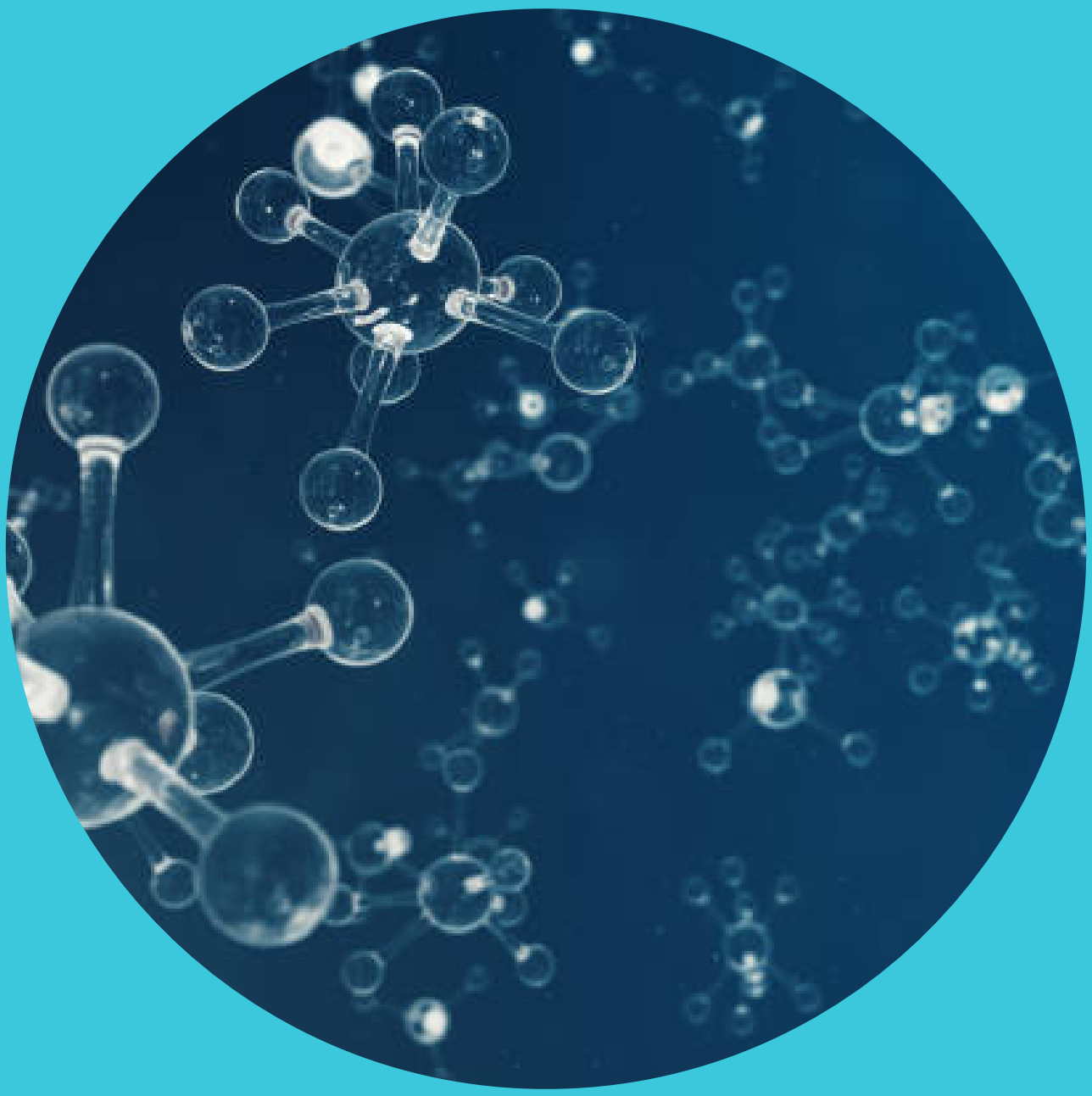
Researchers in Schools



Why doesn't aspirin grow on trees?

Key Stage 4 Programme

Pupil Name

Coursebook Designed by Dr A. Spencer

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Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1			
2			
3			
4			
5			
6 (Feedback)			
7 (Feedback)			

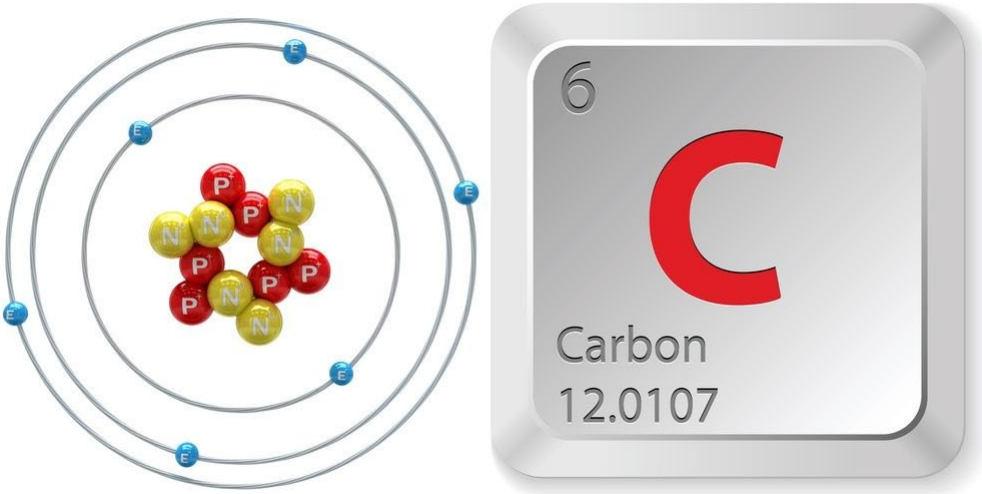
Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Baseline Assignment	
Tutorial 2	Bonding in Dichloroethane	
Tutorial 3	Skeletal Formulae, Lone Pairs and Bond Polarity	
Tutorial 4	Explaining Organic Reactivity	
Tutorial 5	Final Assignment	

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on due date	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Course Rationale



This course will explore the field of organic chemistry. Organic chemistry is the study of carbon, one of the most important elements in the periodic table and the most abundant element by weight in the human body. The unique properties of carbon means it is able to form complex chain-like structures with itself and with other non-metals. These structures are integral to our everyday lives finding uses in pharmaceuticals, electronics, plastics, agrochemicals, new-age materials and sustainably meeting global energy demands.

But what is it about carbon that makes it so versatile? We will explore just how carbon can form such diverse structures and most importantly how we can use its reactivity to construct new carbon-based molecules. This is exactly what thousands of organic chemists do everyday all over the world.

The course will be taught and marked in a style that is used in universities across the world. Some of the content is to the level of a 2nd year undergraduate in chemistry. Although this may sound daunting, the course has been structured in a way that will be accessible and enjoyable for you! Hopefully it will allow you to gain skills in scientific thinking, critical analysis, research, essay writing and an appreciation of complex ideas. These skills will be invaluable in the rest of your time at Manchester Academy and for whatever road you choose to pursue next.

Uni Pathways Mark Scheme 2020 – science-based assignments

	Subject Knowledge	Critical Thinking	Written Communication
1st	The work shows a depth of knowledge and understanding of key concepts and scientific methods, through engaging with relevant sources. Knowledge is used to build and support highly effective scientific arguments and explanations.	Analyses key scientific evidence, arguments, and reasoning. Interprets meaning and makes connections. Identifies and critically evaluates key scientific arguments and evidence, deciding on their credibility, strength, and relative significance, drawing convincing conclusions.	The work has a coherent flow and is well structured. The writing style is appropriate; scientific language and key scientific terms are used accurately and effectively to support the arguments and explanations made. There are no, or very few, errors in spelling or grammar. Consistent referencing, appropriate paragraphing and use of correctly labelled tables and graphs matching the style taught in the course.
2:1	The work shows an understanding of key concepts and scientific methods, drawing on relevant sources. Knowledge is used to build and support effective scientific arguments and explanations.	Analyses relevant scientific evidence, arguments, and reasoning. Identifies and critically evaluates relevant scientific arguments and evidence, deciding on their credibility and strength, drawing reasonable conclusions. Shows some understanding of the relative value of evidence and arguments.	The work is well-structured. The writing style is appropriate; scientific language and key terms are used correctly. There are few errors in spelling or grammar. Mostly consistent referencing and use of tables and figures; matching the style taught in the course.
2:2	The work shows an understanding of key concepts and scientific methods, with no major misconceptions. Beginning to apply this knowledge to build and support effective scientific arguments and explanations.	Identifies and uses basic scientific evidence, arguments, and reasoning. Showing some understanding of the quality of scientific arguments and evidence. Not yet showing understanding of the relative value of evidence and arguments.	The work has some structure. The writing style can sometimes be informal; occasionally scientific language and key terms are not used when it would be appropriate to do so. There are some errors in grammar and spelling do not get in the way of communicating the content. Referencing has some consistency; matching the style taught in the course Limited use of tables and graphs.
3rd	Shows a developing understanding of key concepts and scientific methods, with some misconceptions.	Beginning to analyse scientific evidence, arguments, and reasoning.	The grammar, spelling, style, and structure of the work need improving in order

	Does not yet apply this knowledge to build and support scientific arguments and explanations.	Describes evidence and arguments, while not yet evaluating them.	to communicate ideas to the reader. Scientific language, key terms and references are not always used correctly. Limited, or no use of tables and graphs.

