Kirkcaldy High School

Chemistry

National 4

Unit 3 – Chemistry in Society

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

(a) Fuels
(b) Homologous Series
(c) Everyday Consumer Products

Unit 3 – Chemistry in Society

(a) Metals *page 4*
(b) Materials *page 10*
(c) Fertilisers *page 13*
(d) Nuclear Chemistry *page 15*
(e) Chemical Analysis *page 16*

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	Link the uses of materials to their properties	✓	?	x
2	Describe the reactions of metals with oxygen, water and dilute acid using chemical equations.	✓	?	x
3	Put metals in order of reactivity	✓	?	x
4	Describe how metals can be extracted from their ores	✓	?	x
5	State the meanings of “corrosion” and “rusting”.	✓	?	x
6	Describe how metals can be protected from corrosion.	✓	?	x
7	Explain what is meant by “sacrificial protection”	✓	?	x
8	Describe how metals can be used to form a battery	✓	?	x
9	State how the voltage of a battery varies with the metals used	✓	?	x
10	Define “alloy” and give examples of alloys	✓	?	x
11	State the definitions of “monomer”, “polymer”, and “polymerisation”.	✓	?	x
12	Name a polymer when given the name of the monomer	✓	?	x
13	Describe the differences between “thermosetting” and “thermosoftening” plastics.	✓	?	x
14	State the effects of burning plastics	✓	?	x
15	Describe the properties and uses of ceramic materials	✓	?	x
16	State the reason that fertilisers are important in society	✓	?	x
17	State the three elements that are essential to plant growth	✓	?	x
18	Define what is meant by % composition in a fertiliser	✓	?	x
19	Describe the advantages and disadvantages of natural vs. artificial fertilisers.	✓	?	x

20	Describe the environmental impacts of fertilisers	✓	?	x
21	Explain how elements are formed	✓	?	x
22	State what is meant by “background radiation” and where it originates	✓	?	x
23	Describe the following techniques: “chromatography”, “flame tests”, “pH measurements”, “separation techniques”.	✓	?	x

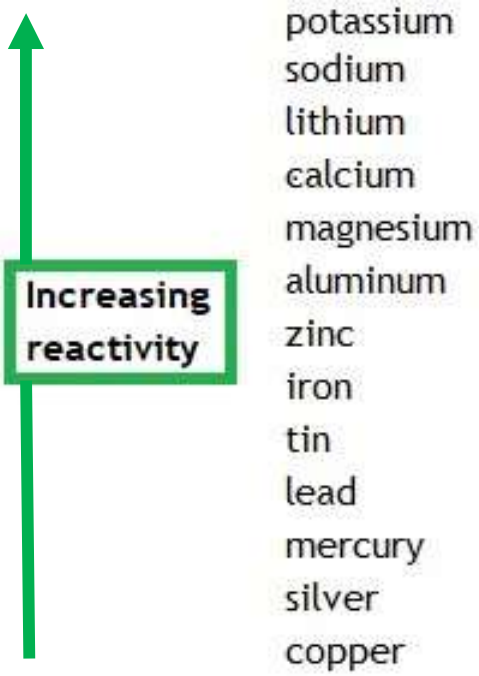
(a) Metals

Metals

- There are 94 metal elements in the Periodic Table
- Metals are very useful materials as they have a wide variety of uses
- The use of a metal is dependent on the properties it has
    - copper is used for making electrical cables because it is a good conductor of electricity
    - aluminium is used to make parts of the body of an aeroplane as it is strong, light and does not corrode
    - silver, gold and platinum metals are used to make jewellery because they are malleable, shiny and very unreactive
    - metals that can conduct heat can be used to make pots and pans for cooking

Reactivity of Metals

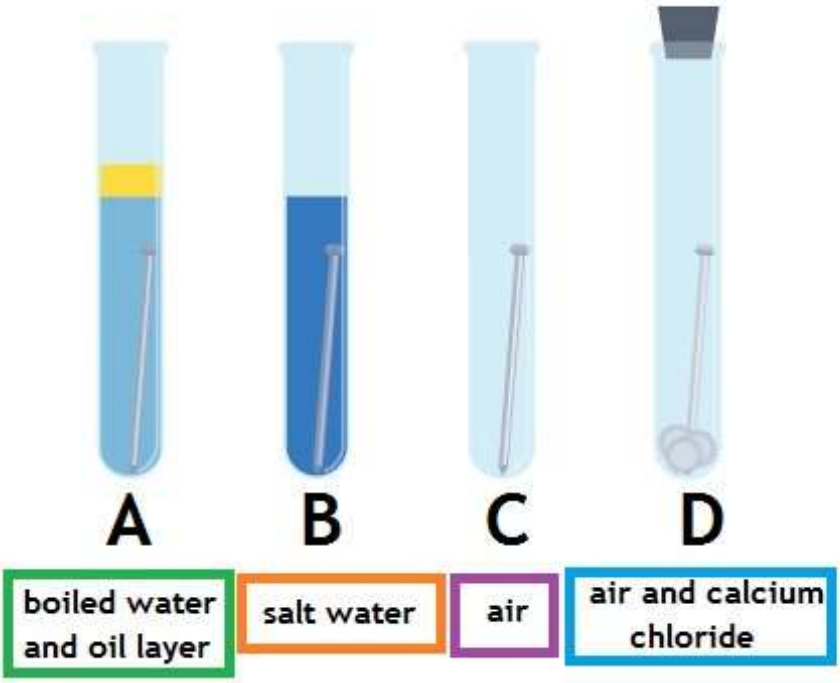
- Metals can be put in order of reactivity which is shown in the reactivity series
- The reactivity series is detailed below



- The reactivity of a metal determines which type of reactions it can participate in
    - Only highly reactive metals (calcium to potassium) will react with water
    - more metals (lead to potassium) react with acid
    - most metals (silver to potassium) will react will oxygen

Corrosion

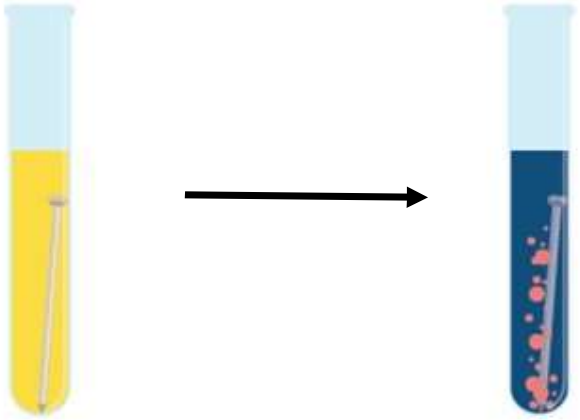
- Corrosion is an everyday reaction that takes place on the surface of a metal
- A metal object corrodes when it is exposed to the open air and/or bad weather
- The corrosion of iron is termed rusting
- The following experiment demonstrates that water and oxygen are required for iron to rust



A	B	C	D
No rust observed - boiled water has no oxygen and oil prevents oxygen entering the test tube	Severe rust observed - Salt water conducts electricity which speeds up rusting	Rust observed - air and moisture result in rusting	No rust observed - calcium chloride dries out the air

Ferroxyl Indicator

- Ferroxyl indicator can be used to show the process of rusting
    - When iron atoms begin to rust, they lose electrons to form iron ions
- Ferroxyl indicator turns from yellow to blue in the presence of iron ions
    - This indicates the presence of rusting, even if there is no reddish-brown rust showing on the surface of the iron

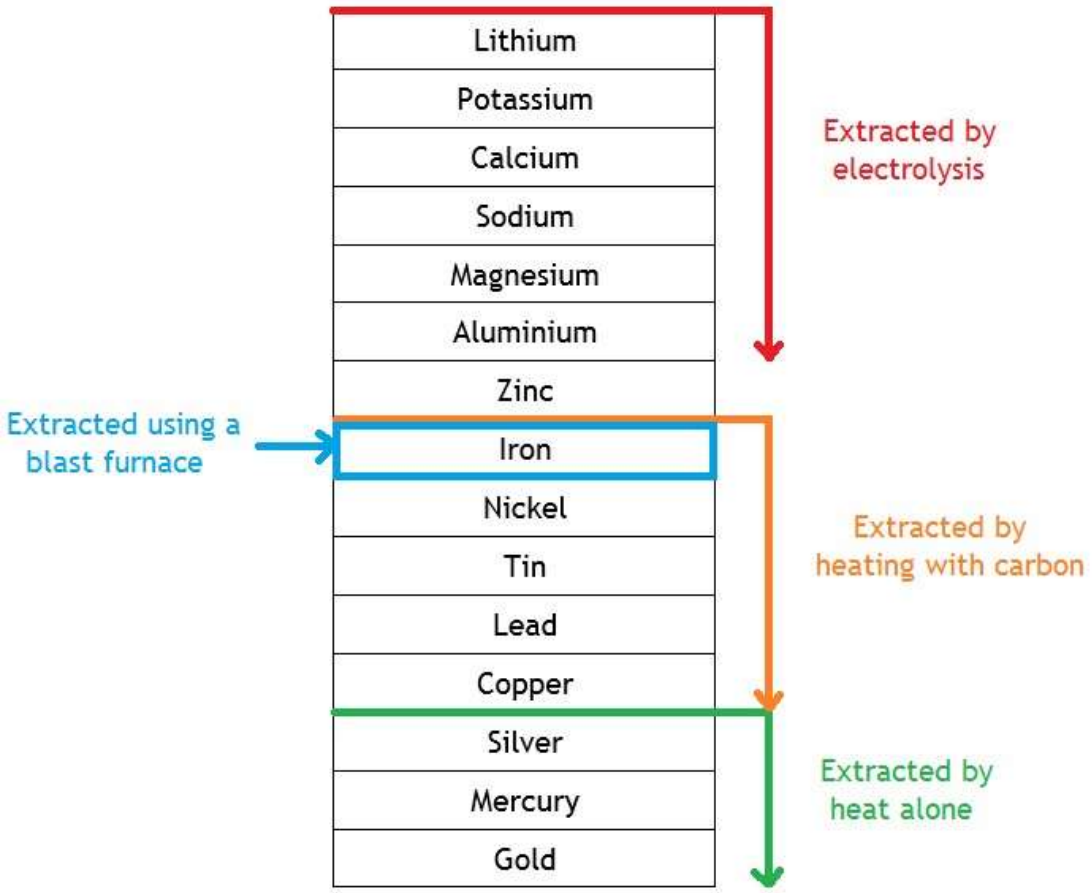


Preventing Rust

- There are a range of different methods that can be used to prevent the rusting of metals
- The methods can be classified as sacrificial protection or physical protection
    - The connection of iron to a more reactive metal can prevent corrosion
        - This method is termed **sacrificial protection**
    - Limiting the exposure of a metal surface to moisture and oxygen using a protective layer can prevent corrosion
        - This method is termed **physical protection**
        - Paint or grease can be used as a barrier, however, this needs regularly renewed
        - Zinc can be used, termed **galvanising**, to create a physical and chemical barrier.

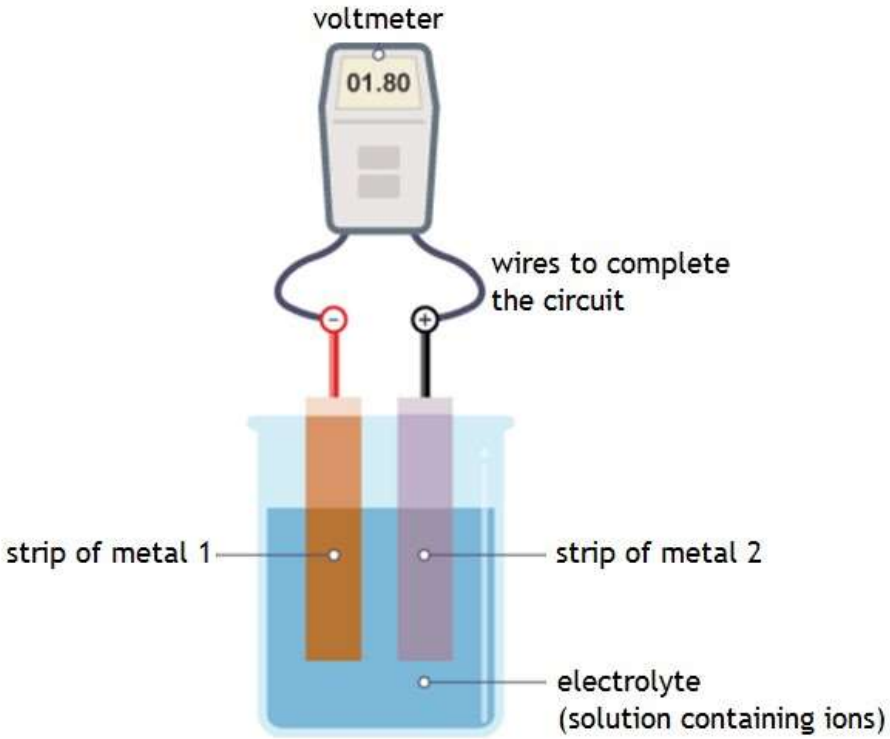
Extraction Methods

- Ores are naturally occurring rocks that contain metals or metal compounds
    - The metals must be extracted from the ore before they can be used
- There are three main extraction methods used
    - Heating
    - Heating with carbon
    - Electrolysis
- The method of extraction used is dependent on the reactivity of the metal
- Metals ions in the ore gain electrons to produce metal atoms during extraction
- The most appropriate extraction method can be determined using the electrochemical series
- This is summarised in the diagram below.



Electrochemical Cells

- An electrochemical cell is an arrangement that generates electricity from a chemical reaction
    - Electrochemical cells can be made up of a single cell or two half cells
    - These cells are shown below



Electron Flow

- The electrons in an electrochemical cell flow from one metal to the other
    - The direction of electron flow can be determined using the electrochemical series
    - The electrons will always flow from the metal higher in the electrochemical series to the metal that is lower in the electrochemical series
    - For example, when magnesium and copper are used, the electrons will flow from magnesium (higher) to copper (lower)

Voltage

- The voltage produced by an electrochemical cell can be estimated using the electrochemical series
    - When the metals used are far apart in the electrochemical series, the voltage produced is high
    - When the metals used are close together in the electrochemical series, the voltage produced is low
- For example, magnesium and copper are far apart producing a higher voltage than zinc and magnesium which are closer together in the electrochemical series

Alloys

- An alloy is a mixture of two or more elements, one of which is a metal
- Alloys often have properties that are different to the metals they contain
- This makes them more useful than the pure metals alone
- There are many different alloys that are used in everyday objects
    - Brass which is used in electrical fittings, is 70 % copper and 3 0% zinc
    - 18 carat gold used in jewellery, is 75 % gold and 25 % copper and other metals
    - Steel, which is used for railway tracks and car body parts, is made from iron and carbon
    - Stainless steel used to produce cutlery, can be made from iron, carbon and chromium

(b) Materials

Plastics

- Plastics are a group of very important synthetic materials that have a wide variety of uses
- Plastics can be engineered for specific uses by matching up the properties of the plastic to its use
    - They are generally lightweight and waterproof
    - They are good heat insulators and good electrical insulators
- There are many everyday examples of plastics
    - Polystyrene – used in drinking cups as it is an excellent heat insulator
    - Polyvinylchloride (PVC) – used in window frames as it is rigid and waterproof
    - Nylon – used for climbing ropes or bristles in toothbrushes as it is light and strong
- Plastics are examples of polymers - very large molecules formed by the joining of many small molecules called monomers
    - This chemical process is called **polymerisation**

Naming polymers

- The name of the polymer comes from the name of the monomer
- For example, the monomer ethene can be used to make the polymer poly(ethene)

Monomer	**Polymer**
Propene	Poly(propene)
Phenylethene	Poly(phenylethene)

Thermosoftening plastics and thermosetting plastics

- There are two main categories of plastic:
    - Thermosoftening (also called thermoplastics) are plastics which will soften when heated and can be reshaped
    - Thermosetting plastics are plastics that do not soften on heating. They are used when resistance to heat is important (e.g. kettles, plugs, laptop chargers etc)

Plastics and pollution

- Nearly all plastics are **non-biodegradable** which can cause environmental issues
    - This means that they will not rot away naturally either through the weather or by bacteria in soil
    - plastics can produce the toxic gas carbon monoxide (CO) when they are burned
- However, some plastics can give off other toxic gases when they burn, depending on which elements are present in the plastic
- Below is a table showing plastics and the toxic gas produced when the plastics in question are burned

Plastic	**Toxic gas produced**
Polystyrene	Carbon monoxide
Polyvinyl chloride	Hydrogen chloride and carbon monoxide
Polyurethane	Hydrogen cyanide and carbon monoxide

Biodegradable Plastics

- Biopol is a **biodegradable polymer** that can be broken down by bacteria in soil
- By producing food packaging and plastic bottles made of biopol instead of conventional plastics, concerns over waste management can be answered
- Biopol can be disposed of in landfill sites as the material will rot away overtime

Ceramics

- Ceramics are inorganic and non-metallic materials
    - They are formed after being exposed to very high temperatures (700-2000°C), then cooled, producing solid crystalline materials
    - Traditional ceramic materials include bricks and cement, clay products and earthenware and silicate glass
    - They are often hard and strong but brittle and can break easily
- More advanced ceramics have been developed with some of the following desirable properties:
    - hard wearing
    - resistant to high temperatures
    - good corrosion resistance
- low conductivity of electricity and heat
- This wide range of properties provides several advantages to using ceramics over other materials
- They offer more heat-resistant and corrosion-resistant than traditional polymers
- They are less dense than most metals (and their alloys) but harder than steel.

