CHEMISTRY

TRANSITION BOOKLET YEAR 11 INTO YEAR 12

I am delighted you have chosen to study Chemistry A level next year at The Bishops' High School. A level Chemistry at Bishops' is an exciting, challenging and immersive subject that you will find both interesting and fulfilling. Chemistry students get to investigate a range of ideas: the big question you'll ask yourself is 'what is the world made of?'. Studying Chemistry after GCSE really develops your practical and mathematical skills.

If you choose Chemistry as a career, you have the potential to help solve all sorts of problems. You could work on a cure for cancer, develop new food, work on sustainability, the opportunities are endless. Even if you don't directly go into the field of chemistry, the A-level provides you with so many transferable skills that universities and the job market are looking for. You'll develop research, problem solving, analytical skills, alongside teamwork and communication.

This booklet will provide you with the information you need to know about what you are studying during the two-year course. In addition, I have put together some information pages about each topic you will cover in the first year, some useful websites and clips to watch and some tasks I would like you to complete before September. These tasks are important to complete so that you have the correct level of background knowledge needed to start the course.

Qualification at a glance

Specification: - AQA A-level Chemistry (7405) https://filestore.aqa.org.uk/resources/chemistry/specifications/AQA-7404-7405-SP-2015.PDF

Assessment: - AQA A-level Chemistry (7405) consists of three externally examined papers and the Science Practical Endorsement.

- Students are expected to carry out core practical experiments that are identified in the content. You will be assessed for practical skills when carrying out these experiments and your corresponding write-ups. The content also features heavily in the exam, similarly to the format at GCSE
- Students complete three exam papers in May/June
  Paper 1 – Physical and Inorganic Chemistry (2 hours), worth 35% of the overall grade
  Paper 2 – Physical and Organic Chemistry (2 hours), worth 35% of the overall grade
  Paper 3 – Synoptic paper and any practical skills (2 hours), worth 30 % of the overall grade

Content

The field of chemistry is divided in to three distinctive areas; physical, organic and inorganic chemistry. The A-level course is also divided this way, and all year 13 content builds upon the work previously studied in year 12. The practical aspects are studied throughout.

Year 12

Physical Chemistry – Topics include: atomic structure, amount of substance, bonding, energetics, kinetics, equilibria and reduction.

Inorganic Chemistry – Topics include: periodicity, group 2 and group 7.

Organic Chemistry – Topics include: alkanes, halogenalkanes, alkenes, alcohols and organic analysis.

Year 13

Physical Chemistry – Topics include: thermodynamics, rate equations, equilibrium, electrode potentials and acid and bases.

Inorganic Chemistry – Topics include: period 3 elements and their oxides, transition metals and reactions of ions in aqueous solution.

Organic Chemistry – Topics include: isomerism, aldehydes and ketones, carboxylic acids, aromatic chemistry, polymers, nitrogen containing compounds, amino acids and DNA, organic synthesis, NMR spectroscopy and chromatography.

Useful websites

Details about specification: - https://filestore.aqa.org.uk/resources/chemistry/specifications/AQA-7404-7405-SP-2015.PDF

Details about degree courses: - https://digital.ucas.com/search

Details about careers: - https://www.prospects.ac.uk/graduate-jobs

Revision notes: - https://www.physicsandmathstutor.com/chemistry-revision/a-level-aqa/

Useful PowerPoints: - http://www.knockhardy.org.uk/ppoints.htm

Revision guide :- https://www.cgpbooks.co.uk/secondary-books/as-and-a-level/science/chemistry/car73-new-a-level-chemistry-aqa-year-1-2-comp

Tasks to Complete in this transition booklet

The topics studied across the two years is broad. Completing the tasks in this booklet will give you an introduction to all of the topic areas you study in year 12. Please read the content below and follow the links to further your understanding.

Please complete all the sections and bring this work with you in September. This will become the starting point for your A-level studies:

- Part 1 – Skills in Chemistry: Please complete the tasks on vocabulary and standard form
- Part 2 to 4 – Read the content provided and complete the tasks at the end of each section.

Part 1 – Skills in Chemistry

1. Vocabulary for practical work

There are many words used in practical work, many of which you may recognise from your GCSE studies.

Please complete the glossary for these command words.

