



Chemistry

Production of Materials

New Revised Edition

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S
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Use the table of contents to record your progress through this book. As you complete each topic, write the date completed, then tick one of the three remaining columns to guide your revision for later. The column headers use the following codes:

?? = Don't understand this very well at all.

RR = Need to revise this.

OK = Know this.

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Introduction

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory sections of the syllabus, along with questions and answers.

It is envisaged this book will be useful in class for both initial understanding and revision, while the more traditional textbook can remain at home for more detailed analysis.

All types of questions – multiple choice, short response, structured response and free response – are provided. Questions are written in exam style and use the verbs specified by the Board of Studies so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of the book contains an extensive set of summary questions, including multiple choice and free response questions. These cover every aspect of the topic, and are useful for revision and exam practice. Marking guidelines are supplied where appropriate.

Verbs To Watch

When you are answering questions in this book, your textbook or any examinations, make sure you answer what the question is asking. To do this you will have to know what each of the terms below means – they dictate what sort of an answer is required. It is essential that you learn their meanings as required by the Board of Studies. Your exam answers will be marked according to what these terms indicate your answer should be saying.

account, account for	State reasons for, report on, give an account of, narrate a series of events or transactions.
analyse	Identify components and the relationships among them, draw out and relate implications.
apply	Use, utilise, employ in a particular situation.
appreciate	Make a judgement about the value of something.
assess	Make a judgement of value, quality, outcomes, results or size.
calculate	Determine from given facts, figures or information.

clarify	Make clear or plain.
classify	Arrange into classes, groups or categories.
compare	Show how things are similar or different.
construct	Make, build, put together items or arguments.
contrast	Show how things are different or opposite.
critically (analyse/evaluate)	Add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to an analysis or evaluation.
deduce	Draw conclusions.
define	State the meaning of and identify essential qualities.
demonstrate	Show by example.
describe	Provide characteristics and features.
discuss	Identify issues and provide points for and against.
distinguish	Recognise or note/indicate as being distinct or different from, note difference between things.
evaluate	Make a judgement based on criteria.
examine	Inquire into.
explain	Relate cause and effect, make the relationship between things evident, provide why and/or how.
extract	Choose relevant and/or appropriate details.
extrapolate	Infer from what is known.
identify	Recognise and name.
interpret	Draw meaning from.
investigate	Plan, inquire into and draw conclusions about.
justify	Support an argument or conclusion.
outline	Sketch in general terms; indicate the main features.
predict	Suggest what may happen based on available information.
propose	Put forward a point of view, idea, argument or suggestion for consideration or action.
recall	Present remembered ideas, facts or experiences.
recommend	Provide reasons in favour.
recount	Retell a series of events.
summarise	Express concisely the relevant details.
synthesise	Put together various elements to make a whole.

1 Energy from Fossil Fuels

To understand this topic you will need to be able to recall information from the Preliminary course about how we obtain energy from non-renewable fossil fuels. Some of the main points are summarised below.

The energy in fossil fuels originates from the Sun, having been converted from solar to chemical energy by the process of **photosynthesis**. During photosynthesis, the red and violet wavelengths of sunlight are absorbed by the pigment chlorophyll and their energy is converted to chemical energy in glucose. Glucose is a carbohydrate, a high energy compound made of carbon, hydrogen and oxygen.



Energy sources are classified as **renewable** (e.g. solar, wind, hydroelectricity, tides, ethanol) or **non-renewable** (e.g. fossil fuels, nuclear fuels and batteries). At present, the world's major energy sources are fossil fuels – crude oil, natural gas, coal and coke – and there is concern that supplies of these fuels are becoming depleted.

Petroleum consists of crude oil and natural gas. It has been formed from the remains of single-celled marine organisms that lived many millions of years ago. Quick burial, without the presence of oxygen (to prevent decay), together with millions of years of heat and pressure from overlaying sediments, has converted them to petroleum. Petroleum contains a mixture of up to 300 hydrocarbons, as well as sulfur and nitrogen compounds. It is separated into useful components by fractional distillation.

Natural gas is a mixture of methane (75-90%), ethane (5-10%), propane and butane (3-6%) plus smaller amounts of other alkanes. It may also contain nitrogen, water vapour, carbon dioxide and traces of hydrogen sulfide. Natural gas is often found with crude oil and is formed in the same way, by heat and pressure acting on buried plant and animal matter for long periods of time. The gas can be trapped beneath impervious layers of rock.

The following questions are designed to help you check that you know this assumed knowledge. Work through them, check your answers, then let your teacher know of any problem areas.

For You To Do

- Electricity in NSW is mostly generated using:
 - A nuclear reactor.
 - Coal.
 - Natural gas.
 - Hydroelectricity.
- Many people want combustion of fossil fuels phased out because:
 - Their combustion generates greenhouse gases.
 - Their supplies are dwindling.
 - Their combustion contributes to acid rain.
 - All of the above.
- Which one of the following substances is NOT an example of a fossil fuel?
 - Coal.
 - Hydrogen.
 - Natural gas.
 - Petrol.
- Outline the meaning of the following terms.
 - Fossil fuel.
 - Renewable fuel.
 - Hydrocarbon.
 - Photosynthesis.
- Outline the composition of natural gas.
 - Justify the statement that natural gas is a mixture.
- Identify three alternative energy sources that, in the future, might replace fossil fuels.
- Compare renewable and non-renewable fuels and give an example of each.
 - Identify the process used to separate the components of petroleum.
 - Identify the property of petroleum components that allows them to be separated by this process.
 - List the main fractions obtained by the fractional distillation of petroleum.
 - Petroleum is classified as a mixture rather than a compound. Explain.
 - Recall your studies of fractional distillation in the Preliminary course. Use diagrams to show how fractional distillation is carried out for:
 - The industrial separation of petroleum into fractions.
 - The separation of two liquids in a laboratory.
- Check your knowledge by completing the following statements:
 - Fossil fuels cannot be replaced when they are used, so we say they are _____.
 - Name four fossil fuels.
 - Petroleum forms from the burial of _____.
 - The original source of energy in fossil fuels is the _____.
 - The energy in fossil fuels was converted from solar to chemical energy by the process in green plants called _____.
 - Identify the two main gases in natural gas.
 - Write an equation for photosynthesis.

2 Carbon Compounds – IUPAC Naming

Fossil fuels are carbon-based substances. You are expected to be able to recall information from the Preliminary course on carbon and its compounds. The main points are summarised below.

Carbon (electron configuration 2.4) forms many compounds because of its properties.

- A carbon atom has 4 valence electrons, so it can form 4 strong covalent bonds, which can be single, double or triple bonds. Saturated compounds contain only single bonds (e.g. alkanes such as ethane). Unsaturated compounds contain double and/or triple bonds (e.g. alkenes such as propene and alkynes such as propyne).
- A carbon atom can join onto other carbon atoms to form chains and rings. The chains can be straight or branched.
- A carbon atom can form strong covalent bonds with other non-metals (e.g. hydrogen, oxygen, nitrogen and the halogens).
- Halogen atoms can replace any hydrogen atoms in hydrocarbons forming haloalkanes or haloalkenes.

Hydrocarbons (e.g. alkanes, alkenes and alkynes) are organic (carbon-based) compounds containing only atoms of carbon and hydrogen.

A **homologous series** is a group or family of compounds with similar structure and chemical properties.

A **functional group** is a grouping of atoms that is common to all members of that series (e.g. single bond, double bond, triple bond).

Table 2.1 Homologous hydrocarbon series.

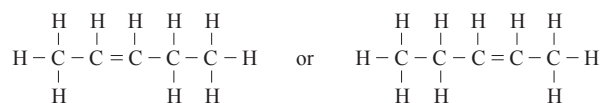
Homologous series	General formula	Functional group
Alkane	C_nH_{2n+2}	$-C-C-$
Alkene	C_nH_{2n}	$-C=C-$
Alkyne	C_nH_{2n-2}	$-C\equiv C-$

IUPAC Naming

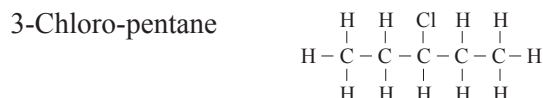
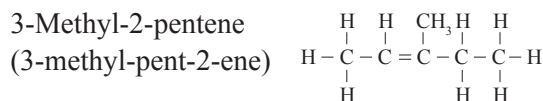
You should recall how to name and write formulas for C_1 to C_8 compounds in the alkane and alkene series using IUPAC nomenclature.

- The stem or prefix of the name tells us the length of the carbon chain, for example:
 C_1 meth- C_2 eth- C_3 prop-
 C_4 but- C_5 pent- C_6 hex-
 C_7 hept- C_8 oct-
- The suffix or ending of the name indicates the family or functional group to which the compound belongs, e.g. -ane (all single bonds).

- Carbon atoms are numbered so that the carbon with a double or triple bond has the lowest number possible; for example, 2-pentene could be written as:



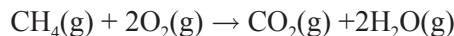
- Any attachments to the main chain are numbered by the carbon to which they are attached, for example:



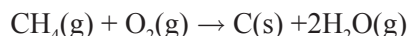
Combustion of hydrocarbons

Complete combustion of hydrocarbons produces carbon dioxide and water as products. In a limited supply of oxygen, **incomplete combustion** occurs and carbon and/or carbon monoxide may also be produced. For example,

Complete combustion of methane can be shown as:



Incomplete combustion could produce:



Use the questions below to check that you know and understand this basic presumed knowledge. Discuss any problems with your teacher.

For You To Do

- The compound containing a double bond would be:
 (A) $\text{CH}_3\text{CHCHCH}_2\text{CH}_2\text{CH}_3$
 (B) $\text{CH}_3\text{CH}_2\text{CH}_3$
 (C) $\text{CH}_3\text{CH}_2\text{CCCH}_2\text{CH}_3$
 (D) $\text{CHCl}_2\text{CHClCH}_3$
- The compound 2-pentene has the structural formula:
 (A) $\begin{array}{c} \text{H} & \text{H} \\ \diagdown & / \\ \text{C} & = & \text{C} \\ / & \diagdown \\ \text{H} & \text{H} \end{array}$
 (B) $\begin{array}{c} \text{H} & \text{H} & \text{H} \\ \diagdown & | & | & | \\ \text{C} & = & \text{C} & - & \text{C} & - & \text{C} & - & \text{H} \\ / & & & | & | \\ \text{H} & & & \text{H} & \text{H} \end{array}$
 (C) $\begin{array}{c} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ | & | & | & | & | \\ \text{H}-\text{C}-\text{C}=\text{C}-\text{C}-\text{C}-\text{H} \\ | & & & | & | \\ \text{H} & & & \text{H} & \text{H} \end{array}$
 (D) $\begin{array}{c} \text{H} & \text{H} & \text{H} \\ \diagdown & | & | & | \\ \text{C} & = & \text{C} & - & \text{C} & - & \text{C} & - & \text{H} \\ / & & & | & | & | \\ \text{H} & & & \text{H} & \text{H} & \text{H} \end{array}$
- Recall definitions of the following terms.
 (a) Homologous series.
 (b) Hydrocarbon.

- (c) Halogen.
 (d) Functional group.
 (e) Alkane.
 (f) Covalent bond.
 (g) Saturated carbon compound.
4. Fossil fuels all contain carbon.
 (a) Describe the position of carbon on the periodic table.
 (b) State the electron configuration of carbon.
 (c) Carbon is able to form an enormous number of compounds. Identify three reasons to account for this.
 (d) Identify three fuels that are naturally synthesised by geological processes acting on carbon compounds.
5. Identify two homologous series of hydrocarbons and state the general formula for each.
6. Would you expect to find a double bond in octane, octene or octyne?
7. Compare saturated and unsaturated hydrocarbons and name one example of each.
8. Write structural formulas for:
 (a) Ethene (also called ethylene).
 (b) Ethane.
 (c) Hexane.
9. In a structural formula, what does the dash (–) represent?
10. Identify the following hydrocarbons.
- (a)
$$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \\ & | & | & | & | & | & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\ & | & | & | & | & | & \\ & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \end{array}$$
- (b)
$$\begin{array}{ccccccc} & \text{H} & & & & & \\ & | & & & & & \\ \text{H} & - \text{C} & - \text{C} & = \text{C} & - \text{H} & & \\ & | & | & | & & & \\ & \text{H} & \text{H} & \text{H} & & & \end{array}$$
- (c)
$$\begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & \text{H} & & \\ & | & | & | & | & & \\ \text{H} & - \text{C} & - \text{C} & = \text{C} & - \text{C} & - \text{H} & \\ & | & & & | & & \\ & \text{H} & & & \text{H} & & \end{array}$$
11. (a) Distinguish between the conditions causing complete and incomplete combustion.
 (b) Identify the products of complete combustion of hydrocarbons.
 (c) Sometimes carbon particles and carbon monoxide are produced by the combustion of carbon compounds. Explain.
12. State two safety issues associated with the use of hydrocarbons.
13. Write structural formulas for the following.
 (a) 2-Pentene (pent-2-ene).
 (b) Propene.
 (c) 3-Octene (oct-3-ene).
 (d) 2-Hexene (hex-2-ene).
 (e) 1,2-Dichloroethene.
 (f) 2,3-Dimethyl-2-butene (2,3-dimethyl-but-2-ene).
14. Name the following hydrocarbons.
 (a) $\text{CH}_2 = \text{CH} \text{CH}_2 \text{CH}_2 \text{CH}_3$
 (b) $\text{CH}_3 \text{CH}_2 \text{CH} = \text{C}(\text{CH}_3) \text{CH}_2 \text{CH}_2 \text{CH}_3 \text{CH}_3$
 (c) $\text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CH}_3$
 (d) $\text{CH}_3 \text{CH}(\text{CH}_3) \text{CH}_3$
15. Write balanced equations for these reactions.
 (a) Complete combustion of methane.
 (b) Photosynthesis.
 (c) Incomplete combustion of ethylene (ethene).
16. Draw electron dot diagrams to show the structure and bonding of:
 (a) Methane.
 (b) Ethylene (ethene).
 (c) Propyne.
17. Check your knowledge with this quick quiz.
 (a) Name C_7H_{14} .
 (b) Name C_4H_8 .
 (c) What is the molecular formula for pentane?
 (d) What do we call a group or family of compounds that have similar structures and chemical properties?
 (e) What do we call a group of atoms common to all members of a homologous series?
 (f) How many electrons in a carbon atom?
 (g) What is the valency of carbon?
 (h) State the name given to compounds composed of carbon and hydrogen only.
 (i) Combustion with a plentiful supply of oxygen is called _____ combustion.
 (j) Combustion with a limited supply of oxygen is called _____ combustion.
 (k) Ethylene (ethene) belongs to the homologous series of hydrocarbons called _____.
 (l) Ethane belongs to the homologous series of hydrocarbons called _____.
 (m) State a common name for ethene.
 (n) What ending would you use for the name of a hydrocarbon containing single C–C bonds?
 (o) The stem of a hydrocarbon with two carbon atoms would be eth-. What stem would you use for a hydrocarbon containing 6 carbons?
 (p) What is the functional group for an alkene?
 (q) State the general formula for an alkane.
 (r) What is the formula for ethylene (ethene)?
 (s) State the molecular formula for ethane.
 (t) Identify the homologous hydrocarbon series containing only single C–C bonds.
 (u) What symbol is used to represent a covalent bond in a compound?
 (v) Halide ions are formed from atoms in which group of the periodic table?