- Ceramics are also cheap to produce as the raw materials they are made from are readily available and inexpensive
- These useful properties have made them vital components for:
- Space shuttles (heat shield)
- Hair straighteners
- Ceramic replacement joints (used in medicine)

Novel Materials

Kevlar

- Bulletproof vests are made of Kevlar
    - Kevlar is a new synthetic polymer which is extremely strong and light

Poly(ethanol)

- Hospital laundry bags will dissolve when washed
- Poly(ethanol) is a polymer that is soluble in water

Conductive polymers

- Most plastics are natural insulators
- There are several advantages of making plastics which are conductors:
    - They are easier to manufacture
    - They are lighter and cheaper than metals
    - They prevent the build-up of static electricity which can damage microcircuits
    - Some conductive polymers are also biocompatible, making them suitable for use in medical devices

Thermochromic plastics

- Change colour on heating (used in baby feeding spoons that change colour when hot)

Nitinol

- Nitinol is an alloy of nickel and titanium, and is known as a shape memory alloy, which can be used in spectacle frames

(c) Fertilisers

- Fertilisers are used to replace essential elements in soil which have been removed by plants
    - Fertilisers are required due to the increase in population requiring more efficient food production
    - The main three elements are nitrogen (N), phosphorus (P) and potassium (K)
- Fertilisers are added to soil, the dissolve in the water present in the soil The elements can then be up taken by plants through the water
- To allow fertilisers to be used to enhance plant growth they must be soluble in water
- Fertilisers can be natural or synthetic (man-made)
    - Manure and compost are examples of natural fertilisers
    - Ammonium nitrate, potassium nitrate and ammonium phosphate are compounds commonly used in synthetic fertilisers
- fertilisers are commonly produced from neutralisation reactions
- Using fertilisers can have a negative impact on the environment
    - fertilisers can leach into bodies of water
    - increase nitrate or phosphate levels in the water encourage algae growth, which forms a bloom over the water surface
    - the formation of a bloom on the water surface reduce oxygen levels causing water plants to die

Percentage Composition

- The percentage composition of a fertiliser indicates the percentage of each type of element in the fertiliser

1. Percentage composition can be calculated using the following steps
2. Write the formula from the question
3. Calculate the gram formula mass of the fertiliser
4. Write the mass of each element present
5. Calculate the percentage of a specific element by dividing the mass of the element by the gram formula mass of the fertiliser

- For example, the percentage composition of ammonium nitrate is shown below

Step 1 $\mathbf{NH_4NO_3}$

Step 2 GFM = (2xN) + (4xH) + (3xO)

GFM = (2x14) + (4x1) + (3x16)

GFM = 80g

Step 3 2 x N = 28g

4 x H = 4g

3 x O = 16g

Step 4 $\%N = \frac{28}{80} \times 100 = 35\%$

$\%H = \frac{4}{80} \times 100 = 5\%$

$\%O = \frac{48}{80} \times 100 = 60\%$

- The total percentage should always equal 100%

(d) Nuclear Chemistry

- All of the naturally-occurring elements on planet Earth were made inside stars
    - Stars themselves mostly consist of hydrogen, the smallest and lightest of all the elements
    - Stars are gigantic nuclear furnaces, and can join protons, neutrons and electrons to form larger elements
- Radiation comes from radioactive substances
    - **Background radiation** can come from many sources including rocks, cosmic rays and medical uses

(e) Chemical Analysis

- Chemical Analysis is involved in all aspects of Chemistry
- It is important that the following simple analytical techniques can be carried out

Roles of Analytical Chemists

- Analytical chemists assess the chemical structure and nature of substances
- Their skills are needed for drug development, forensic analysis and toxicology for example
- Analytical chemists can specialise in areas as varied as toxicology, pharmaceuticals and forensic science

Precipitation Reactions

- Two soluble (ionic) solutions react to produce an insoluble salt
- This can be used to identify the type of ions present in a sample e.g. ions in water or soil **pH**

pH Testing

- This can be used to monitor the pH of different environmental samples
- Water and soil samples can be tested to determine whether they are acidic, alkaline or neutral to indicate pollution levels

Flame Testing

- When a solution containing metal ions are burned in a Bunsen flame the metal ions present in the compound produces a characteristic flame colour
- The colour produced can be used to identify the metal in the compound
- The flame colours produced by different ions are detailed in the data book

Separation techniques

- There are a range of different separation techniques that can be used
    - Paper chromatography
        - Simple separation technique that can be used to analyse mixtures containing coloured compounds such as inks and dyes
    - Filtration
        - separating an insoluble solid from a liquid
    - Evaporation
        - separating a soluble solid from a liquid
    - Distillation
        - separating liquids depending on their boiling points