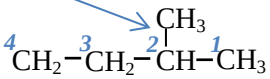
“**meth**yl”





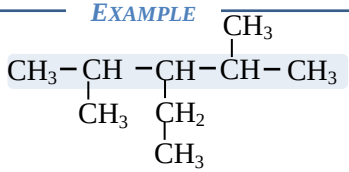
If we had numbered this left to right, the side group would be at position three. Aim for the smallest number.

“***2***-methyl”



“*2-methylbutane*”

EXAMPLE

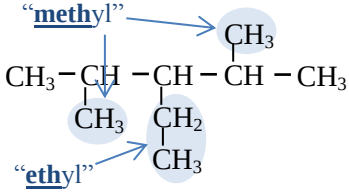


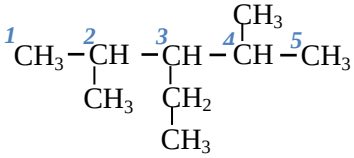
Longest chain is **5 carbons**.

Name: **pent*ane***

“**meth**yl”

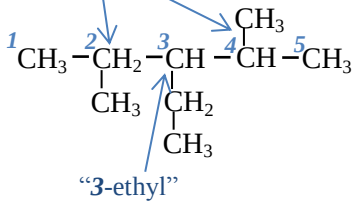
“**eth**yl”





“***2,4-di***methyl”

“***3***-ethyl”

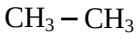


“***3***-ethyl-2,4-dimethylpentane”

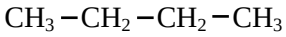
USE: *"NAMING ALKANES"*

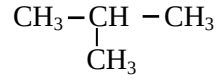
I CAN SYSTEMATICALLY NAME ALKANES ☐

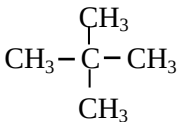
Write the systematic name for the following alkanes.

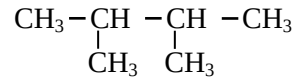
1. 

2. 

3. 

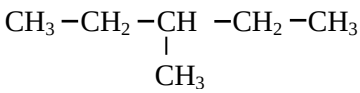
4. 

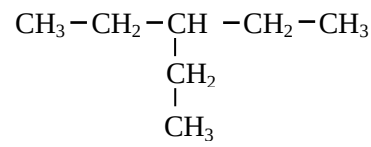
5. 

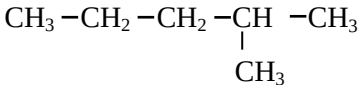
6. 

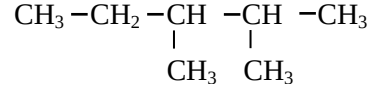
7. 

8. 

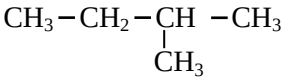
9. 

10. 

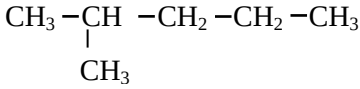
11. 

12. 

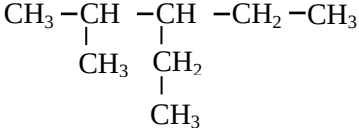
13.



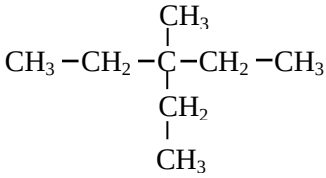
14.



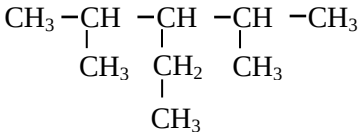
15.



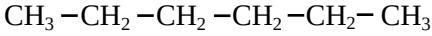
16.



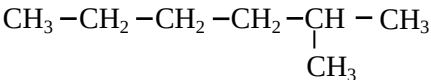
17.



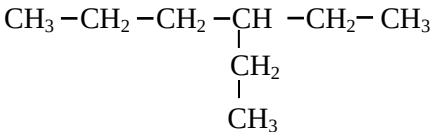
18.



