Kirkcaldy High School

Chemistry

National 4

Unit 2 – Nature's Chemistry

NOTES

Course Overview

Contents

The National 4 Chemistry Course is split into three units. *Italic* shows the contents of this notes booklet.

Unit 1 – Chemical Changes in Structure

(a) Reaction Rates
(b) Atomic Structure and Bonding
(c) Energy Changes of Chemical Reactions
(d) Acids and Bases

Unit 2 – Nature's Chemistry

Unit 3 – Chemistry in Society

(a) Metals
(b) Materials
(c) Fertilisers
(d) Nuclear Chemistry
(e) Chemical Analysis

Assessment

There is NO final exam for National 4 Chemistry. To pass the course you must…

- Complete and pass three Unit tests (50 % pass mark each)
- Complete an experimental write-up
- Complete an "Added Value" unit (poster or essay on a Chemistry topic)

Success Criteria

✓ I am confident that I understand this and I can apply this to problems

? I have some understanding but I need to revise this some more

× I do not understand this and I need help with it

I will be successful if I can…		Self-Evaluation		
1	State the definition of a fuel	✓	?	x
2	Describe where in a molecule energy is stored	✓	?	x
3	List the three main fossil fuels	✓	?	x
4	Describe how fossil fuels were formed	✓	?	x
5	Name the type of compounds that make up crude oil	✓	?	x
6	State whether combustion is an exothermic or endothermic reaction	✓	?	x
7	List the products formed by the combustion of a hydrocarbon	✓	?	x
8	Define the term exothermic	✓	?	x
9	Explain the fire triangle	✓	?	x
10	List the products formed by incomplete combustion of a hydrocarbon	✓	?	x
11	Write word equations for complete and incomplete combustion	✓	?	x
12	Describe the importance of catalytic convertors in cars	✓	?	x
13	Discuss ways to reduce carbon emissions	✓	?	x
14	Discuss the impact burning fossil fuels has on the carbon cycle	✓	?	x
15	Discuss the advantages and disadvantages of using fossil fuels as an energy source	✓	?	x
16	List alternative sources of energy	✓	?	x
17	Compare the advantages and disadvantages of biofuels to those of fossil fuels	✓	?	x
18	Name the elements present in a hydrocarbon	✓	?	x
19	Describe what happens to crude oil as a result of fractional distillation	✓	?	x
20	State the properties used to separate the fractions in crude oil	✓	?	x

21	Discuss the properties of the different fractions present in crude oil	✓	?	x
22	Name the first eight alkanes	✓	?	x
23	Draw the full structural formulae for the first eight alkanes	✓	?	x
24	State the molecular formulae and general formula for the alkanes	✓	?	x
25	Name the first eight alkenes	✓	?	x
26	Draw the full structural formulae for the first eight alkenes	✓	?	x
27	State the molecular formulae and general formula for the alkenes	✓	?	x
28	Explain the process of cracking	✓	?	x
29	Name the elements present in a carbohydrate	✓	?	x
30	Give examples of carbohydrates	✓	?	x
31	Write the chemical formula of glucose	✓	?	x
32	Describe the structure of starch	✓	?	x
33	Describe the chemical tests for glucose and starch	✓	?	x
34	Name the process used to make alcohols for sugars	✓	?	x
35	Discuss alternative uses for carbohydrates e.g. to make alcohols, as fuels	✓	?	x
36	State that alcohol content is measured in units	✓	?	x
37	State that many useful products can be made from plants	✓	?	x
38	Give examples of plants and the products they can produce	✓	?	x

(a) Fuels

Fuels

- A fuel is any compound that has stored energy that can be released when the compound is burned
- Energy is captured in chemical bonds through processes such as photosynthesis and respiration
- Exothermic reactions release energy and endothermic reactions take in energy