Please complete the glossary:

Key Word	Definition
Accuracy	
Anomaly	
Categoric variable	
Continuous variable	
Control variable	
Dependent variable	
Independent variable	
Measurement error	
Precision	
Random error	
Repeatable	
Reproducible	
Resolution	
Systematic error	
True value	
Uncertainty	
Validity	
Zero error	

2. Standard form

Scientists often write numbers in standard form. When doing this the number is always written in the form

$A \times 10^n$ where A is a number between 1 and 10

n is the number of places we move the decimal point (+ to the right, - to the left)

Look at the number written in full and then put the decimal point straight after the first number (that isn't zero). Then count how many places you would have to move the decimal point to get it back to where it was.

Please complete the table:

Number	Standard Form	Number	Standard Form
8 937	8.937×10^{3}	0.001 68	
6 832 000 000	6.832×10^{9}	0.000 009 36	
0.02678	2.678×10^{-2}		6.73×10^{-4}
0.000 000 000 000 376	3.76×10^{-13}		3.193×10^{5}
8 245 000	8.245	602 000 000 000 000 000 000 000	

Units

Scientists often use a **prefix** on the front of the unit.

terra (T)	$\times 10^{12}$	1 000 000 000 000
giga (G)	$\times 10^{9}$	1 000 000 000
mega (M)	$\times 10^{6}$	1 000 000
kilo (k)	$\times 10^{3}$	1 000
milli (m)	$\times 10^{-3}$	0.001
micro (μ)	$\times 10^{-6}$	0.000 001
nano (n)	$\times 10^{-9}$	0.000 000 001
pico (p)	$\times 10^{-12}$	0.000 000 000 001

Some examples are shown in the table below

Distance	In metres		
	Working	Standard form	Full number
25.6 km	25.6×10^{3} m	2.56×10^{4} m	2560 m
1.28 mm	1.28×10^{-3} m	1.28×10^{-3} m	0.001 28m
786 pm	786×10^{-12} m	7.86×10^{-10} m	0.000 000 000 786

Questions

1. Complete the table after the examples shown:

Distance	In metres		
	Working	Standard form	Full number
375 Gm			
128 nm			
0.786 nm			
35 mm			
20.1 Tm			

45 pm			
27.6 µm			

2. The radius of a hydrogen atom is 25 pm. Write this in metres in both standard form and as a full number.

standard form …….. full number ……..

3. The radius of a copper atom is 0.135 nm. Write this in metres in both standard form and as a full number.

standard form …….. full number ……..

4. The radius of a carbon atom is 70 pm. The nucleus is 10000 times smaller. Give the radius of a carbon nucleus in metres in both standard form and as a full number.

standard form …….. full number ……..

5. The radius of a nitrogen atom is 65 pm. The radius of a silver atom is 0.160 nm. Give the radius of both atoms in standard form in metres and state which atom is bigger.

nitrogen atom …….. silver atom …….. larger atom = ……

6. The diameter of a carbon atom is 140 pm. How many carbon atoms would fit in a line of carbon atoms 0.30 m long? Show your working and give your answer to 3sf.

_____

_____

7 The diameter of a copper atom is 0.270 nm. How many copper atoms would fit in a line of copper atoms 50 cm long? Show your working and give your answer to 3sf.

_____

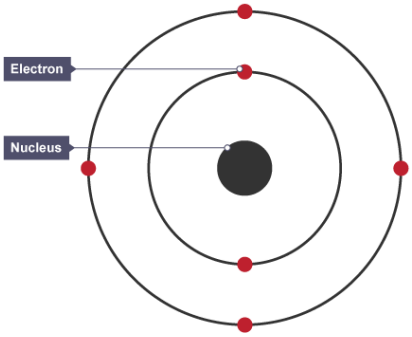
_____

Part 2 - Physical Chemistry

It was only about a century ago that scientists began to discover the nature of atoms and the fact there are made up of subatomic particles. This led to the understanding of how molecules and compounds are held together and why Mendeleev's periodic table made sense. Physical is the study of how matter behaves on a molecular and atomic level and how chemical reactions occur.

AS level physical chemistry studies seven areas in more detail:

1. Atomic Structure



The subatomic particles (protons, neutrons and electrons) are shown in the diagram of the atom.