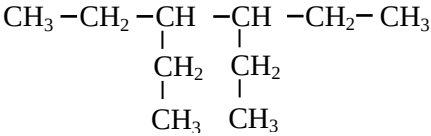
19.



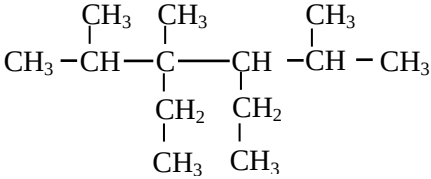
20.



21.



22.



NOTE: two identical side chains or groups = “di”,
three identical side chains or groups = “tri”,
four identical side chains or groups = tetra”

LEARN: *"I LIKE TO READ, THEN DRAW"*

I CAN DERIVE STRUCTURAL FORMULAE OF ALKANES BY NAME

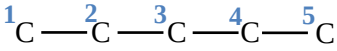
I CAN USE DIFFERENT REPRESENTATIONS OF STRUCTURAL FORMULAE

EXAMPLE

STEP ONE: identify the longest chain by looking towards the end.

2,3-dimethylpentane

STEP TWO: draw out a chain of carbons and number it.



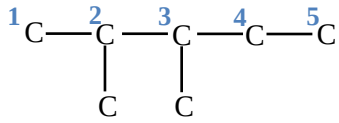
pent = 5, therefore 5 carbons

STEP THREE: identify any side chains from the name.

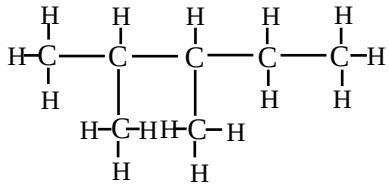
2,3-dimethylpentane

*There are **two** methyl groups at position **2** and **3**.*

STEP FOUR: draw in the side chains.

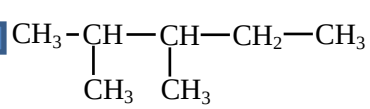


STEP FIVE: Every carbon must have four bonds. Fill with hydrogen.



Above: "extended structural formula"

$CH_3CH(CH_3)CH(CH_3)CH_2CH_3$



"compressed structural formula"

"partially extended structural formula"

USE: *"I LIKE TO READ, THEN DRAW"*

Write extended, partially extended, or compressed structural formulae for the following alkanes. Do this on refill.

1. methane
2. ethane
3. propane
4. butane
5. pentane
6. 2-methylpentane
7. 3-methylpentane
8. methylpropane
9. 2-methylbutane
10. hexane
11. 2-methylhexane
12. 3-methylhexane
13. 2,3-dimethylhexane
14. 2,2-dimethylhexane
15. 3-ethylhexane
16. 3-ethyl-2-methylhexane
17. heptane
18. 4-propylheptane
19. 2,2,3-trimethylhexane
20. 2,3,4-trimethylhexane
21. 3-ethyl-2,2-dimethylhexane
22. 3-ethyl-2,3-dimethylhexane

LEARN: *"A SYMPHONY OF FORMULAE AND ISOMERS"*

DEFINE MOLECULAR, STRUCTURAL FORMULA AND EMPIRICAL FORMULA ☐
DEFINE STRUCTURAL ISOMER ☐

The empirical formula only tells us the *ratio* of atoms present; whereas the molecular formula will tell the *exact number of each type of atom present*. The structural formula gives us the most information as it will also tell us the *bonding sequence of all atoms*.

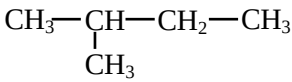
EXAMPLE	STRUCTURAL FORMULA	MOLECULAR FORMULA	EMPIRICAL FORMULA
hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$	C_6H_{14}	CH_2
butane	$CH_3CH_2CH_2CH_3$	C_4H_{10}	CH_2
methylpropane	$CH_3CH(CH_3)CH_3$	C_4H_{10}	CH_2

A structural isomer can be defined as a compound which has the same molecular formula but different structural formula. In the table above, butane and methylpropane can be described as structural isomers of each other.