Combustion

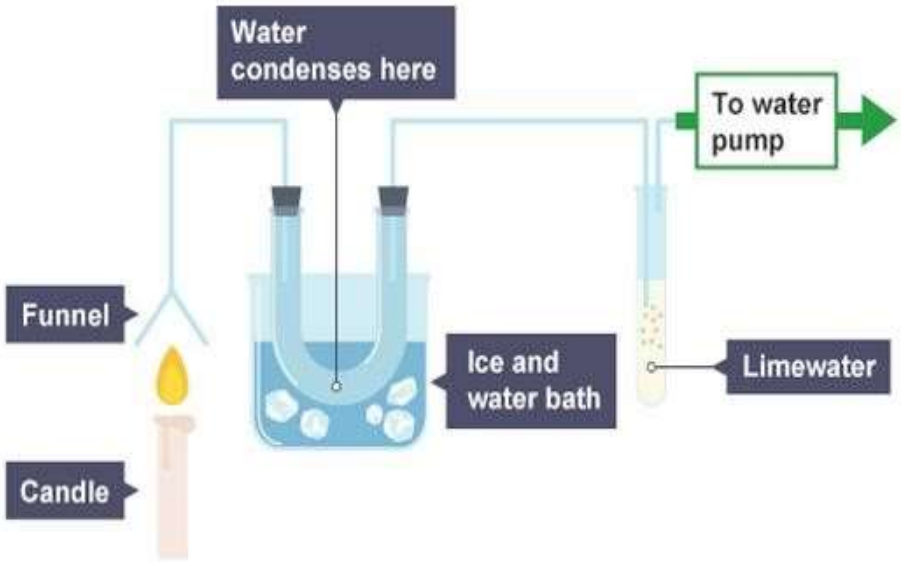
- Combustion is the reaction of burning a compound in oxygen
- Hydrocarbons burn in oxygen to produce carbon dioxide and water
- This is known as complete combustion

Combustion Reaction

- The experiment shown in the diagram below is used to demonstrate the products formed by the complete combustion of a hydrocarbon
- The oxygen combines with the carbon to form carbon dioxide and the hydrogen to form water

hydrocarbon + oxygen → carbon dioxide + water

- Carbon dioxide gas turns limewater from colourless to cloudy/ chalky
- The water produced condenses in the U-tube, cooled by the ice water
    - Water turns cobalt chloride paper from blue to pink



Incomplete Combustion

- When the supply of oxygen is limited, hydrocarbons combust to produce carbon monoxide, carbon (soot) and water
- Air pollution from the burning of hydrocarbons can be reduced by catalytic converters in car exhaust systems. These minimise the output of carbon monoxide

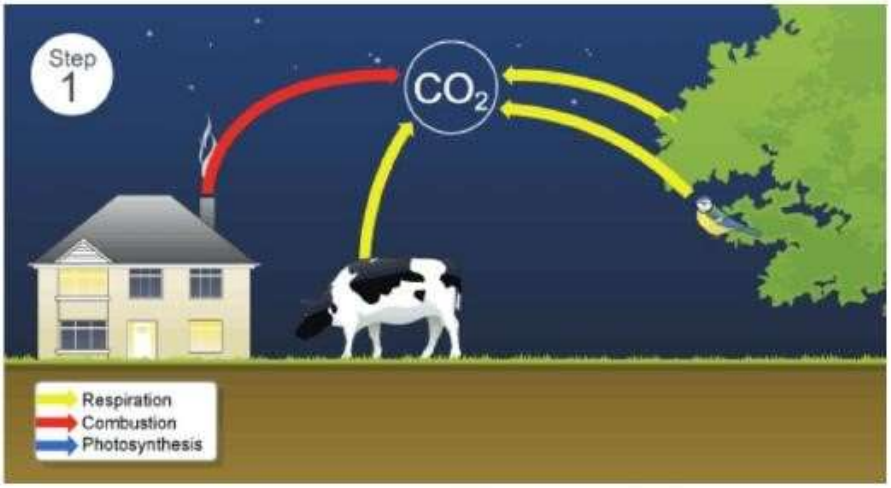
The Fire Triangle

Fossil Fuels

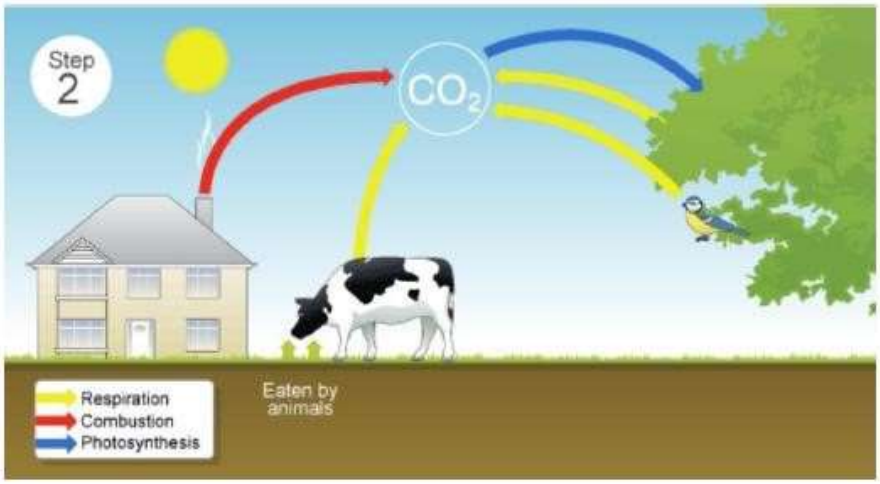
- Fossil fuels include coil, crude oil and gas.
- They are used extensively to satisfy the demands of an energy-dependent world
- Fossil fuels contain mainly hydrocarbons with minor impurities
- They originate from the decayed and fossilised remains of plants and animals that lived millions of years ago
- Coal is formed from dead land plant and animal material
- Crude oil and gas are formed from dead marine organisms
- The combustion of fossil fuels impacts on the environment and contributes to the carbon cycle as they burn to produce carbon dioxide

The Carbon Cycle

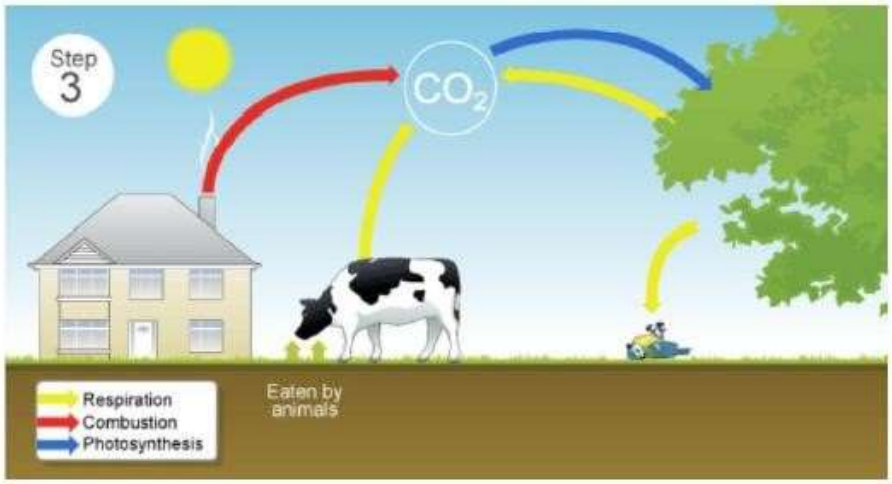
- Carbon is present in all living things
- When living things die, the carbon they contain is recycled by other living things in the carbon cycle



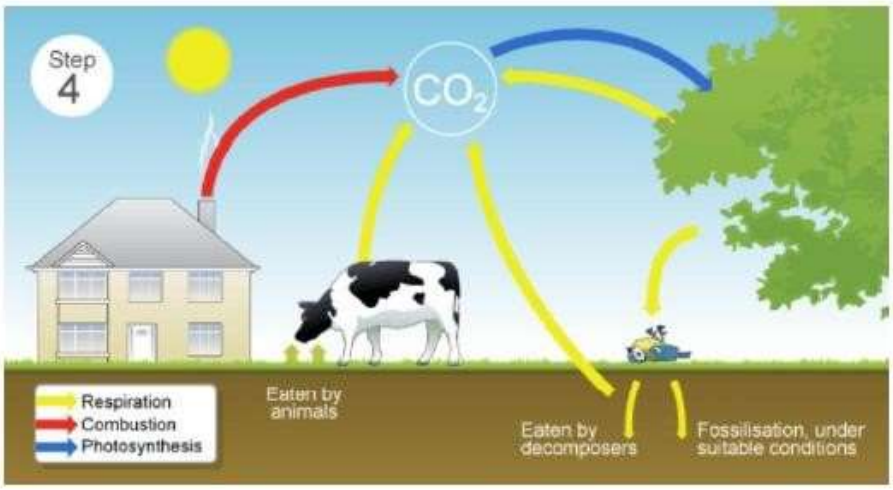
Carbon enters the atmosphere as **carbon dioxide** from **respiration** and **combustion**.



Carbon dioxide is absorbed by producers to make carbohydrates in **photosynthesis**.



Animals feed on the plant passing the carbon compounds along the food chain. Most of the carbon they consume is exhaled as **carbon dioxide** formed during **respiration**. The animals and plants eventually **die**.



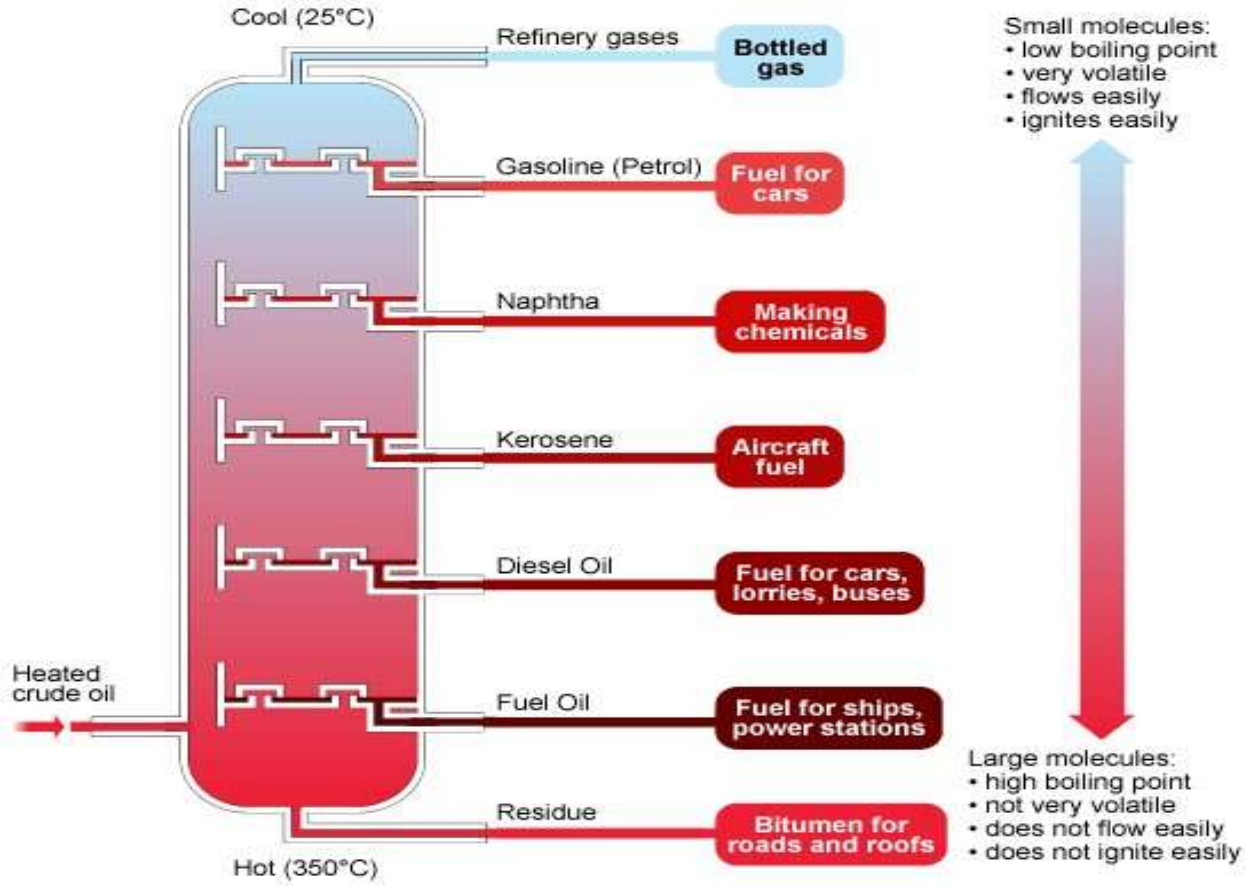
The dead organisms are eaten by decomposers and the carbon in their bodies is returned to the atmosphere as **carbon dioxide**. In some conditions decomposition is blocked. The plant and animal material may then be available as fossil fuel in the future for **combustion**.

Fossil Fuels and the Environment

- Fossil fuels are a finite energy source
    - This means they will run out one day
- Fossil fuels are being used up far faster than they can be formed
- The burning of fossil fuels contributes to global warming and acid rain
- We can reduce the impact of the burning of fossil fuels by reducing the energy we require for everyday activities
- Ways to reduce your carbon emissions include
    - Walk / cycle/ take public transport instead of driving
    - Switch off lights and other electrical items when they are not being used
    - Put on a jumper instead of the heating
    - Recycle
- Alternative energy sources
    - Wind power
    - Solar power
    - Biomass
    - Biomass is a source of biofuel which can be burned to release energy
    - Biomass can also be converted to other usable forms of energy (methane gas / fuels used for transportation such as ethanol and biodiesel)
    - Biofuels are fuels produced from plant material
- Hydrogen as fuel
    - Hydrogen is being marketed as an alternative fuel to petrol
    - Advantages of hydrogen over petrol include
    - Hydrogen is renewable
    - Hydrogen does not produce carbon dioxide

Fractional Distillation

- Fractional distillation is the process used for separating crude oil into fractions by boiling point
- A fraction is a group of hydrocarbons with similar chemical properties *e.g.* boiling points
- The fractioning column is hot at the bottom and cool at the top
    - Substances with high boiling points condense at the bottom
    - Substances with low boiling points condense at the top
- As you go up the fractioning column, the hydrocarbons have
    - Lower boiling points
    - Lower viscosity (flow more easily)
    - Higher flammability (ignite more easily)
    - Lower mass
    - Smaller carbon chains



(b) Homologous Series

Hydrocarbons

- Hydrocarbons are molecules containing only hydrogen and carbon
- A homologous series is a family of hydrocarbons with similar chemical properties and the same general formula
- Alkanes and alkenes are examples of a homologous series of hydrocarbons

Naming Hydrocarbons

- When we name hydrocarbons, the prefix tells us how many carbon atoms are in the chain

Prefix	Number of Carbon Atoms
Meth	1
Eth	2
Prop	3
But	4
Pent	5
Hex	6
Hept	7
Oc	8

Full Structural Formula

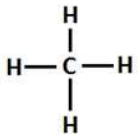
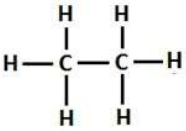
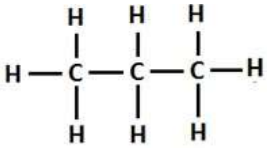
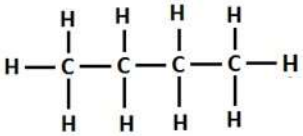
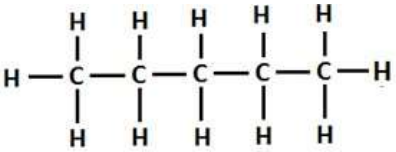
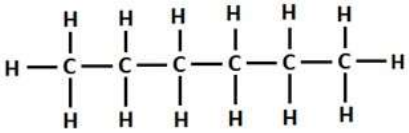
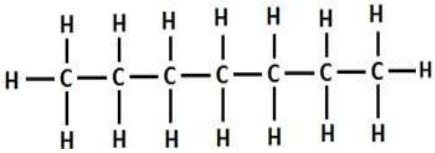
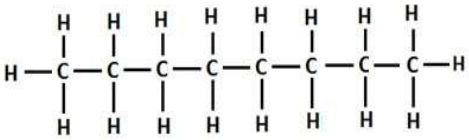
- The full structural formula of a molecule shows how the atoms are arranged including the bonds made and elements present
- It is important to remember that carbon atoms have to make 4 bonds and hydrogen atoms can make only one bond

Chemical Formula

- The chemical formula of a molecule states how many atoms of each element are present in the molecule
- The elements are represented by their elemental symbol

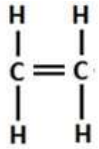
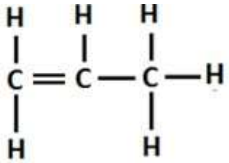
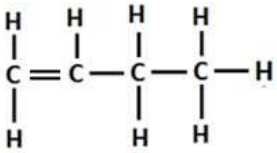
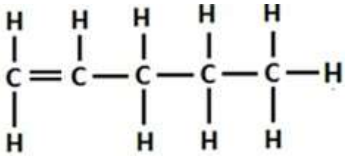
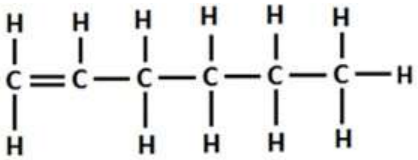
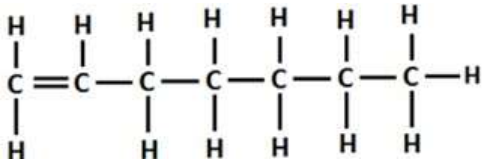
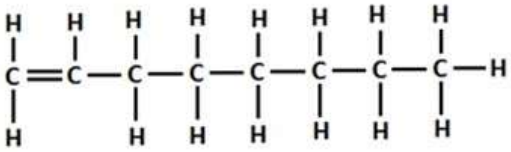
Alkanes

- Have the general formula C_nH_{2n+2}
- Are saturated – they contain only single C-C bonds
- Have no reaction with bromine water (bromine water remains yellow)
- The table below includes the names, chemical formulae and full structural formulae for the alkanes containing up to eight carbon atoms

Name	Chemical Formula	Full structural Formula	Shortened Structural Formula
Methane	CH_4		CH_4
Ethane	C_2H_6		CH_3CH_3
Propane	C_3H_8		$CH_3CH_2CH_3$
Butane	C_4H_{10}		$CH_3CH_2CH_2CH_3$
Pentane	C_5H_{12}		$CH_3CH_2CH_2CH_2CH_3$
Hexane	C_6H_{14}		$CH_3CH_2CH_2CH_2CH_2CH_3$
Heptane	C_7H_{16}		$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$
Octane	C_8H_{18}		$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

Alkenes

- Have the general formula C_nH_{2n}
- Are unsaturated – they contain C=C double bonds
- Rapidly decolourise bromine water (bromine water changes from yellow to colourless)
- The table below includes the names, chemical formulae and full structural formulae for the alkenes containing up to eight carbon atoms

Name	Chemical Formula	Full structural Formula
Ethene	C_2H_4	
Propene	C_3H_6	
Butene	C_4H_8	
Pentene	C_5H_{10}	
Hexene	C_6H_{12}	
Heptene	C_7H_{14}	
Octene	C_8H_{16}	

Cracking

- Fractional distillation of crude oil produces mainly long chain hydrocarbons
- Cracking is a process used to meet the demand for shorter alkanes and alkenes
- During cracking, an alkane and an alkene are always produced

(c) Everyday Consumer Products

Carbohydrates

- Plants are a source of carbohydrates and oils
- Carbohydrates can be used for food or fuel
- Carbohydrates are compounds which contain carbon hydrogen and oxygen

Glucose and Starch

- Glucose is a simple carbohydrate with the molecular formula $C_6H_{12}O_6$
- Starch is a complex carbohydrate formed by joining many glucose molecules
- Chemical tests can be carried out to distinguish between glucose and starch
- Benedict's solution tests for glucose
    - Glucose turns Benedict's solution from blue to brick red
- Iodine tests for starch
    - Starch turns iodine from brown to blue/black
- Starch is broken down into glucose in the body during digestion and can then be used for energy

Fermentation

- Enzymes present in yeast can convert glucose into ethanol
- This process is called fermentation
- Different plants are used to produce different alcoholic beverages
    - Barley is used to make beer
    - Apples are used to make cider
    - Grapes are used to make wine
    - Potatoes are used to make vodka
- The alcohol content of drinks is measured in units

Plants to Products

- Plants can be used to produce many useful products today
- Carbohydrates can be used for food or fuel