The protons and neutrons are held in the centre by a strong force called a **nuclear force**. The nucleus is surrounded by electrons in shells (or orbitals) which get further away from the nucleus.

The masses of atoms are measured by a mass spectrometer and it can be used to identify different isotopes that make up an element. An isotope is an atom that has the same number of protons (atomic number) and a different number of neutrons.

Further reading: https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.1.%20Atomic%20Structure.pdf

2. Amount of Substance

Quantitative chemistry covers a broad range of topics from the mole, the reactant mass (how much product you will give from a given amount of reactant), balancing equations, gases and concentrations of solutions. Many of these areas you will have begun to study at GCSE. An understanding of these calculations enables scientists to accurately calculate expected amounts of products for given reactions and design improvements to reactions to change the yield.

<u>The mole</u>

A mole is the amount of a substance that contains 6.02×10^{23} particles. The mass of 1 mole of any substance is the same as its M_r (the relative formula mass in grams

e.g. One mole of sodium has 6.02×10^{23} particles and a mass of 23.0 g

Two moles of carbon has 12.04×10^{23} particles and a mass of 24.0 g (2 x 12.0 g)

One mole of calcium carbonate ($CaCO_3$) contains has 6.02×10^{23} particles and has a mass of 100.0 g (40 + 12 + 16 + 16 + 16)

To calculate the moles of a substance:

Number of moles = $\frac{mass\ of\ a\ substance\ (in\ grams)}{Relative\ formula\ mass}$

Empirical Formula

If you measure the mass of each reactant used in a reaction, you can work out the ratio of atoms of each reactant in the product. This is known as the empirical formula. This may give you the actual chemical formula, or the actual formula may be a multiple of this. For example, hydrogen peroxide is H_2O_2 but would have the empirical formula HO.

Use the following to find an empirical formula:

1. Write down reacting masses

2. Find the amount in moles of each element

3. Find the ratio of moles of each element

Example: A compound contains 2.232 g of ion, 1.284 g of sulfur and 1.920 g of oxygen. What is the empirical formula?

Element	Iron	Sulfur	Oxygen
Calculate the number of moles = mass/M_r	2.232/55.8	1.284/32.1	1.920/16.0
Amount in moles	0.040	0.040	0.120
Divide by the smallest	0.040/0.040	0.040/0.040	0.120/0.040
Ratio	1	1	3
Formula	**$FeSO_3$**		

The method to calculate the formula is the same if the question gives you a percentage instead of mass.

Percentage yield

Even though no atoms are gained or lost in a chemical reaction, it is not always possible to obtain the calculated amount of a product because: • the reaction may not go to completion because it is reversible
• some of the product may be lost when it is separated from the reaction mixture
• some of the reactants may react in ways different to the expected reaction.

The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield.

$$\textbf{Percentage yield} = \frac{\textbf{Amount of product produced}}{\textbf{Maximum amount of product possible}} \times 100$$

Further reading: https://www.bbc.co.uk/bitesize/topics/z87mw6f

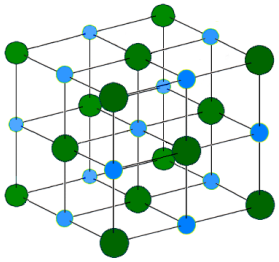
https://www.chemteam.info/Mole/Mole.html

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.2.%20Amount%20of%20Substance.pdf

3. Bonding

Chemical bonding involves either **transferring** (ionic) of electrons, or the **sharing** (covalent) of electrons on the highest energy level to achieve the electronic structure of a **noble gas**.

a) IONIC COMPOUNDS



- An ionic compound is a giant structure of ions.
- It is held together by **strong electrostatic attraction of oppositely charged ions.**
- The forces act in all directions in the lattice, and this is called ionic bonding.
- They have high melting and boiling points, because a lot of energy is required to break the many strong ionic bonds.
- When dissolved in water or melted, ionic compounds conduct electricity because the ions are free to move and carry current.

An example is sodium chloride (salt): Na^+ and Cl^-

Group 1 – ALKALI METALS react with non-metals to create an ion with a +1 charge.
Group 7 – HALOGENS react with alkali metals to form halide ions with a -1 charge.

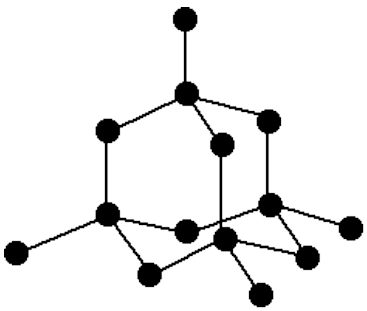
b) COVALENT BONDING

- When atoms share electrons, this is covalent bonding. Covalent bonding is strong.
- Covalently bonded substances consist of simple molecules e.g. HCl, H_2, O_2, Cl_2, NH_3, CH_4.
- Others have giant covalent structures (macromolecules) e.g. diamond, silicon dioxide.

Simple Covalent Molecules

- Substances that consist of simple molecules have low boiling and melting points.
- Substances that consist of simple molecules have **weak intermolecular forces between the molecules**. The weak intermolecular forces are broken when a substance boils or melts, not the covalent bonds. Only a small amount of energy is needed to break these weak forces, so they have low boiling and melting points.
- Substances that consist of simple molecules don't conduct electricity, because simple molecules do not have an overall electric charge.

Giant Covalent structures

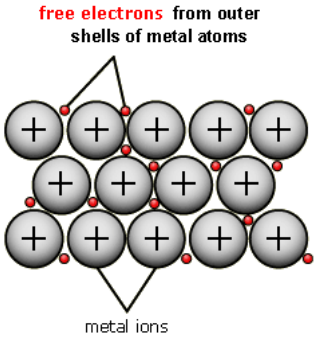


- Examples of covalent structures include diamond and graphite (forms of carbon) and silicon dioxide (silica).
- In diamond (right), each carbon is joined to 4 other carbons covalently. Diamond is very hard.
- In graphite, each carbon is joined to 3 other carbons, forming layers.
- In graphite, the layers can slide over each other due weak intermolecular forces between the layers. This means that graphite is soft and slippery.
- Due to the delocalised electrons in graphite, it can conduct heat and electricity.

Fullerenes

- Carbon can also form fullerenes with different numbers of carbon atoms.
- They are based on hexagonal rings of carbon atoms.
- They can be used as lubricants, to deliver drugs in the body and catalysts.
- Nanotubes can be used for reinforcing materials, for example tennis rackets.

c) METALS



- Metals consist of giant structures of atoms arranged in a regular pattern.
- **Metallic bonding is the electrostatic attraction between the positive metal ions and the delocalised electrons.**
- The electrons on the outer shell of metal ions are delocalised.
- Metals can conduct heat and electricity because of the delocalised electrons in their structures.
- Metals are malleable as the layers of atoms are equally sized so can easily slide over each other, so metals can be bent and shaped.

- Alloys are made from a mixture of 2 or more different types of metals.
- The different sized atoms distort the layers in the structure, making it harder for them to slide over each other. This makes the material harder.

Further reading: https://www.bbc.co.uk/bitesize/topics/zq6h2nb

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.3.%20Bonding.pdf

4. Energetics

Energy is conserved in chemical reactions. The amount of energy in the Universe at the end of a chemical reaction is the same as before the reaction takes place.

An exothermic reaction is one that transfers energy to the surroundings so the temperature of the surroundings increases – "it gets hotter".

During a chemical reaction:

- Energy must be supplied to break bonds in the reactants
- Energy is released to form bonds in the products.

The difference between the sum of the energy needed to break bonds in the reactants and the sum of the energy released when bonds in the products are formed is the overall energy change of the reaction.

Further reading: https://www.bbc.co.uk/bitesize/topics/z34kgdm

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.4.%20Energetics.pdf

5. Kinetics

Kinetics studies the rate reactions take place. At GCSE you study five factors that can impact the rate of reaction; concentration, pressure, temperature, surface area and catalysts. Collisions are only successful if they are energetic enough to break the bonds (the activation energy).

Further reading: https://www.bbc.co.uk/bitesize/topics/zs3gfcw

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.5.%20Kinetics.pdf

6. Equilibria

Many chemical reactions are irreversible, with the reactants turning into products (such as burning a fuel). Some reactions however are reversible meaning the reaction can happen in both directions. Determining the position of equilibrium is therefore vital for scientists to ensure they can achieve the greatest proportion of desired products, by changing the conditions (such as temperature and balance). This becomes a difficult balance for scientists to ensure they produce a substantial yield without impacting the cost too significantly to achieve a compromise.

Further reading: https://www.bbc.co.uk/bitesize/guides/zyhvw6f/revision/1

https://www.bbc.co.uk/bitesize/guides/z9tvw6f/revision/1

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.6.%20Equilibria.pdf

7. Redox

A redox reaction is one in which reduction and oxidation both occur for a given reaction. This can occur via the addition of oxygen (oxidation) or removal of oxygen (reduction) such as the reaction of copper oxide with carbon:

Copper oxide + carbon → copper + carbon dioxide

The definition however expands to include the reactions that include electron transfers, with oxidation reactions being the result of a loss of reaction and reduction reactions results in a gain of reactions.

Further reading: https://www.bbc.co.uk/bitesize/guides/zsm7v9q/revision/2

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Physical-I/Detailed/1.7.%20Oxidation,%20Reduction%20and%20Redox%20Equations.pdf

Tasks for Part 2 – Physical chemistry

Please complete the following seven tasks, making sure to complete each one on a separate page under the appropriate heading.

1. **Atomic Structure** - Research the following Scientists and produce a report on their contributions to the development of atomic theory, include experiments that they carried out. ● John Dalton ● J.J. Thompson ● Geiger, Marsden and Rutherford ● Niels Bohr ● James Chadwick

2. **Amount of Substance** - Try the following calculations:

   Calculate the number of moles for the following examples:
   a) 32.0 g of methane (CH_4)
   b) 20.0 g of calcium carbonate ($CaCO_3$)
   c) 5.30 g of Na_2CO_3

   Empirical formula:

   a) The smell of a pineapple is caused by ethyl butanoate. A sample is known to contain only 0.180 g of carbon, 0.030 g of hydrogen and 0.080 g of oxygen. What is the empirical formula of ethyl butanoate?
   b) Find the empirical formula of a compound containing 0.0578 g of titanium, 0.288 g of carbon, 0.012 g of hydrogen and 0.384 g of oxygen.

c) 300 g of a substance are analysed and found to contain only carbon, hydrogen and oxygen. The sample contains 145.9 g of carbon and 24.32 g of hydrogen. What is the empirical formula of the compound?

Percentage yield:

a) An industrial process to produce fertiliser obtained 56.0 tonnes of fertiliser. The theoretical yield was 84.0 tonnes. What is the percentage yield?
b) An industrial process to extract iron produces 670 tonnes of iron. The theoretical yield is 700 tonnes. What is the percentage yield?
c) An experiment to produce magnesium oxide gives an actual yield of 0.80 g. The theoretical yield is 1.6 g. What is the percentage yield?

3. **Bonding** – Create a table showing the similarities and differences between ionic, covalent and metallic bonding

4. **Energetics** – Write a method for a "calorimetry" experiment, using this link to help https://www.bbc.co.uk/bitesize/guides/znp4jxs/revision/2

5. **Kinetics** – Summarise the different methods you studied to calculate the rate of reaction for your GCSE required practicals. This should include; production of a gas, loss of mass and the disappearing cross reaction.

6. **Equilibria** – Research the Haber Process, the optimum conditions and uses of ammonia

7. **Redox reactions** – Make a summary diagram for redox reactions https://www.youtube.com/watch?v=jyvcVjrZnJA

Part 3 - Inorganic Chemistry

The Periodic Table contains all the elements that have been discovered, and inorganic chemistry at A-level examines how the properties of the elements are related to their electronic structures and how this corresponds with their position in the periodic table.