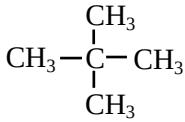
The structural isomers of pentane, C_5H_{12}, are shown below:

pentane $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

methylbutane



dimethylpropane



USE: *"A SYMPHONY OF FORMULAE AND ISOMERS"*

Draw the structural isomers of hexane by writing/drawing their structural formula. Write the molecular formula, empirical formula and systematic name for each one.

LEARN: *"PHYSICAL PROPERTIES"*

DESCRIBE THE APPEARANCE AND PROPERTIES OF ALKANES ☐

APPEARANCE

Clear colourless gases/liquids or white waxy solids.

VERY LOW MELTING AND BOILING POINTS

The simplest alkane is methane (CH_4). It is a non-polar molecule. Longer alkanes are also considered non-polar molecules. There are very strong intramolecular forces between atoms but very weak instantaneous dipole attractions between alkane molecules which only require very little heat energy to overcome; this means alkanes in general have very low melting and boiling points.

LONGER CHAIN MEANS GREATER MELTING/BOILING POINT.

Alkanes of a larger molecular mass tend to have greater melting and boiling points than smaller alkanes. The reason for this is because as the alkane molecules get larger there are more atoms present to contribute to forming intermolecular attractions between molecules. Very long molecular chains can also tangle with each other so more heat energy is needed to separate the molecules.

For example, hexane is a liquid at room temperature whereas methane is a gas. Alkanes at a length of around 20-25 carbon atoms are the alkane molecules present in candle wax, a solid at room temperature.

DENSITY/SOLUBILITY AGAINST WATER

Alkanes are non-polar so will not dissolve in water (polar). Since liquid alkanes are less dense than water, alkanes will float on top of the water.

ELECTRICAL CONDUCTIVITY

Alkanes do not have delocalised electrons or mobile ions so will not conduct electricity.

USE: *"PHYSICAL PROPERTIES"*

Give brief reasons for the following observations.

1. Hexane is sold in hardware stores. It is used to help clean greasy (non-polar) spills/stains.

2. Methane, ethane, propane, butane and pentane are gases at room temperature but hexane is a liquid.

3. Even though hexane is a liquid at room temperature, bottles of hexane have very noticeable odours when the lid is unscrewed.

4. In some countries, where the ambient temperature is quite hot, candles will melt on a hot day.

5. Octane floats on water.

LEARN: *"FIRE!"*

WRITE EQUATIONS FOR THE COMBUSTION OF ALKANES ☐

Combustion (burning) is an exothermic reaction with oxygen. When alkanes combust the products of the reaction will vary depending on how much oxygen is available.

The reactions for the combustion of alkanes are as follows:

COMPLETE COMBUSTION (PLENTY OF OXYGEN AVAILABLE)

alkane + O_2 → CO_2 + H_2O

clean burning flame

INCOMPLETE COMBUSTION (LIMITED OXYGEN)

alkane + O_2 → CO + H_2O

some smoke, smelly

COMBUSTION WITH SCARCE AMOUNTS OF OXYGEN

alkane + O_2 → C + H_2O

sooty flame, black solid deposits

Note: if a question does not specify the type of combustion occurring then assume that complete combustion is taking place. You will also need to balance your equations.

Tip: balance carbons by putting numbers in front of CO_2/CO/C first, then balance hydrogen by putting numbers in front of H_2O, finally, balance oxygen by putting numbers (or fractions) in front of O_2.

USE: *"FIRE!"*

Write balanced full equations for the ***complete combustion*** of the following alkanes. One has been completed for you to show how to derive fractions (not all equations will need fractions).