Baseline Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	
Name of RIS teacher	
Title of Assignment	

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark
Written communication	
	mark

Baseline Assignment (problem-set): Pupil Feedback Report

Name of Pupil	
Name of School	
Name of RIS teacher	
Title of Assignment	

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark
Written communication	
	mark

Problem Set	
Comment	*mark*

Final Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	
Name of RIS teacher	
Title of Assignment	

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark
Written communication	
	mark

Subject Vocabulary

Word	Definition	In a sentence
Atom	An atom is the smallest part of an element that can exist.	A molecule of oxygen is made up of two **atoms**.
Element	An element is a substance that cannot be broken down into any other substance.	The periodic table is an organised collection of all known **elements**.
Compound	A substance that contains two or more elements that are chemically bonded.	Water is a **compound** that is integral to all life on earth.
Organic chemistry	The branch of chemistry that deals with carbon compounds.	Working in the plastics industry requires knowledge of **organic chemistry**.
Pharmaceutical	A compound used as a medicinal drug.	He was prescribed a **pharmaceutical** to treat his illness.
Subatomic particle	Objects that make up atoms.	An atom of carbon has 18 **subatomic particles**.
Proton	Subatomic particle with a positive charge and relative mass of 1.	An atom of carbon contains 6 **protons**.
Neutron	Subatomic particle with no charge and relative mass of 1.	An atom of carbon contains 6 **neutrons**.
Electron	Subatomic particle with negative charge and negligible mass.	An atom of carbon contains 6 **electrons**.
Nucleus	The central part of an atom that contains protons and neutrons.	The **nucleus** of an atom is where most of its mass is contained.
Atomic number	The number of protons contained within the atom; this is the top number next to the element symbol in the periodic table.	Carbon contains 6 protons, so it has an **atomic number** of 6.
Periodic table	A chart showing all the elements arranged in order of increasing atomic number.	Elements in the same group of the **periodic table** tend to have similar properties.
Covalent bond	A covalent bond forms when two non-metal atoms share a pair of electrons.	Methane contains a **covalent bond** between carbon and hydrogen.

Electronegativity	Electronegativity is a measure of an atom's attraction for the electrons in a bond.	Nitrogen is more **electronegative** than carbon.
Polarity	An uneven distribution of electrical charge over a bond or molecule.	Bonds in water have a very high **polarity** giving it unique properties.
Nucleophile	A molecule or substance that has a tendency to donate electrons.	With a lone pair of electrons, nitrogen often acts as a **nucleophile**.
Electrophile	A molecule or substance that has a tendency to accept electrons.	With a highly polar carbon oxygen bond, acetone acts as an **electrophile**.
Synthesis	The production of chemical compounds by reaction from simpler materials.	Pharmaceuticals often have a complicated multi-step **synthesis**.
Retrosynthetic analysis	A technique of working backwards to plan the synthesis of an organic molecule.	We will use **retrosynthetic analysis** to plan the synthesis of aspirin.
Synthon	A unit within a target molecule that represents a potential starting molecule.	In the synthesis of paracetamol, we break it down into two **synthons** to work out how best to make it.

Launch Event

The launch event is your opportunity to learn more about this course and Uni Pathways. You will watch some videos, listen to your teacher and have some discussion. Below is some room to make notes for some of the videos you will watch during the event.

Virtual Campus Tours

Notes…

The Scholars Programme Alumni

Notes…

Student Ambassadors

Notes…

Tutorial 1 – What is Organic Chemistry?

What is the Purpose of Tutorial 1?

- To state the definition of a mixture, an element and a compound
- To recall some examples of common pharmaceuticals
- To differentiate between the Dalton atomic model and the Rutherford atomic model

Introduction to Organic Chemistry

Watch the clip from the TED talk on **organic chemistry**; write down your thoughts to share them with the group

Activity 1

This starter is based around the definitions of elements, compounds and mixtures (the definitions of these are in the glossary of terms).

Write in below the term whether the substance is an element, compound or mixture.

Oxygen	**Carbon Dioxide**	**Dynamite**
Potassium Nitrate	**Brass (An Alloy)**	**Carbon**
Potassium	**Vinegar**	**Calcium Carbonate**
Air	**Iron**	**Coffee**
Calcium	**Caffeine**	**Sodium Chloride**

What are Pharmaceuticals?

Below you have a list of different **pharmaceuticals**. Circle any that you have heard of before and in the space below, write what you think they are used for.

Paracetamol

Aspirin

Penicillin

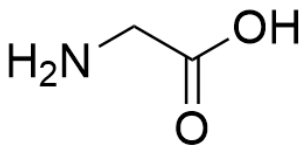
Statins

Morphine

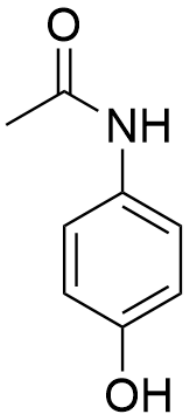
Steroids

Pharmaceuticals are a compound used as a medicinal drug. They are essential to the health and wellbeing of everyone on the planet.

In the field of **organic chemistry**, a huge amount of work goes into the development of new pharmaceuticals. Pharmaceuticals tend to be based on the element **carbon**. This is to allow them to interact with your body (which itself is just a big bundle of carbon).



Glycine-a building block of life



Paracetemol-a pharmaceutical

Notes…

Atomic Structure

Atoms are the smallest part of an **element** that can exist, they are the building blocks that make up all matter.

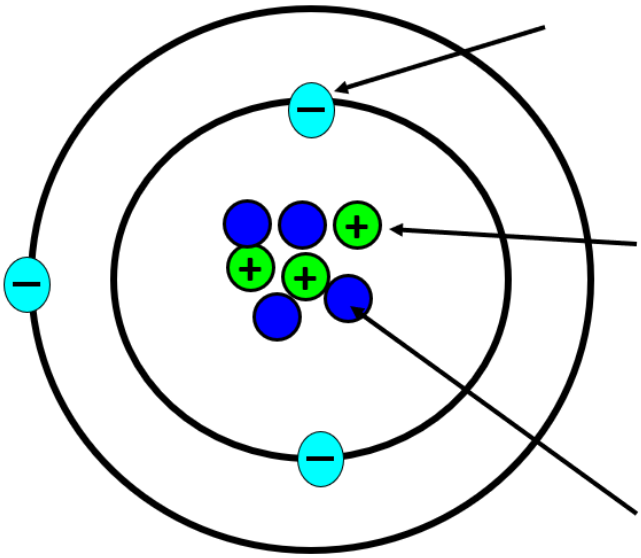
The widely accepted structure of an **atom** that we have today was discovered by **Ernest Rutherford** in 1911.

The model contains a **nucleus** at the centre of the **atom** which is **positively charged** and contains most of the mass of the atom. The **nucleus** is surrounded by **electron shells** that hold negatively charged particles.

The nucleus contains two **subatomic particles**, **protons** and **neutrons. Protons** have a relative mass of 1 and have a charge of +1. **Neutrons** have a relative mass of 1 and have a charge of 0 (they have no charge).

The electron shells contain **electrons**, they have a relative mass of 1/1840 and have a charge of -1. The first electron shell can hold 2 electrons, the second 8 and the third 8.

Label the diagram and table below with the information on subatomic particles.



Particle	Mass	Charge
Proton		
Neutron		
Electron		

Getting to Know the Subatomic Particles

From the tiles below, pick out the properties that relate to a proton, an electron and a neutron. The first one has been done for you to get you started.

Has a negative charge	Is in the nucleus	Would not be attracted to a negatively charged plate	Has a negligible mass	Would be attracted to a negatively charged plate
Is in the shells around the nucleus	Has a positive charge	Has a relative mass of 1	Would be repelled by a negatively charged plate	Has no charge

A Proton…

1. Has a positive charge
2. …
3. …
4. …

A Neutron

1. …
2. …
3. …
4. …

An Electron

1. …
2. …
3. …
4. …

HINT-You may have to use some tiles more than once

BONUS

Do you think it matters if there are more protons than electrons? How would this change the properties of the atom? What about more neutrons?

Discuss your thoughts with your neighbour.

Homework 1-Baseline Assignment

Essay question…

You are expected to write a short essay (250 words) on why carbon is so important in the chemical industry. Include a brief introduction to the properties of carbon and include at least two examples of carbon-based compounds that you came across in the lesson; one of these must be a pharmaceutical.

Your essay should be split into 3 parts…

1. A short introduction of carbon itself and some of its properties (50 words).
2. An explanation as to why carbon is so important in chemistry, referring to examples we covered in the tutorial; you should also refer to some of its properties (150 words).
3. A conclusion to sum up your ideas (50 words).

Make sure you use scientific specific vocabulary throughout and justify your answers. Please cite any sources which you have used to support your answer.

Problem set…

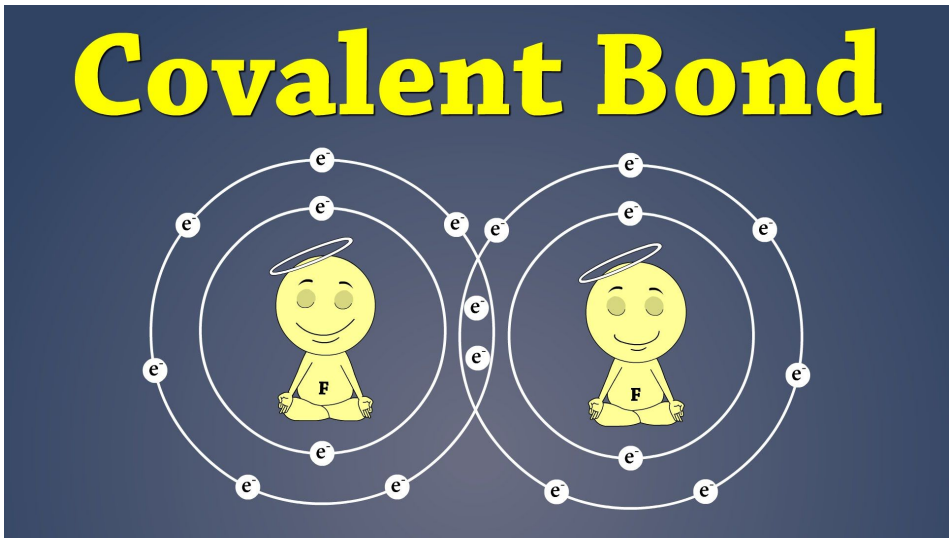
1. State the definition of an atom, an element, a compound and the periodic table. (4 marks)
2. Explain the Rutherford model for atomic structure. (5 marks)
3. Explain the different ways in which the rate of a reaction can be increased. (11 marks)
4. Balance the following equations: (5 marks)

$N_2 + H_2 \longrightarrow NH_3$

$C_2H_6 + O_2 \longrightarrow CO_2 + H_2O$

You will find it useful to use diagrams to support your answers. Make sure you are using key words correctly and that your answers are well-structured. You are allowed to look up information to support your answers and will not be expected to cite your sources. You may find it useful to refer to some of your notes from KS3 chemistry.

Tutorial 2 – Covalent Bonding



What is the Purpose of Tutorial 2?

- To explain how a covalent bond forms by sharing of electrons
- To draw a single covalent bond as a dot and cross diagram
- To state the definition of electronegativity

Starter Activity

Answer these questions during the first 5 minutes of the tutorial:

1. State the definition of an **element**.

2. Which of these statements best describes the definition of a **pharmaceutical**?

   A. The smallest unit of matter.
   B. A substance that has been made illegal by the government.
   C. A compound used as a medicinal drug.
   D. A compound that is contained in group 1 of the periodic table.

3. Explain the **Rutherford model** of an atom, including all the **subatomic particles** and their properties.

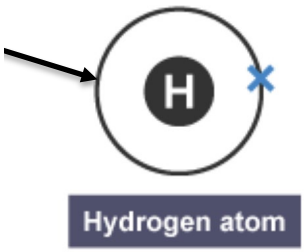
Introduction to Chemical Bonds

Why do **elements** form chemical bonds?

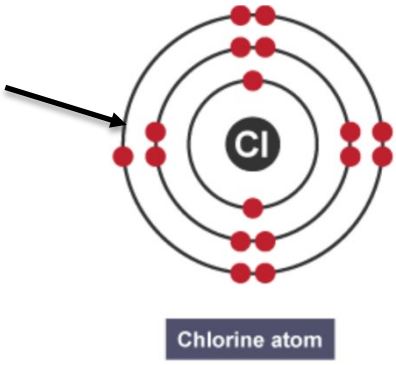
Elements have a desire to have a **full outer shell of electrons**. This is because it is the **lowest energy state** for the atom, and it is therefore most **stable**.

For every element we will talk about in this course, a **full outer shell** consists of **8 electrons**. **Hydrogen** is the only exception which requires **2 electrons** to fill its outer shell.

One space for an electron in a hydrogen atom for a full outer shell of **2**



One space for an electron in a chlorine atom for a full outer shell of **8**



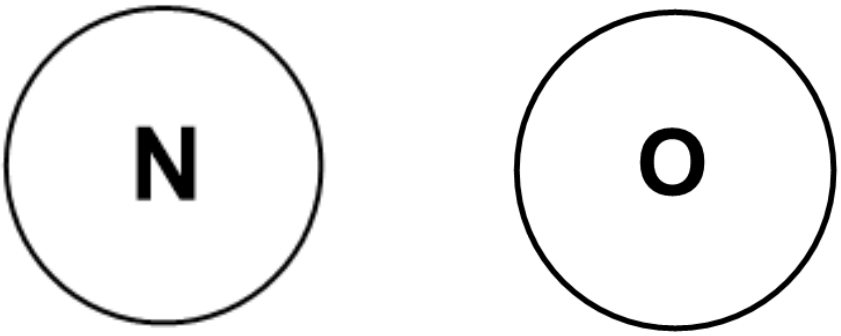
We can tell how many **electrons** are in the **outer shell** of an element by the group number it is in on **the periodic table**.

Group number = number of electrons in outer shell

Hydrogen is in **group 1** and has **1 electron** in its outer shell. Chlorine is in **group 7** so **has 7 electrons** in its outer shell.

Activity 1

Fill in the outer shell electrons for both of these atoms. Use a cross or a dot to represent an electron.

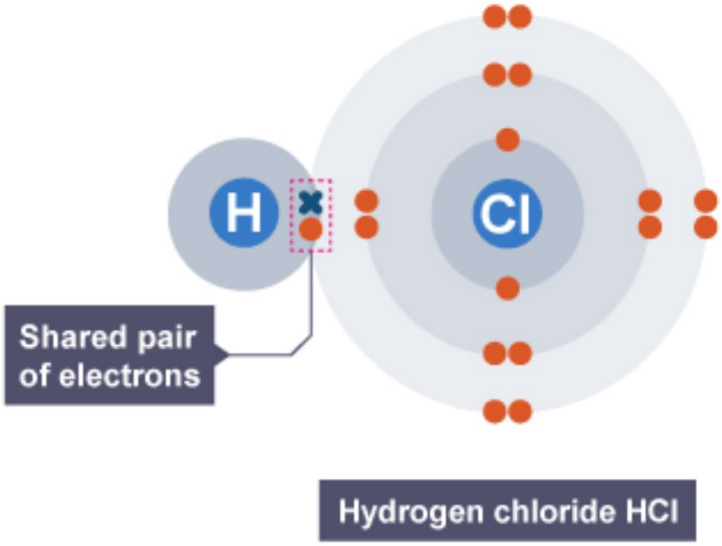


Notes…

How does a **covalent bond** form?

We now know that atoms want to have **a complete outer shell** of electrons, but how can this be achieved without us magically making electrons out of thin air?

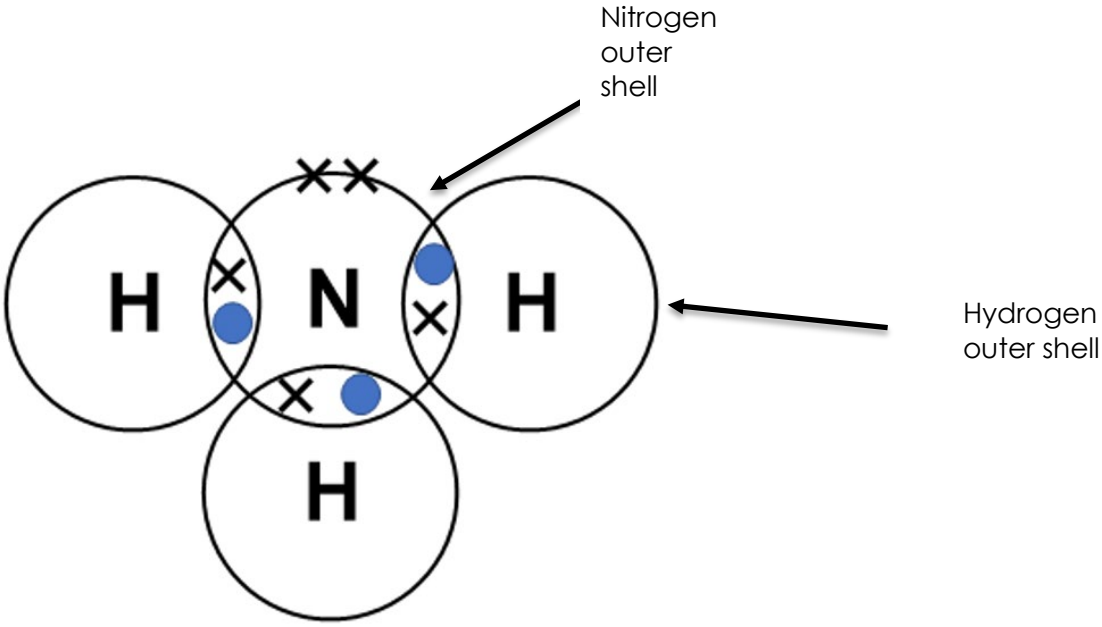
Two atoms are able to **share a pair of electrons** to complete their outer shell; this binds the two atoms together and we call this a **covalent bond**.



Dot and Cross Diagrams

The most common way that we depict **covalent bonds** is with **dot and cross diagrams**. We use a circle to depict the outer electron shell and dots and crosses for the electrons.

Here is a dot and cross diagram of NH_3. The **blue dots** are electrons from **hydrogen** and the **black crosses** are electrons from **nitrogen**.



We are going to go through an example as to how to draw these using the example of hydrogen fluoride. Fill in the sections below as we go through them in the tutorial.

1. Draw out the atoms

2. Draw on the outer shell electrons

3. How many electrons are needed to fill the outer shell?

4. Draw the covalent bonds formed

Finally check everything for a sanity check.
Now we will work through the example of CO_2 on your mini whiteboards.

Dot and cross diagrams independent task

In the spaces provided, **draw dot and cross diagrams** depicting the **covalent bonds** in the following molecules. Remember to use the steps which we have worked through previously to structure your answer.

1. H_2S

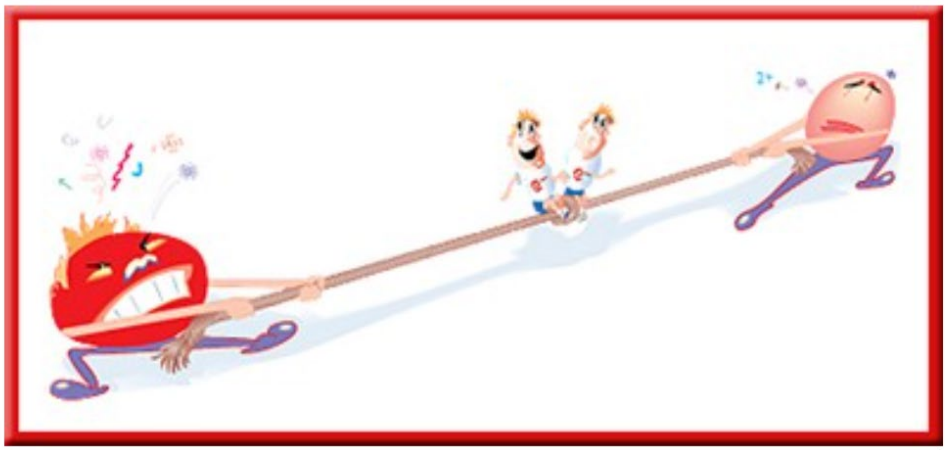
2. H_2CO

3. CH_3CH_3

Notes…

Electronegativity

Imagine that the pair of **electrons** in a **covalent bond** are in the middle of a rope in a tug of war. Now imagine that both **nuclei** in the bond are at each end of the rope…(nuclei is just the plural of nucleus).



Imagine this is our molecule of HCl. What if the Cl nucleus went to the gym every day and so was really strong and muscular? What if the H atom was much smaller and less strong?

Write below what you think would happen to the electrons:

It turns out, we have a name for the 'strength' of a nucleus in how well it does in this tug of war.

Electronegativity- A measure of the ability of an **atom** to attract a pair of **electrons** in a **covalent bond**.

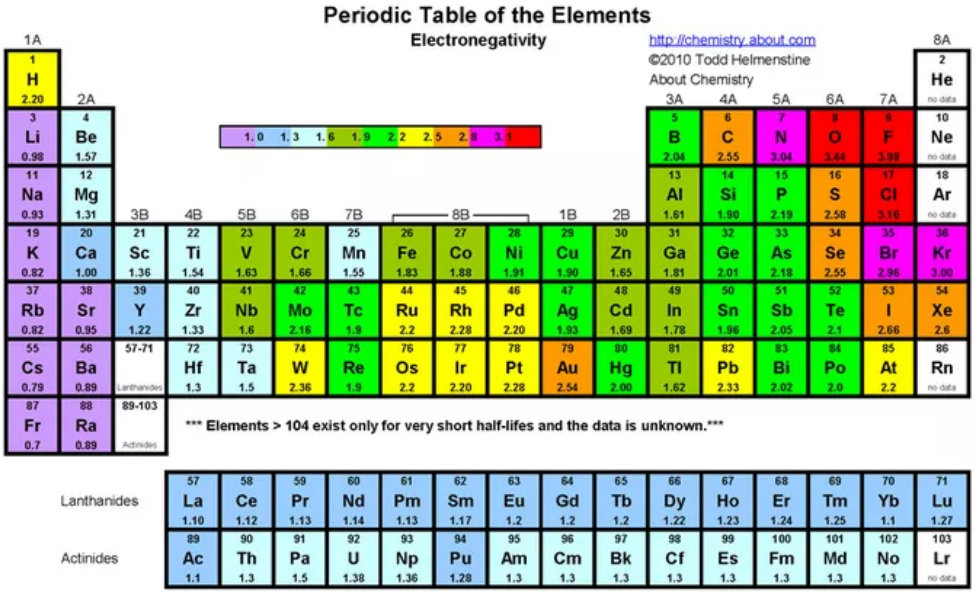
How do we measure **electronegativity**?

We measure **electronegativity** using **the Pauling scale**, first used by the American chemist Linus Pauling.

It gives a number out of **4** for how well each **element** attracts a pair of **electrons** in a covalent bond.

Fluorine is the **most electronegative** and **francium** is the **least electronegative**.

As a general rule…the **top right** of the **periodic table** contains the **most electronegative elements**.



Using the Pauling Scale of Electronegativity

Answer these questions below about electronegativity.

1. Complete the gap in these sentences…

   Fluorine (F) is _____ electronegative than oxygen (O).
   Carbon I is _____ electronegative than sodium (Na).
   Boron (B) is _____ electronegative than nitrogen (N).

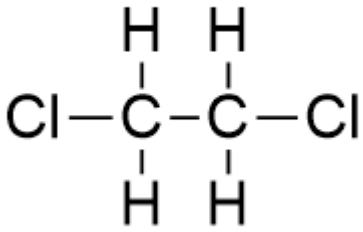
2. Point the direction that the electrons would move within these bonds…

C-H C-Li C-Cl C-C

Notes…

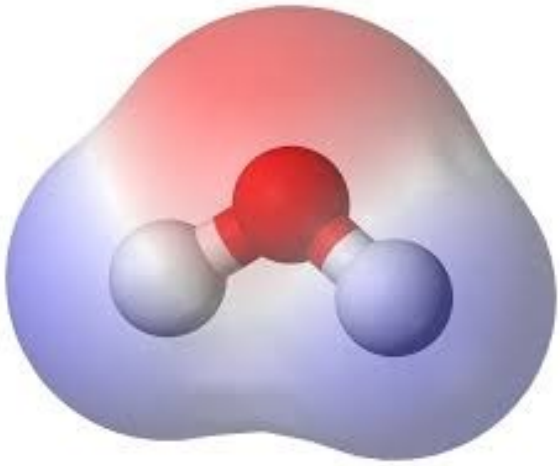
Homework 2-Bonding in Dichloroethane

Dichloroethane is a chemical that is commonly used in the chemical industry and is one I used a lot during my PhD. Below is the structure of dichloroethane.



Draw a dot and cross diagram to show the bonding in dichloroethane. For each of the C-Cl bonds, indicate where the electrons would be positioned in that bond.

Tutorial 3 – Polarity and non-bonding electrons



What is the Purpose of Tutorial 3?

- To assign partial charges to covalent bonds based on the difference in electronegativity between different elements
- To recognise elements that have lone pairs of electrons
- To draw organic compounds using skeletal formulae

Starter Activity

Answer these questions in the first 5 minutes of the tutorial:

1. Are these statements true of false?
   - The second shell of an atom can hold up to 7 electrons.
   - Atoms bond so that they can gain a full outer-shell.
   - A covalent bond is formed by the sharing of electrons in the outer shell.

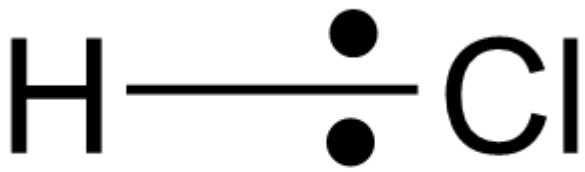
2. Draw a dot and cross diagram to represent the covalent bond formed in hydrogen bromide.

3. What might be the limitation of representing covalent molecules in dot and cross diagrams?

Bond Polarity

In the last tutorial, we discussed **electronegativity** and how the electrons in a **covalent bond** do not always stay in the middle of the bond.

For example, in HCl, chlorine is **more electronegative** than hydrogen, so the pair of electrons are much closer to chlorine.

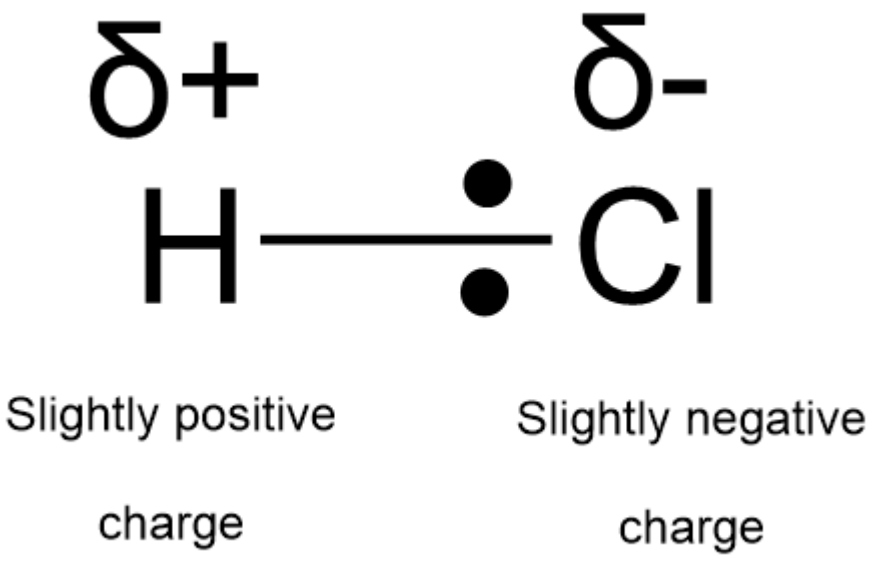


We know that electrons are **negatively** charged.

Q. Do you think that negative charge is evenly spread throughout this molecule? Write your thoughts below.

If the **electrons** are pulled towards chlorine, it will gain a **slightly negative charge**. In turn, hydrogen will gain a **slightly positive charge**. We use the Greek letter δ to mean 'slightly'.

We now say that this bond has **polarity**. The **polarity** of a bond is very important in how it reacts.



Notes…

Bond Polarity Task

For each of these covalent bonds, assign positive and negative charges to the atoms involved.

1. C-O
2. H-I
3. C-N
4. C-H
5. C-C
6. C=O
7. C-Cl
8. C=NH

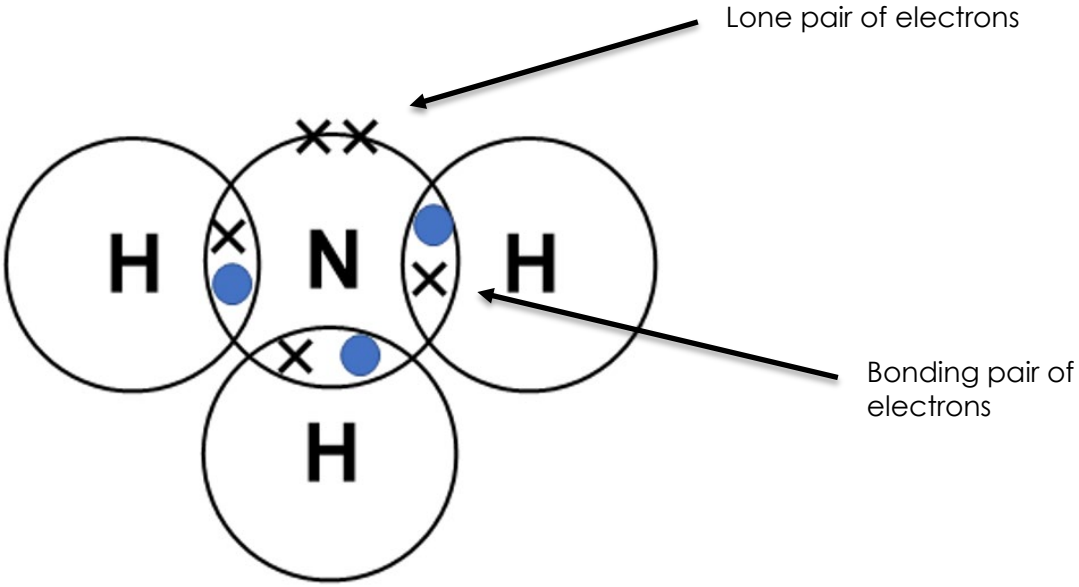
BONUS: If it is a double bond, do you think that gives greater or less bond polarity? Suggest a reason for your answer.

Lone pairs

Ammonia is a covalent molecule that we discussed in the previous tutorial. It has a central nitrogen atom bonded to 3 hydrogen atoms.

Nitrogen has 5 electrons in its outer shell, 3 of these are used up in the covalent bonds and so 2 are left over.

These two **non-bonding electrons** are called a **lone pair**.



Lone pairs are areas of concentrated negative charge in a molecule, and therefore are very important for reactivity.

Lone Pair Task

Sort these covalent molecules into two groups: has a lone pair(s) and doesn't have a lone pair(s). Then decide which atom(s) has the lone pairs.

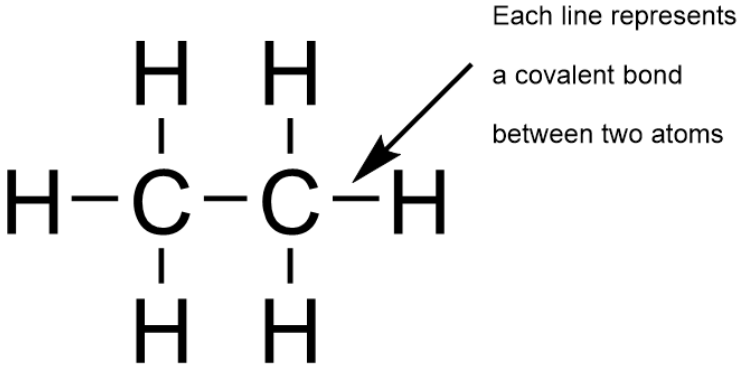
CH_4, H_2O, H_2S, C_2H_5, CH_3Cl

Molecule	Contains a lone pair? (Y/N)	Which atom has the lone pair?

BONUS: How do you think a lone pair might interact with one of the polar molecules we discussed previously?

Skeletal Formulae

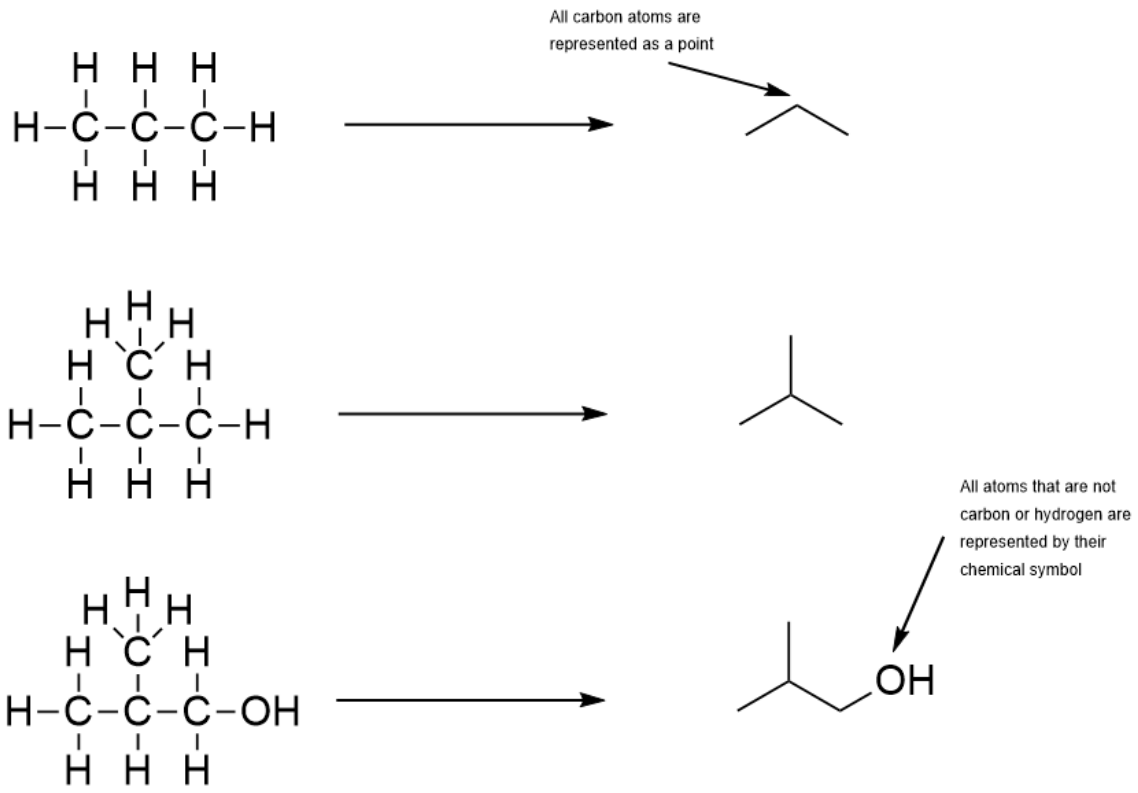
How we represent organic molecules is very important. Up to this point, we have used **structural formulae**, where a line is used to represent a **covalent bond** and the atoms are given their chemical symbol.



Drawing these out can be time consuming so we more often represent molecules using **skeletal formulae**.

Skeletal formulae do not show the carbon and hydrogens and just show the carbon skeleton, where each point is a carbon atom.

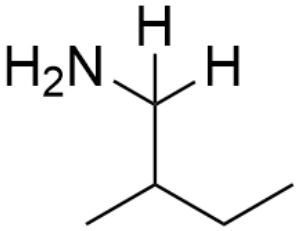
Any other atom is given its chemical symbol.



Common mistakes in skeletal formulae

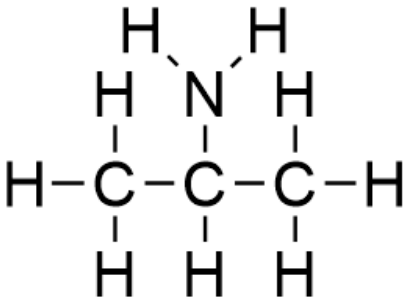
For each of these bad skeletal formulae, write next to the structure what is bad about it. We will work through these together as a class.

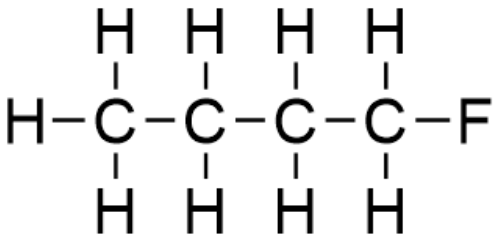
Skeletal formula of methane



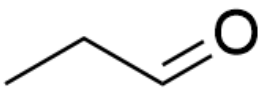
Skeletal formulae independent task

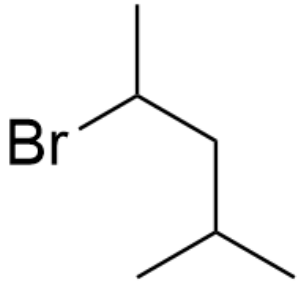
Convert these molecules to skeletal formulae:





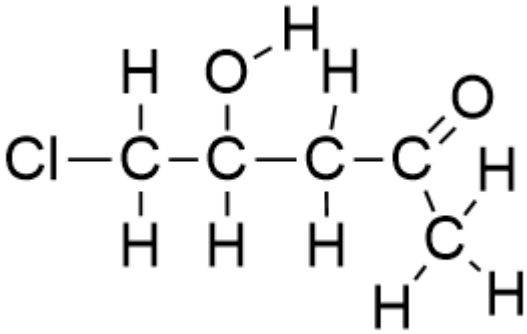
Convert these skeletal formulae to structural formulae:





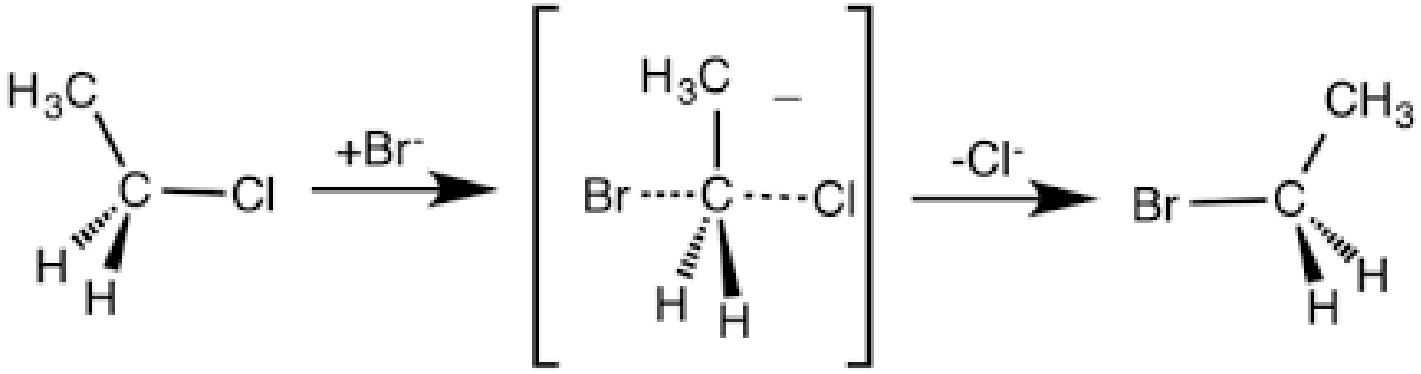
Homework 3-Skeletal Formulae, Lone Pairs and Bond Polarity

Start by drawing this molecule in skeletal formulae.



Next, draw on all of the partial charges and therefore the polarities of each bond.
Draw on all of the lone pairs on the oxygen atoms.
Explain how you think this molecule could react (50 words).

Tutorial 4 – Electrophiles and Nucleophiles



What is the Purpose of Tutorial 4?

- To identify the difference between a nucleophile and an electrophile
- To apply your knowledge of bond polarity and lone pairs to assign different molecules as either a nucleophile or an electrophile
- To describe how a new covalent bond forms between a nucleophile and electrophile

Starter activity

1. Draw a dot and cross diagram for H_2O. Label the lone pairs and the bonding pairs.

2. Assign partial negative and positive charges to the atoms in H_2O. How might these partial charges affect the properties of water?

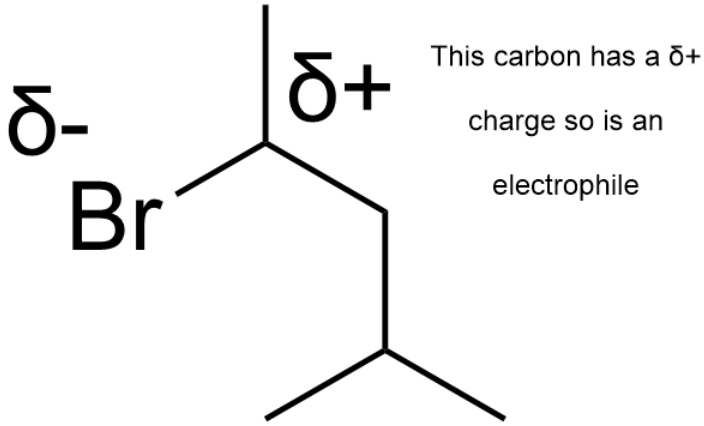
3. Draw Ethanol (C_2H_5OH) in skeletal formula.

Electrophiles vs Nucleophiles

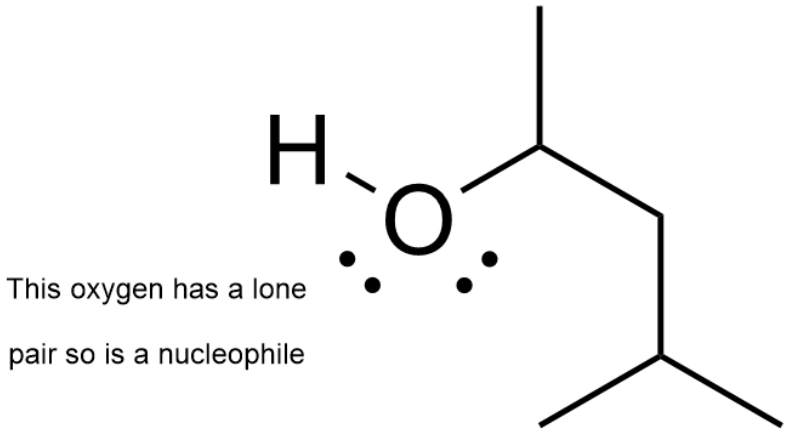
In the last tutorial we discussed the **polarity** of bonds and **lone pairs**. These types of properties can define the **reactivity** of molecules.

We can split molecules into two categories based on how they react, these are called **electrophiles** and **nucleophiles**.

Electrophiles are **electron pair acceptors**. This means they are **positively charged** or have a **δ+ charge**.



Nucleophiles are **electron pair donators**. This means they are **negatively charged** and have a **lone pair of electrons**.



The suffix "phile" means loving, so you can think of nucleophiles as nucleus loving molecules.

Assign these different characteristics as either being that of a **nucleophile** or an **electrophile**.

1. Has a lone pair of electrons
2. Is positively charged
3. Accepts a lone pair of electrons
4. Is negatively charged
5. Donates a lone pair of electrons

Electrophile	Nucleophile

Notes…

Examples of Nucleophiles and Electrophiles

Electrophiles will always have a **δ+ charge** and **nucleophiles** will always have a **lone pair.**

Based on this, decide if the following molecules are **nucleophiles** or **electrophiles**.

HINT-It may help to draw them in skeletal formulae.

H_2O

CH_3Cl

CH_3OH

NH_3

CH_2CO

CH_3COCH_3

^{-}OH

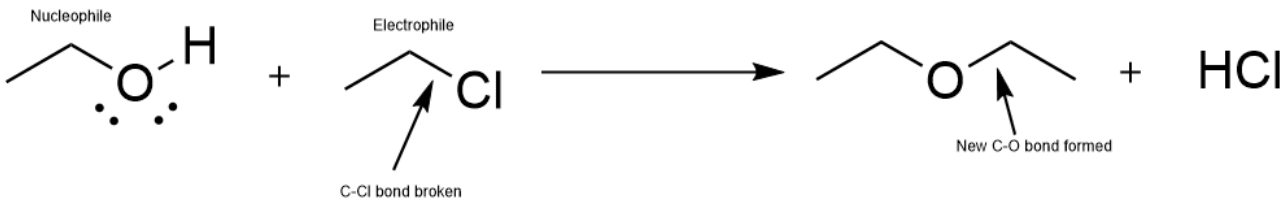
H^+

BONUS: Do you think some of these are stronger nucleophiles/electrophiles than others? If so, decide which ones and give a reason why.

How do Nucleophiles and Electrophiles React Together?

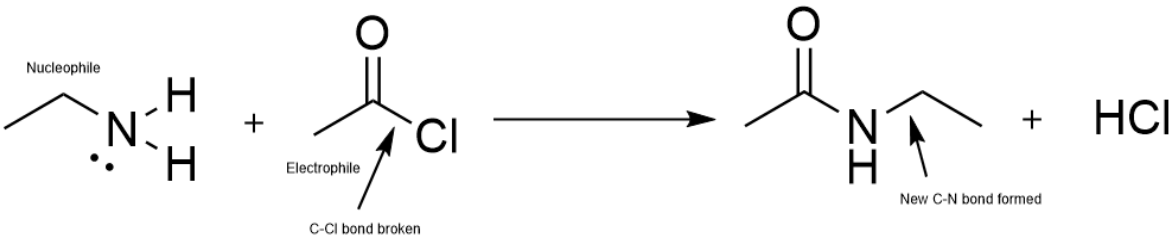
A **nucleophile** is able to donate a pair of electrons to an electrophile. This forms a new **covalent bond**.

However, for this to happen, another **covalent bond** must be **broken** (carbon can only ever form 4 covalent bonds).



In this example, the C-Cl bond is the **electrophile** and the O atom is the **nucleophile**, how do we know this?

The new **covalent bond** is formed between the oxygen and the **δ+ carbon.**



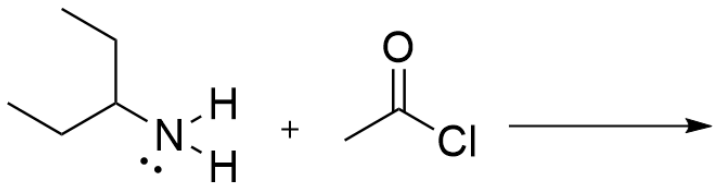
In this example, the new **covalent bond** is formed between the **nitrogen** and the **δ+ carbon** in the **electrophile**.

Which reaction do you think will have a lower activation energy?

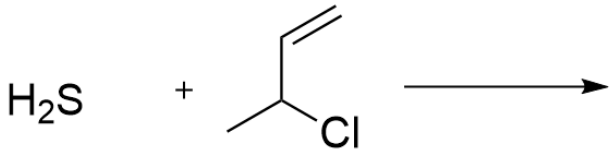
Nucleophile and electrophile reactivity independent task

For each reaction, assign which reagent is the nucleophile and electrophile. Then draw the product and explain how it forms.

1.



2.



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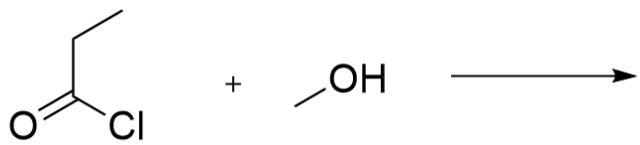
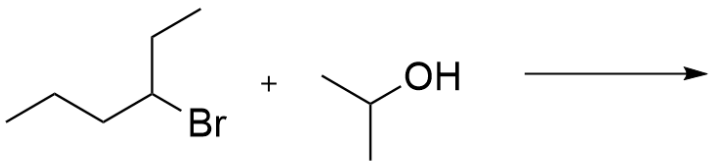


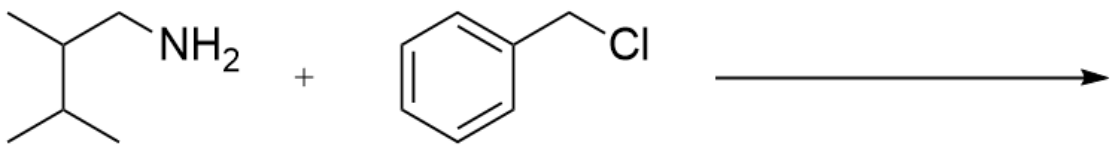
4.



Homework 4-Explaining Organic Reactivity

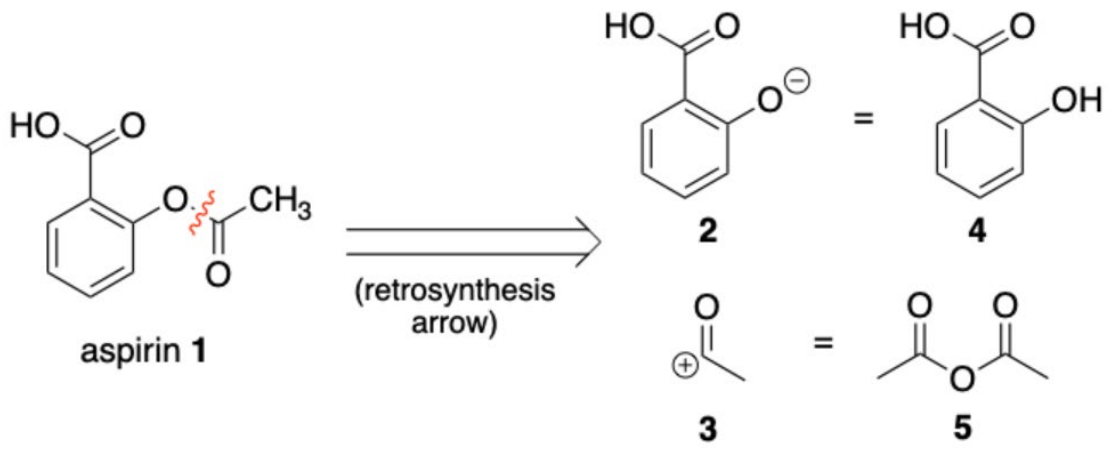
1. Explain the differences between nucleophiles and electrophiles. (30 words)

2. For the following reaction, decide which reagent is a nucleophile, which is an electrophile and the product of the reaction.



Do you think the product can also act as a nucleophile? Could this pose a problem in the reaction? Explain your answer (30 words).

Tutorial 5 – Retrosynthesis



What is the Purpose of Tutorial 5?

- To discuss the difference between a forward synthesis and a retrosynthesis
- To plan a retrosynthesis that includes plausible chemical steps
- To critique the choice of certain synthons and particular synthetic steps

Starter activity

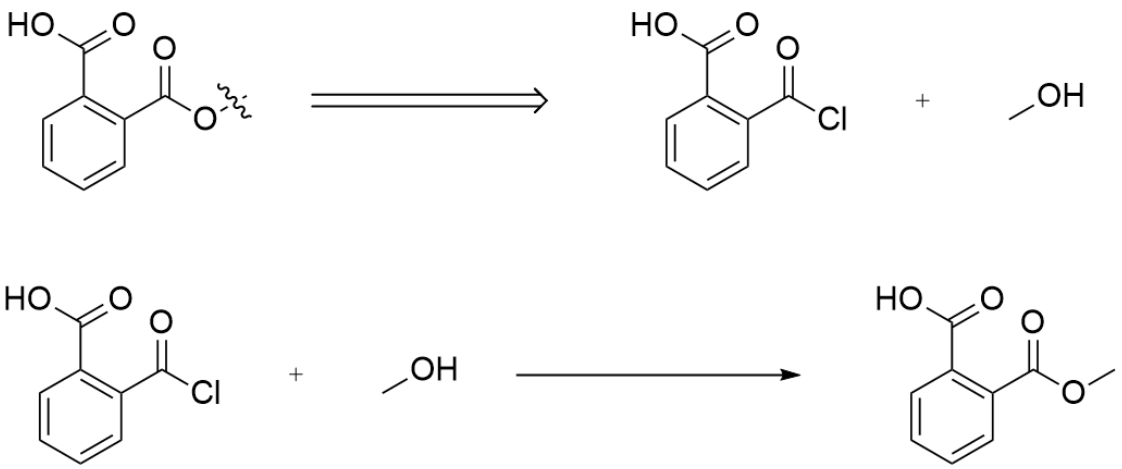
1. Assign which one of NH_3 and CH_3Cl is a nucleophile and which is an electrophile.

2. Explain why in each case.

3. Draw the reaction between NH_3 and CH_3Cl, labelling the bond breaking and bond forming in each case.

Retrosynthesis vs Forward Synthesis

Think, pair, share
What is the difference between the two representations of the same reaction?



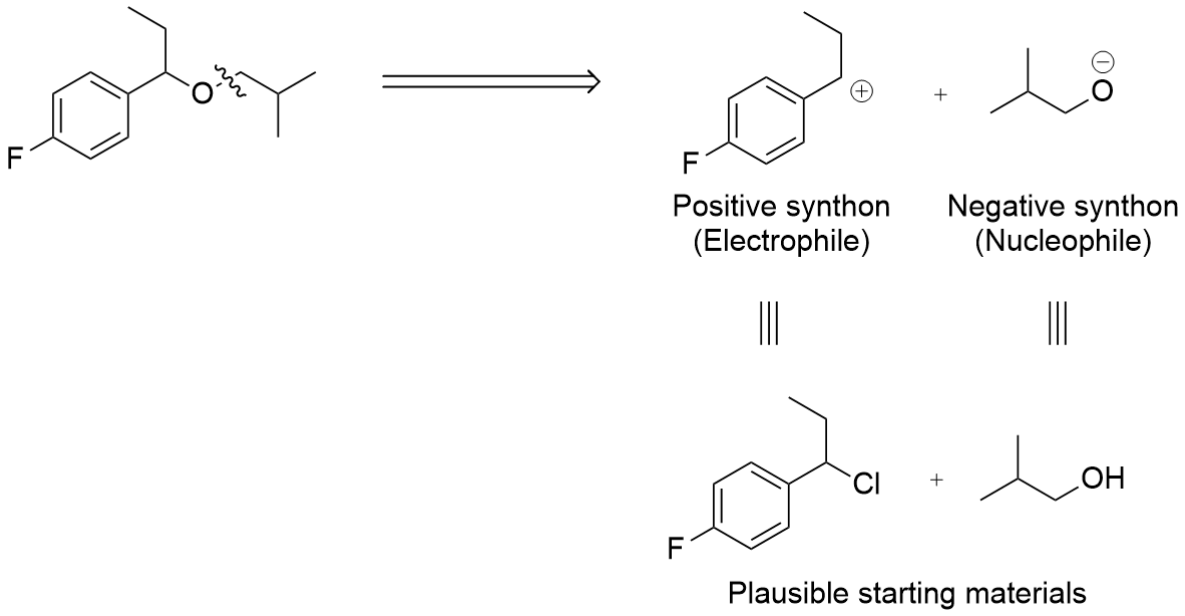
Notes…

Retrosynthesis is a way that organic chemists work out how to make complex molecules.

We take our end product and break the bonds that might need to be made, these are called **disconnections**.

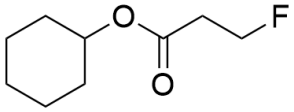
The parts that we break it up into are called **synthons**.

These **synthons** can then be transferred into **plausible starting materials**.

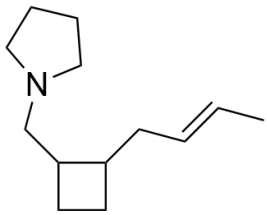


How do we construct a retrosynthesis?

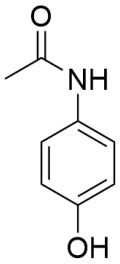
Look at how I construct this retrosynthesis on the board…



The next one we will go through together…

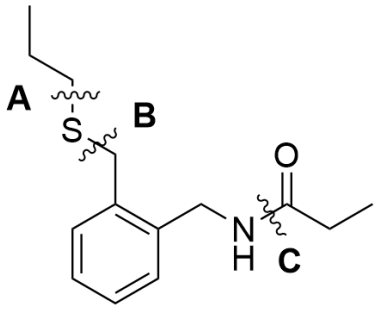


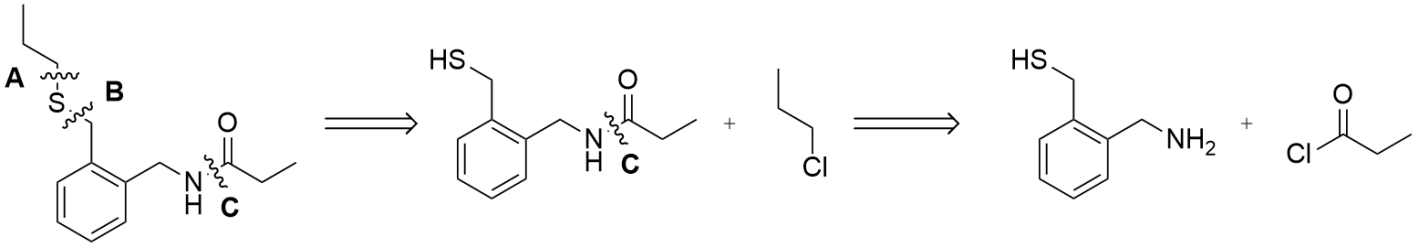
Try this one on your own…



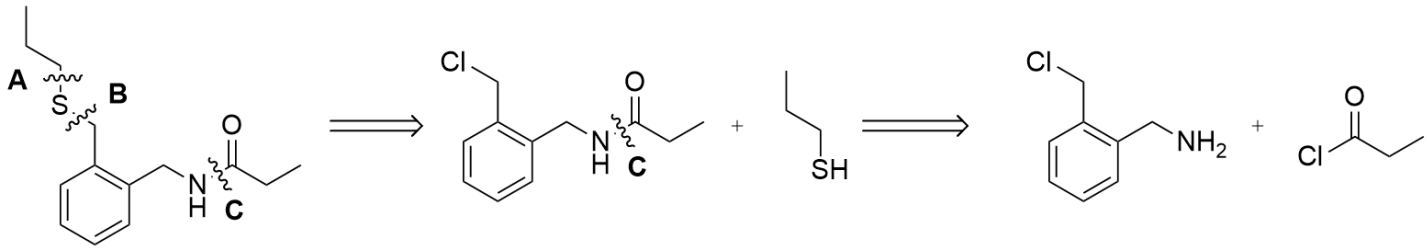
Good and Bad Choices of Disconnections

Have a look at the following options for disconnections, which one of **A**, **B** or **C** would be the best disconnection?



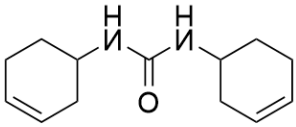


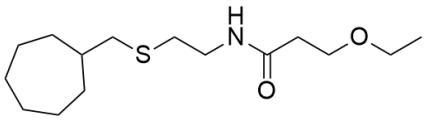
If we disconnect at **A** first, we are left with a starting material with two nucleophiles in it, and no way of knowing which one would react with this electrophile. This would be a **bad** choice for a disconnection.



Now we've made our first disconnection at **B**, you can see that we end up with plausible starting materials that we know how they will react. This is an example of a **good** choice of a disconnection.

Give a retrosynthesis and a forward synthesis for the following molecules.

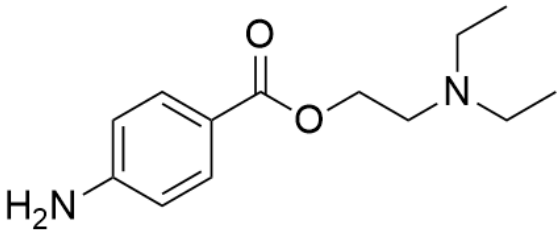




Notes…

Homework 5-Final Assignment

The local newspaper has recently reported on a contamination of drinking water with the drug Procaine, likely from the local chemical manufacture facility. Given that Procaine has been linked to negative side effects, there has been understandable concern amongst the community. Your chemistry teacher has just taught you a module on organic chemistry and wants you to use the example of Procaine to explain what you have learnt.



Procaine

How does the bonding within Procaine affect its properties and how would you propose to make it from readily available starting materials? (2000 words)

The assignment should be spilt into 4 parts, with each part consisting of approximately 500 words.

1. An introduction into organic chemistry and how it is used in the pharmaceutical industry, followed by a brief background into Procaine itself.
2. An explanation of the type of bonding between the different elements in Procaine, a definition of electronegativity and how it affects the polarity of each bond. You should include a dot and cross diagram of single and double covalent bonds.
3. A retrosynthesis and a forward synthesis of Procaine, detailing suggested reagents and a justification for your reasoning. You will need to identify in each reaction what is acting as the nucleophile and as the electrophile.
4. A conclusion of your explanations.

You will find it useful to use diagrams and correct scientific vocabulary to support your explanations throughout.

You will need to do some background research into Procaine itself, considering the chemical structure and side effects that might occur when using the drug. Then use the knowledge you have learnt during the course to write your assignment using Procaine as the example.

You must cite any sources from where you have gathered information to support your answers.

Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on your final assignment
- To respond to the feedback from your Uni Pathways teacher
- To write targets for improvement on your final assignment

Final assignment feedback from your Uni Pathways Teacher

(Remember to look at the mark scheme to help you understand what you have done well so far, and how you can do even better in your final assignment)

Here are three things that my Uni Pathways Teacher thought I did well in my draft assignment
•   •   •

Here are three things that my Uni Pathways Teacher thinks that I could do to get a higher mark in my final assignment
•   •   •

Tasks from my Uni Pathways Teacher to do during the feedback tutorial to help me improve
•   •   •
My response:

Actions I will take to improve my final assignment after this tutorial…
•   •   •

Hand in date for my final assignment:	

Tutorial 7 – Final tutorial

What is the Purpose of Tutorial 7?

- To receive feedback and a grade on your final assignment.
- To reflect on the programme including what you enjoyed and what was challenging.
- To ask any questions you may have about university.

Final assignment feedback from my Uni Pathways Teacher

Final mark:	University style grade:
Feedback: Here are three things that my Uni Pathways teacher thought I did well in my final assignment • • •	

Here are three things that my Uni Pathways teacher thinks I should remember for when I am doing this kind of study in the future
• • •

University

What questions do you still have about University after taking part in Uni Pathways?
•   •   •

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should you use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Notes

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