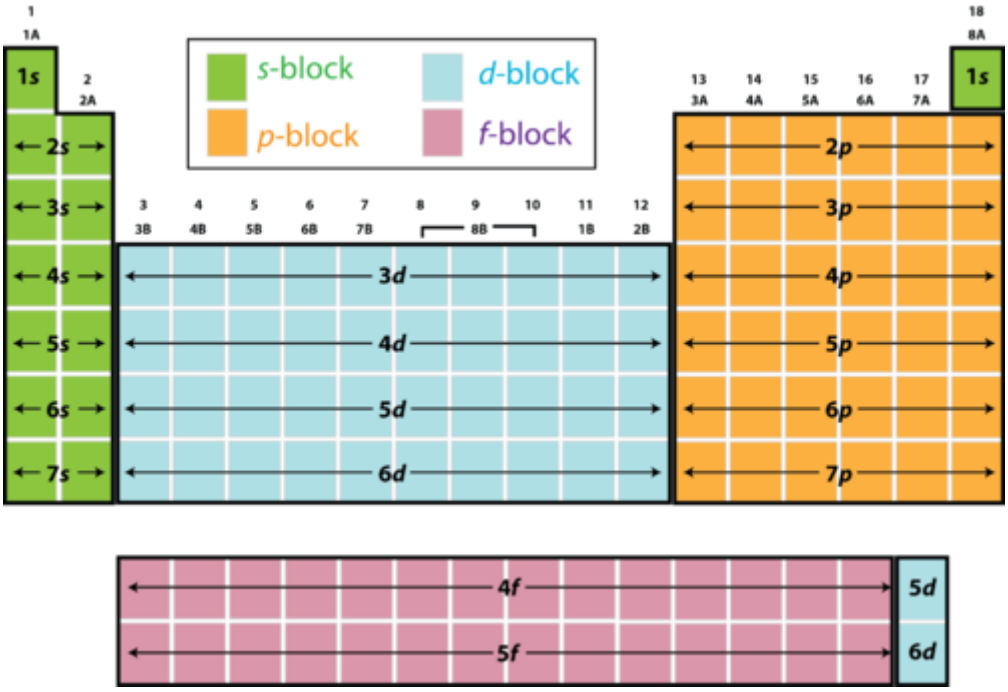
AS-level inorganic chemistry studies three areas in more detail:

1. Periodicity

At GCSE we learn how electrons are arranged in shells or orbitals and the maximum number of electrons that can be found in each shell. In the Periodic table metals are arranged to the left, and non-metals to the right. The group number (vertical columns) informs us how many electrons are in the outer shell and the period number (horizontal rows) tells us how many shells each specific element has.

In the modern periodic table the elements are arranged by order of atomic number (the proton number).

At A-level we classify the elements further in terms of *s-, p-, d-* and *f-* orbitals as shown in the diagram below.



2. Group 2, the alkaline Earth Metals

All the group 2 elements have two electrons in their outer shell (the s orbital). As you go down the group, the elements get heavier due to the additional protons and neutrons, and therefore as they also contain more electrons the outermost electrons are further from the nucleus. This leads to a variety of properties we can study from reactivity, atomic radius, solubilities of their compounds to their melting and boiling points. The elements in group 2 are called the alkaline Earth metals because their oxides and hydroxides are alkaline (pH greater than 7).

3. Group 7 (17), the Halogens

Group 7 elements are found on the right-hand side of the Periodic Table and are made up of non-metals. The elements exist as diatomic molecules, meaning they consist of two atoms such as F_2, Cl_2, Br_2 and I_2. Astatine, another halogen, is rare and radioactive. Trends in the group can be related to their atomic structure. The topic includes the reactions of the elements and their compounds using the ideas of redox reactions and oxidation states. The topic also studies the use of the element chlorine and some chlorine containing compounds.

Further reading: https://www.bbc.co.uk/bitesize/topics/zxnftv4
https://www.youtube.com/watch?v=oDvQvu_xfAw&t=208s
https://www.youtube.com/watch?v=8qh5myTmcRs

Tasks for Part 3 – Inorganic chemistry

Please complete the following three tasks, making sure to complete each one on a separate page under the appropriate heading.

1. **Periodicity** - Research the following Scientists and produce a report on their contributions to the development of the Periodic table ● Hennig Brand ● Johann Dobereiner ● de Chancourtois ● John Newlands and ● Dmitri Mendeleev

2. **Group 2** - Research the uses of group 2 elements and their compounds (including limestone, the barium meal and magnesium hydroxide)

3. **Group 7** - Summarise what you already know about group 7 elements from GCSE. Use this link to help https://www.bbc.co.uk/bitesize/guides/ztq6cwx/revision/1

Part 4 - Organic Chemistry

At GCSE level combined science, organic chemistry teaches about hydrocarbons and the group of molecules called alkanes. All organic compounds are based on chains of carbon atoms, but these can be straight, branched or in rings forming millions of different compounds. These compounds include halogenalkanes, alkanes, alkenes and alcohols.

AS-level organic chemistry studies several types of organic compounds in more detail, and how you can use different techniques such as infra-red spectroscopy and test tube reactions to study these compounds in more detail. Some examples of these compounds are shown below:

1. Alkanes and alkenes

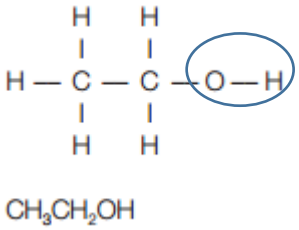
- Alkanes are hydrocarbons with single bonds only
- Alkenes are hydrocarbons that contain a double covalent carbon-carbon bond by sharing four electrons between a pair of atoms
- Alkanes and alkenes can be distinguished by adding bromine water. Bromine water is orange in colour. If this is added to alkanes, the bromine water stays orange (it does not react). If it is added to alkenes however, the bromine water decolourises.

2. Alcohols

- Alcohols contain the functional group –OH
- The first 3 members of the series are methanol, ethanol and propanol.

Methanol, ethanol and propanol:

- Burn in air
- Dissolve in water to form a neutral solution
- React with sodium to produce hydrogen
- They are used as fuels and solvents, and ethanol is the main alcohol in alcoholic drinks.

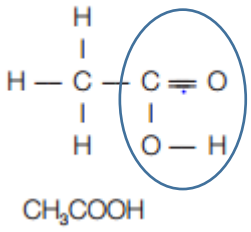


Oxidation

- Ethanol can be oxidised to form ethanoic acid.
- It can be oxidised by chemical oxidising agents or microbial action.
- Vinegar is an aqueous solution which contains ethanoic acid.

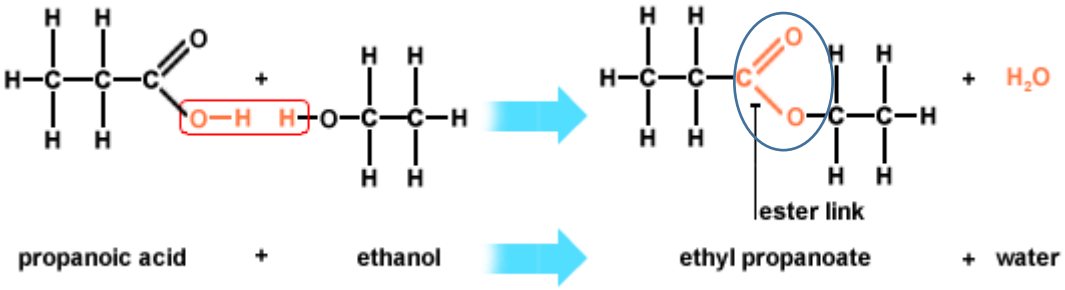
3. Carboxylic acids

- Ethanoic acid is a member of the carboxylic acids, they have the functional group –COOH.
- Dissolve in water to produce acidic solutions
- React with carbonates to produce carbon dioxide
- React with ethanol in the presence of an acid catalyst to produce esters
- They do not ionise completely, so do not release many H+ ions, so it is a weak acid.



- This means they have a higher pH (weak acid) than solutions of strong acids of the same concentration.

4. **Esters**
   - Ethel ethanoate is the ester produced by ethanoic acid and ethanol.
   - They have the functional group –COO-.
   - They are volatile compounds with distinctive smells and are used as flavourings and perfumes.



Further reading: https://www.bbc.co.uk/bitesize/topics/ztsyh39

https://www.youtube.com/watch?v=ZeUNWY7YDAo

https://pmt.physicsandmathstutor.com/download/Chemistry/A-level/Notes/AQA/Organic-I/Detailed/3.1.%20Introduction%20to%20Organic%20Chemistry.pdf

Tasks for Part 4 – Organic chemistry

Please complete the following three tasks, making sure to complete each one on a separate page under the appropriate heading.

1. **Organic analysis** - Research the technique of infra-red spectroscopy, covering how it works and how it can be used as a tool for identifying functional groups in organic compounds.

2. **Organic molecules** – Produce a summary map, poster, or presentation about the different types of organic molecules https://www.bbc.co.uk/bitesize/guides/z3v4xfr/revision/1