1. $CH_4 + O_2 \rightarrow CO_2 + H_2O$

2. $C_2H_6 + O_2 \rightarrow$

3. $C_3H_8 + O_2 \rightarrow$

4. $C_4H_{10} + O_2 \rightarrow$

5. $C_5H_{12} + O_2 \rightarrow$

6. $C_6H_{14} + O_2 \rightarrow$

7. $C_7H_{16} + O_2 \rightarrow$

25 oxygen in total on right hand side of reaction arrow

8. $C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O$

2 oxygen in total on left hand side of arrow

LEARN: *"THE CHEMICAL MASTER OF ALKANES"*

DESCRIBE THE CHEMICAL PROPERTIES OF ALKANES, INCL. OBSERVATIONS ☐
DEFINE "*SUBSTITUTION REACTION*" ☐

The term *chemical properties* refers to how a certain molecule reacts and what it reacts with. Combustion can be thought of as one of the chemical properties of alkanes.

Another chemical property of alkanes is the **substitution reaction**. A substitution reaction is when an atom or small group of atoms is replaced by a different atom or small group of atoms.

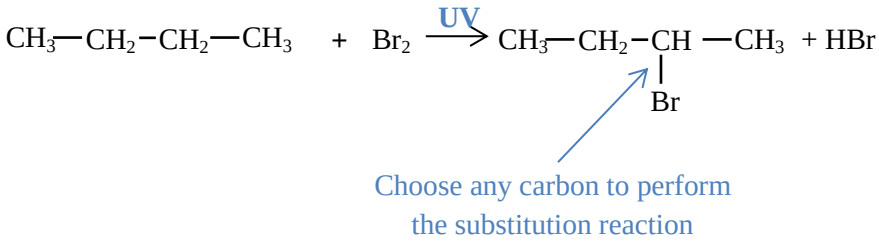
SUBSTITUTION

Requires ultraviolet (U.V) light. Very slow (takes several minutes)

SUBSTITUTION WITH HALOGENS

Halogens are group 17 elements. That is, we are referring to F_2, Cl_2, Br_2, I_2.
In a substitution reaction, a C-H bond is broken and a C-X bond is formed. An X-X bond is also broken to form a hydrogen halide, H-X (where X is a halogen).

e.g:



OBSERVATIONS

Bromine water is orange whereas hydrogen halides and all organic compounds are clear and colourless. In the reaction above, the orange bromine water would turn colourless as the bromine is being used.

Hydrogen halides are also acidic so will turn **damp** blue litmus to a red colour.
Other: Cl_2 is very pale green solution, I_2 is a brown solution.

USE: *"THE CHEMICAL MASTER OF ALKANES"*

1. Fill in the gaps/boxes for the following reactions:

A] $CH_3 - CH_3 +$ Cl_2 $\xrightarrow{\square}$ $CH_3 - CH_2Cl$ + $\square$

B] $CH_3 - CH_2 - CH_3$ + $\square$ $\xrightarrow{\square}$ $\square$ + HI

C] $\square$ + $\square$ $\xrightarrow{\square}$ $CH_3 - CH_2Br$ + HBr

2. Describe the expected observations for the reactions A to C above.

A]

B]

C]

3. Label the following reactions as substitution or combustion reactions.

A) C_3H_8 + $5O_2$ → $3CO_2$ + $4H_2O$

B) butane + Bromine water → 1-bromobutane + hydrogen bromide

C) propane + oxygen → water + carbon dioxide

D) $CH_3CH_2CH_2CH_3$ + Cl_2 → $CH_3CH_2CH_2CH_2Cl$ + HCl

turn over

4. Using the example below, describe what is meant by the term *substitution reaction*.

$$CH_3 - CH_3 + F_2 \xrightarrow{UV} CH_3 - CH_2F + HF$$

5. Suppose the following reaction was to be carried out:

$$\text{hexane} + \text{bromine water} \xrightarrow{UV} \text{1-bromohexane} + \text{hydrogen bromide}$$

A] Without the use of litmus paper, how could you verify that a reaction had taken place?

B] Describe how you would use litmus paper to test whether the final product was acidic or basic.

C] What is the function of U.V light?

NOTES/QUESTIONS FOR MYSELF OR MY TEACHER: