Researchers in Schools

Chemicals: Characterising Compounds

Key Stage 3 Programme

Pupil Name	
Coursebook Designed by	Dr. S. Malik

Contents

Timetable and Assignment Submission 1
Timetable – Tutorials 1
Timetable – Homework Assignments 1
Assignment Submission – Lateness and Plagiarism 1
Course Rationale 2
Uni Pathways Mark Scheme 2020 – science-based assignments 3
Baseline Assignment (essay based): Pupil Feedback Report 5
Final Assignment (problem-set): Pupil Feedback Report 6
Subject Vocabulary 7
Tutorial 1 – Importance of purity 8
What is the Purpose of Tutorial 1? 9
Tutorial 2 – Introduction into organic chemistry and functional groups 14
What is the Purpose of Tutorial 2? 14
Tutorial 3 – Introduction to spectroscopic analysis of compounds – Infra-red (IR) spectroscopy 17
What is the Purpose of Tutorial 3? 17
Tutorial 4 – Mass of a substance 22
What is the Purpose of Tutorial 4? 22
Tutorial 5 – Debate on a scientific law 26
What is the Purpose of Tutorial 5? 26
Tutorial 6 – Feedback tutorial 30
What is the Purpose of Tutorial 6? 30
Final assignment feedback from your Uni Pathways Teacher 30
Tutorial 7 – Final tutorial 32
Appendix 1 – Referencing correctly 34
How do I reference? 35
Notes 36

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		
Tutorial 3		
Tutorial 4		
Tutorial 5	Final assignment	

Assignment Submission – Lateness and Plagiarism

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

Course Rationale

Welcome Year 9 pupils!

During this course we will be looking at chemical compounds in more detail. This will include looking at how to calculate the masses from formula and be able to characterise structures using two spectroscopic analysis techniques – mass spectrometry and infra-red spectroscopy. These techniques you will see in more detail at A-level and laboratories at undergraduate, graduate level and beyond.

We will learn how to assign structures using the spectral data obtained from these techniques. Together, we will hold a no-doubt fascinating and engaging debate about animal testing and its importance in research. Finally, we will be researching current scientific affairs, such as the current global problem caused by the coronavirus (COVID-19).

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

Final 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*

Subject Vocabulary

Word	Definition	In a sentence
Organic	In chemistry, describes chemicals that contain the element Carbon	
Pure	A substance not mixed with anything else	
Spectroscopy	The study of the way matter absorbs or sends out light and other radiation (= energy from light or heat that you cannot see)	
Functional group	A group of atoms that gives a chemical compound its characteristics, such as the ability to react with particular substances	
Alcohol	Alcohol is also of a group of similar chemical substances used as solvents (= substances that dissolve others) and in fuel and medicines	
Carboxylic acid	An organic acid (= one containing carbon) that contains a carboxyl group, for example acetic acid or formic acid	
Ester	A chemical compound produced by a reaction between an acid and an alcohol, in which the hydrogen of the acid has been replaced by an alkyl group of atoms	

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 – Importance of purity

What is the Purpose of Tutorial 1?

To understand the importance of purity of drugs.

By the end of this tutorial, you should be able to:

- Define the term pure, drug.
- List three of the methods of separation used in laboratories.
- Name the analytical techniques used to characterise compounds and can be used to determine purity.
- Defend the importance of purity, specifically in the drug development process, with examples.

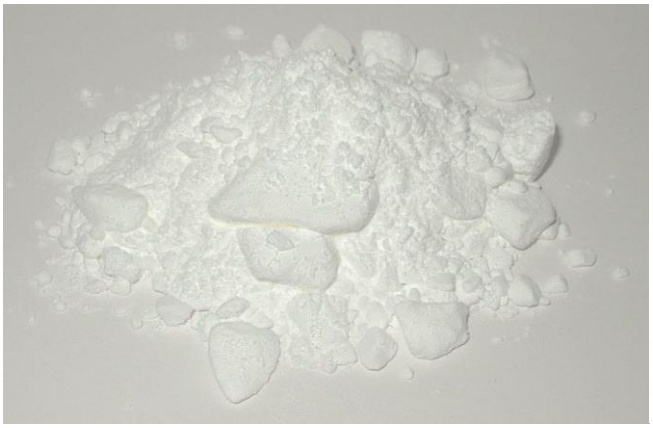
Popular hot drinks, such as coffee and some tea, contain a powerful stimulant called caffeine, a go-to drink for people to have to wake up and feel alert.

The amount of caffeine varies in drinks:

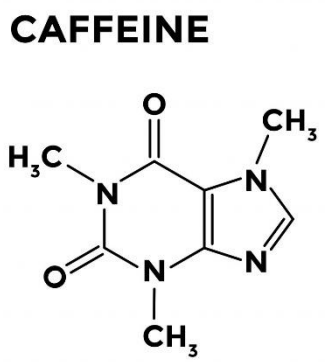
- 1 mug of filter coffee – 140mg caffeine
- 1 can of energy drink – 80mg caffeine
- 1 mug of tea – 75mg caffeine
- Small bar of chocolate – 25-50mg caffeine

If we were to design a new energy drink for teenagers to help them be more alert and stimulated to learn, how much mass of caffeine would you think is suitable?

If we wanted to **design** an energy drink with enough caffeine to give the desired stimulatory effect, how do we get pure caffeine (this would be **extracted** from a natural source like coffee beans or tea leaves and **purified**)? Or if we know the chemical structure of the compound – it's mass and **functional groups** – this can also be **synthesised**.



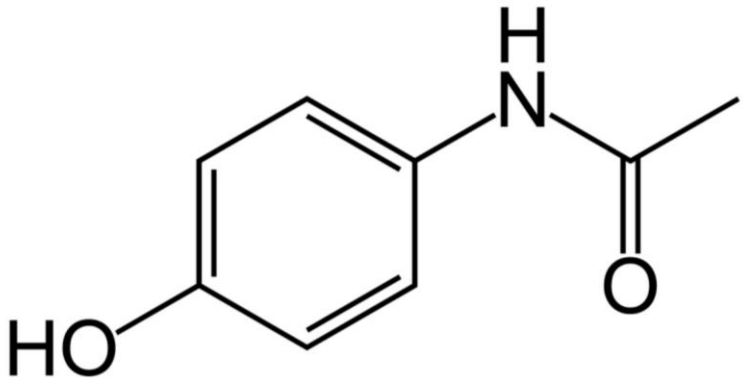
Pure caffeine is a white powder



Chemical structure of caffeine

A pure substance is one made of only one substance; examples around us include:

Salt (Sodium chloride - NaCl)



Synthetic drugs - paracetamol

Activity
Think – pair – share

As a pair assign which substances are pure and which are a mixture. Mark with a tick in the column you are choosing and be prepared to share with the group.

Pure or a mixture	Pure	Mixture
Carbon dioxide gas		
Air		
Water		
Iron		
Steel		
Steam		

What physical property is measured in compounds to determine its purity?

List three points on why purity is important in the drug discovery process and be prepared to share your answer with the rest of the group.

What analytical techniques can be used to determine if a compound is pure?

Explain why the drug thalidomide is not used to treat morning sickness in pregnant women today.

Homework: Baseline Assignment

The World Health Organization declared a global pandemic of coronavirus disease in March 2020 due to a novel virus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The management of the spread of infection involves scientists around the world discovering vaccines, antimicrobial drugs and rapid detection kits.

When a chemist is designing a synthetic plan for a new antimicrobial drug discovered against SARS-CoV-2 named DRUG X, she states 'most important factors of a novel final product is its purity and its yield.

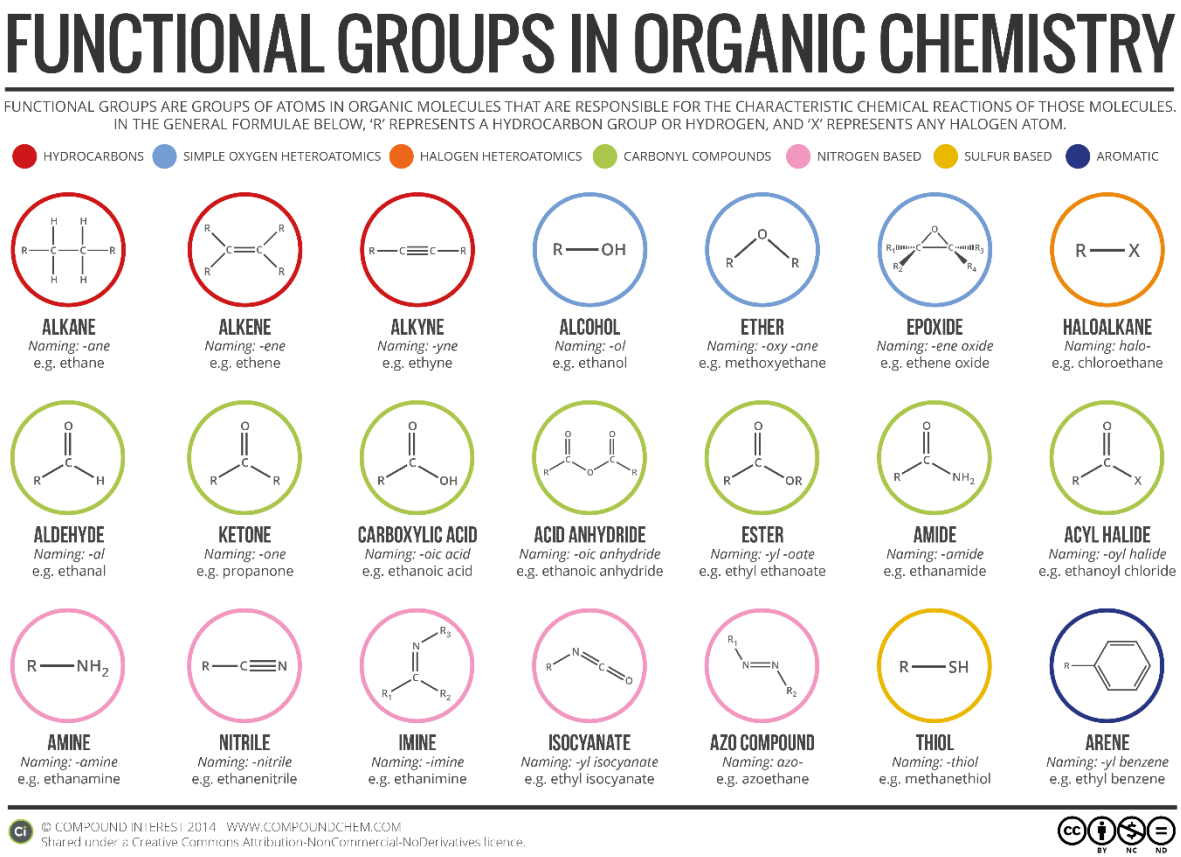
Do you agree with this statement? Give reasons for your answer.

Your answer should be 300-400 words in length, and should include:

a) What does it mean to have a pure substance and give 3 examples of pure substances? (20 marks)
b) List the different techniques that could be used to resolve a mixture of compounds or solvents and give examples. (40 marks)
c) State the implications of administering/taking an impure medicinal drug on a patient and give an example in history. (20 marks)
d) Conclusion: Do you agree with the chemist and explain your reasons why? (20 marks)

Write using paragraphs, use subject specific vocabulary, and correct spelling and grammar.

Tutorial 2 – Introduction into organic chemistry and functional groups



What is the Purpose of Tutorial 2?

To look at the chemical structure of drugs around us and be introduced to structure elucidation.

By the end of this tutorial, you should be able to:

- Define the term 'organic'.
- Recognise different organic functional groups.
- Describe 3 uses for organic compounds.
- Determine which analytical techniques can be used to determine if a compound is pure.
- Describe the importance of purity in organic compounds.

'Organic' is a term you may have seen before possibly in supermarkets on food labels or when hearing or reading about farming. In chemistry, 'organic' means any compound that is Carbon-based and attached to other elements: Oxygen, Nitrogen, Sulfur, Hydrogen or Phosphorus. Organic compounds are found both naturally and synthetically.

Where is Carbon on our periodic table and how many bonds can it make?

Give three organic compounds and their uses.

Five of the functional groups we will be looking to analyse through this booklet:

Name	**Functionality**
Alcohol	
Carboxylic acid	
Ester	
Carbonyl group	
Hydroxyl group	

What analytical techniques can be used to determine the structure of a compound?

Can the analytical techniques you have listed above determine purity? (Think, pair, share.)

Homework

Will be assigned on the day

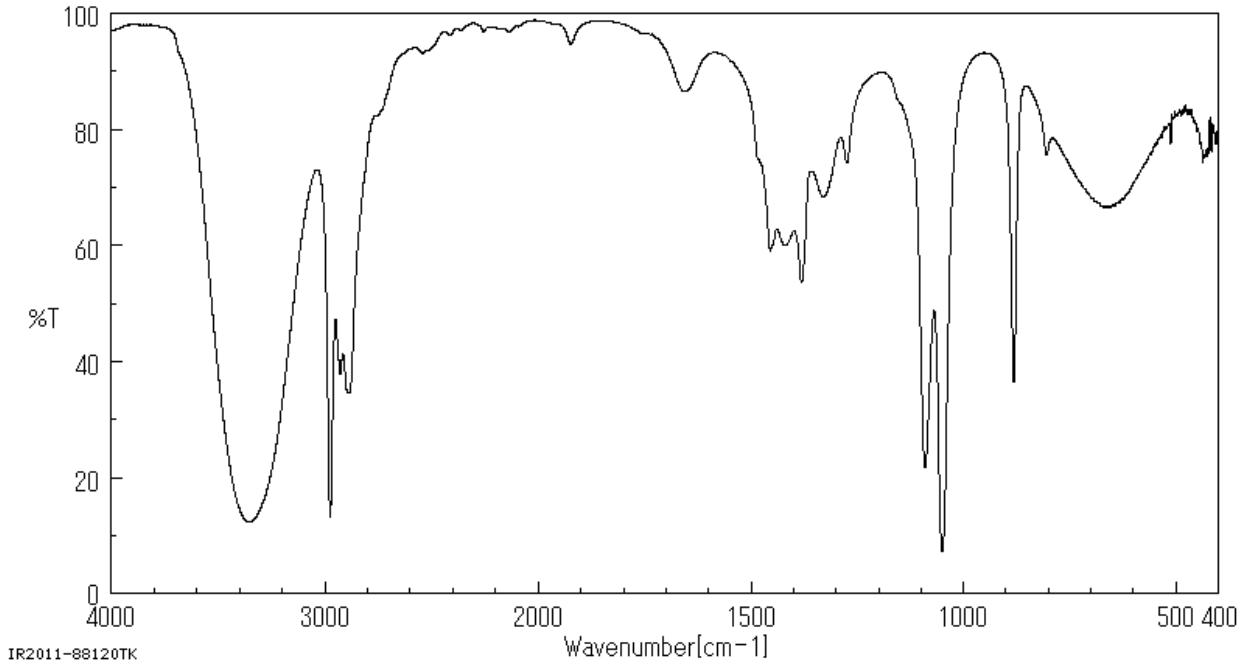
Tutorial 3 – Introduction to spectroscopic analysis of compounds – Infra-red (IR) spectroscopy

What is the Purpose of Tutorial 3?

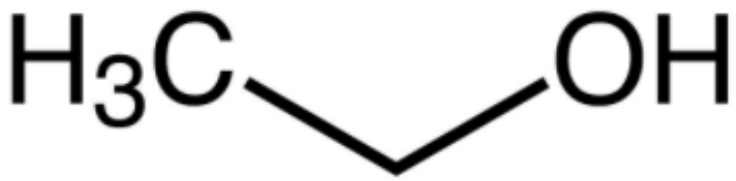
Tutorial 3 will be introducing an analytical technique, IR spectroscopy, and briefly describe how it works to give us a spectrum, essential to characterise a compound. We will then move on to characterising compounds using spectral data.

By the end of this tutorial, you should be able to:

- Briefly describe how an IR spectrometer works.
- Know that each main functionality in a compound interacts differently with IR beam passing through the sample.
- Characterise compounds using their spectral data.
- Assign functional groups to different peaks.



IR spectrum for compound ethanol



Chemical structure of the compound ethanol

What is the fingerprint region?

Assign the following spectra to the compounds listed:

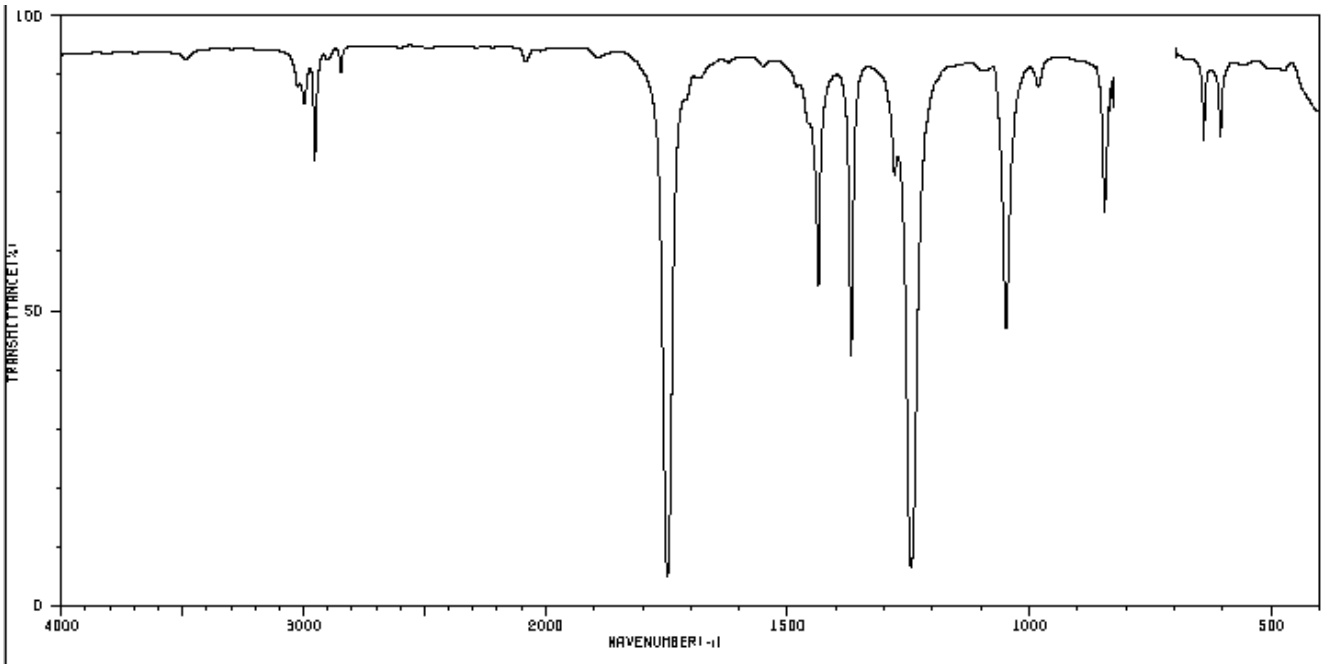
What does characterising a compound mean?

What is a functional group?

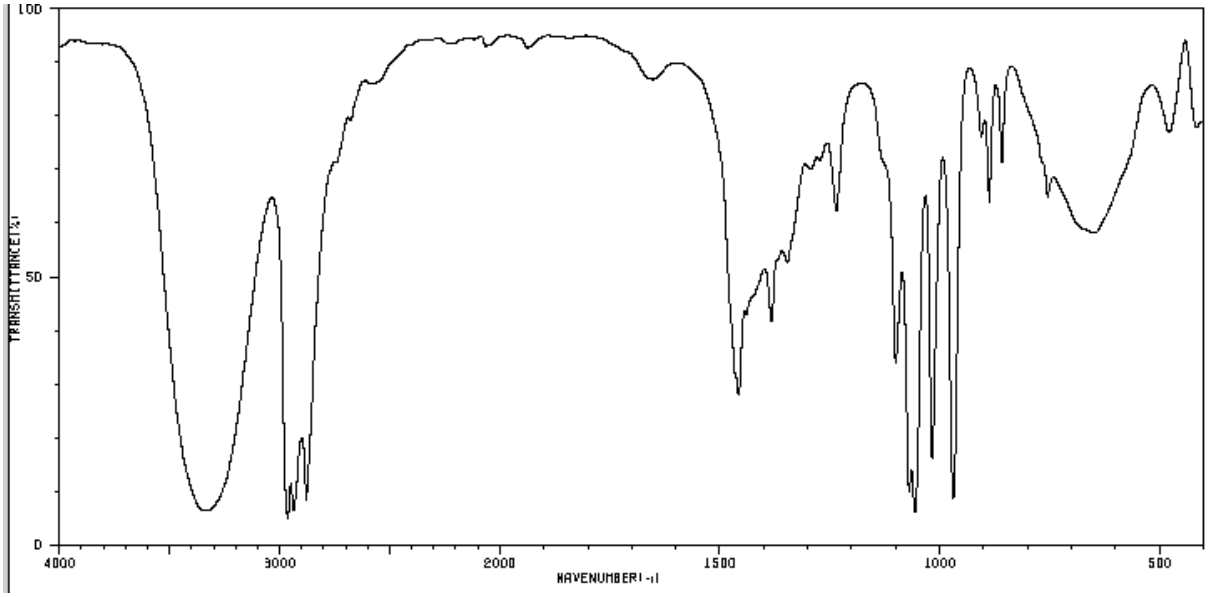
Functional group	Chemical structure
Carboxyl group	
Alcohol	
Amino	
Alkyl	
Carbonyl group	

Describe with a diagram or with sentences how an IR spectrometer works.

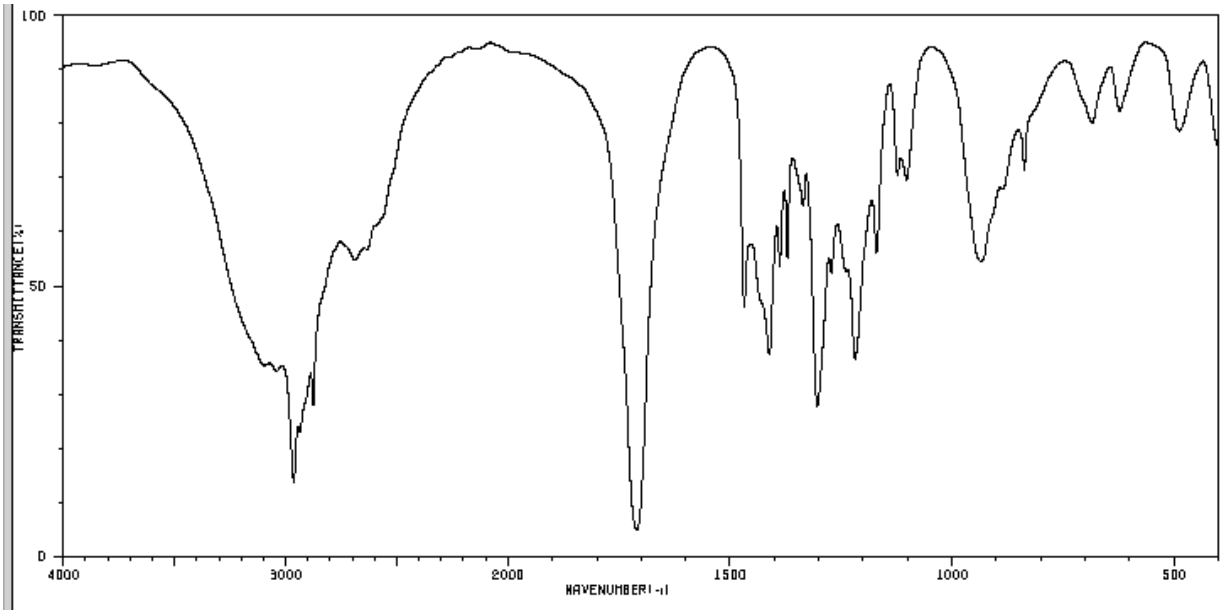
Assign the following three IR spectrums to the three different compounds. (Hint: Look out for any obvious peaks and assign to a functional group using the data tables.)



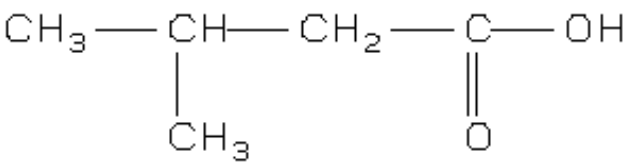
Spectrum 1

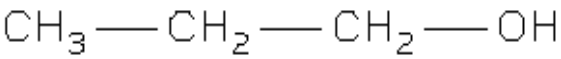


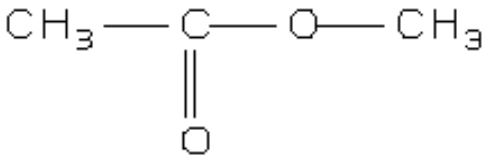
Spectrum 2



Spectrum 3







A

B

C

Assign structure A, B or C to Spectra 1,2 or 3

Homework: IR spectrometry peaks

Will be assigned on the day

Tutorial 4 – Mass of a substance

What is the Purpose of Tutorial 4?

Tutorial 4 will be introducing an analytical technique called 'Mass Spectrometry' and briefly describe how it works to give us a spectrum, essential to characterise a compound. We will then move on to characterising compounds using spectral data.

By the end of this tutorial, you should be able to:

- Briefly describe how a mass spectrometer works.
- Assign a final mass with a compound using mass spectrometry.

Mass of amount of material in an object – reported in the SI unit of kg

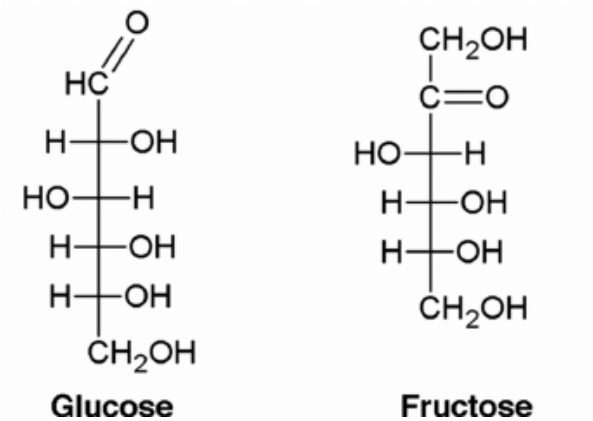
So, the mass of the strawberries on the scales is 0.146 kg

However, as chemists, we are able look at the mass at a more atomic level. If we look at the periodic table, we can see **relative atomic masses** assigned to each element. If we know the structure of the sugars found in strawberries, we can assign a **relative formula mass** to it and determine a more accurate mass for a specific compound in strawberries.

Any mass taken for an element from the periodic table has the unit g/mol.

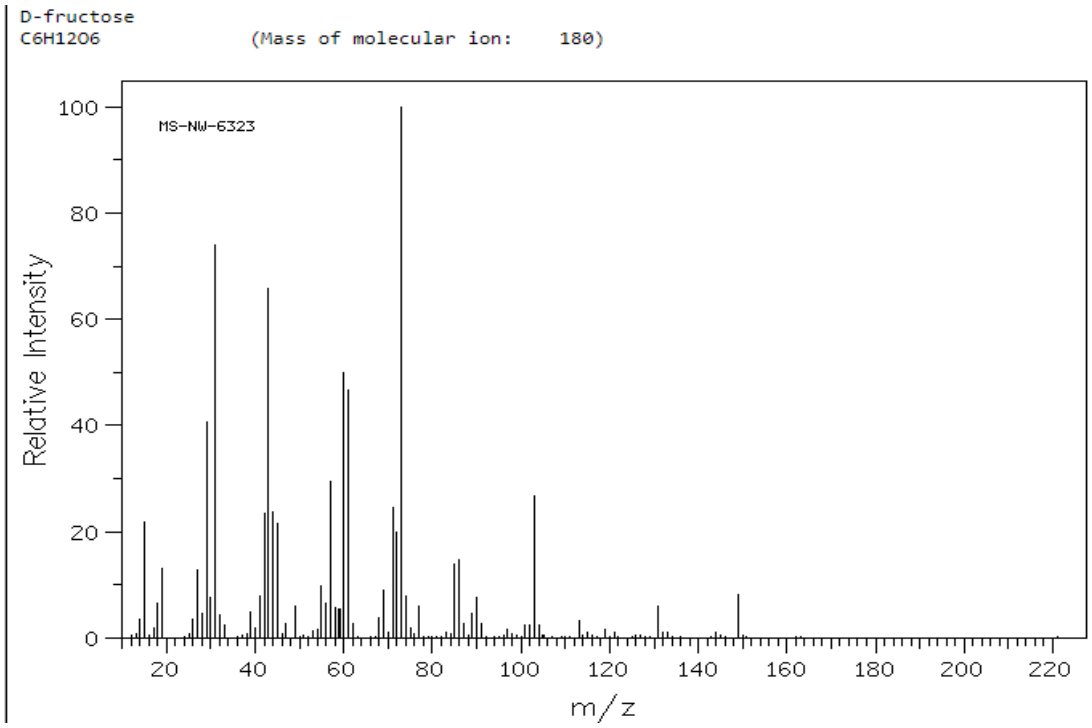
Element	Relative atomic mass (g/mol)
C	
H	
N	
O	
S	

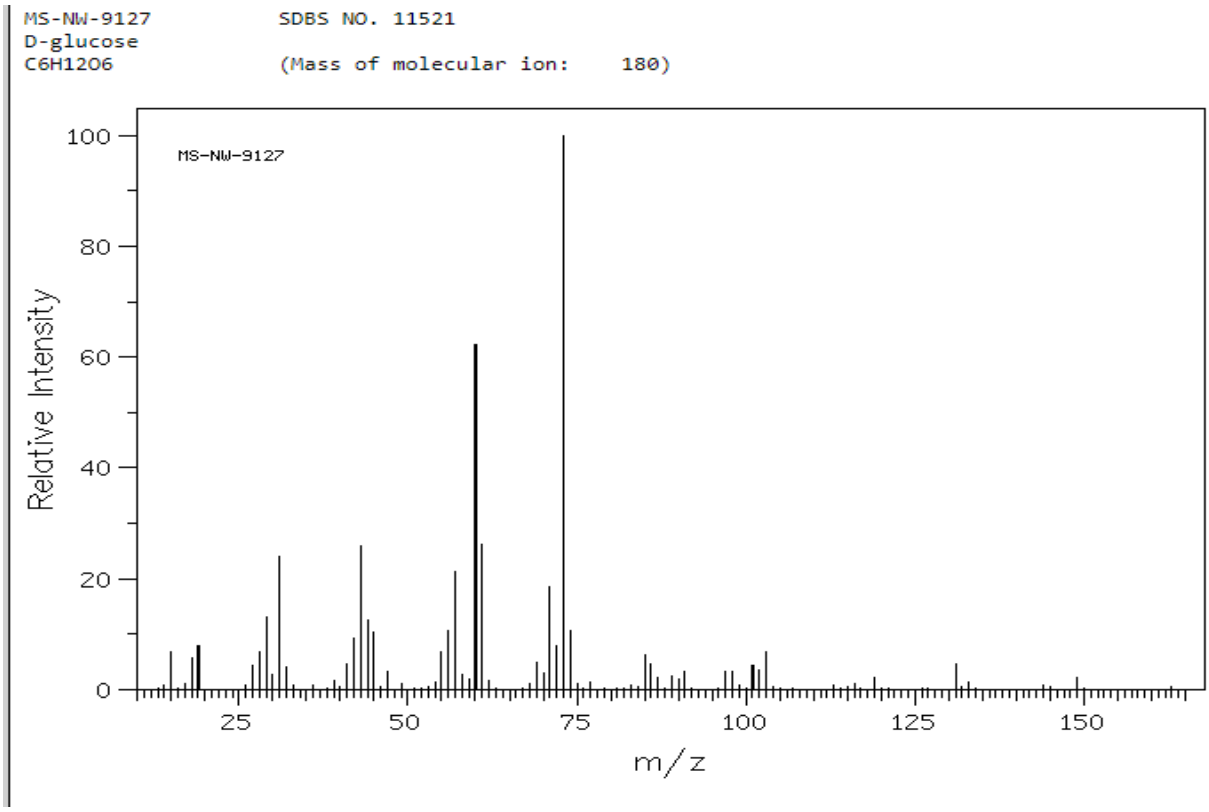
Compound	Relative formula mass (g/mol)
CO2	
H2O	
C6H5N3	
C8H16	
C8H18	



Linear structure of sugars glucose and fructose

Sugar found in strawberry	Relative formula mass (g/mol)
Glucose	
Fructose	





Having looked at the mass spectra above, can we distinguish between glucose and fructose?

How can we distinguish between them?

Homework: Mass spectrometer peaks

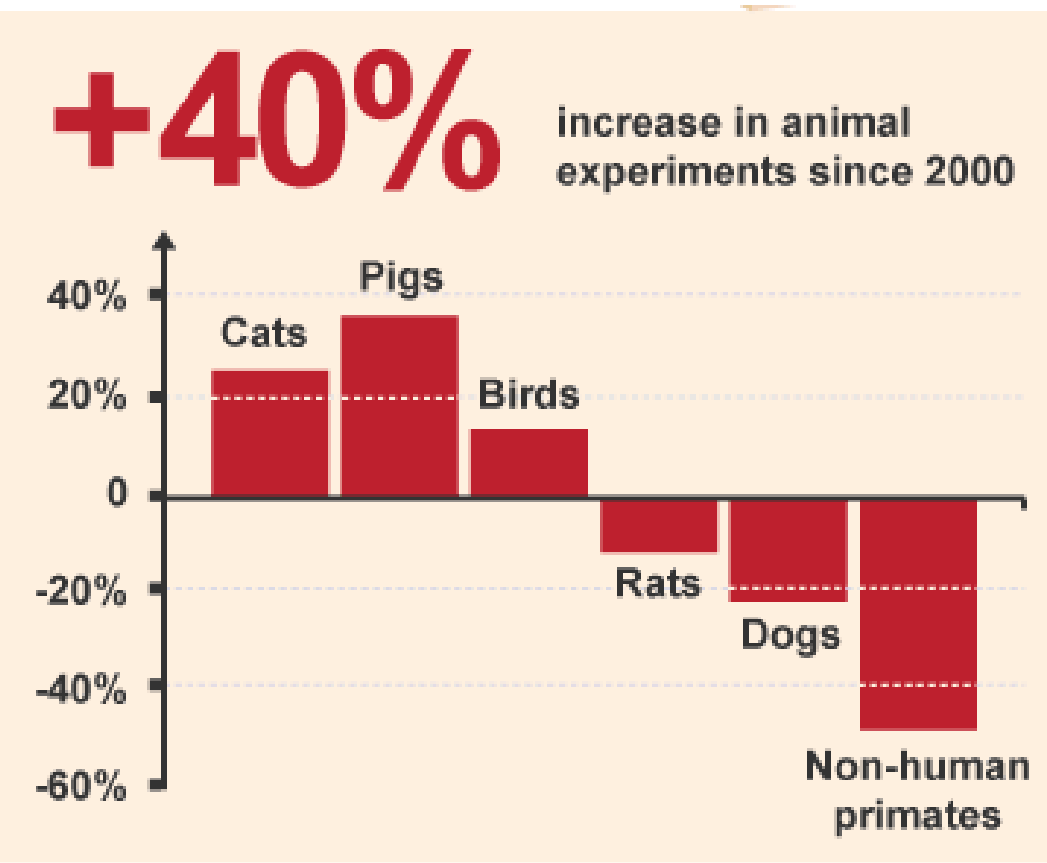
Will be assigned on the day

Tutorial 5 – Debate on a scientific law

What is the Purpose of Tutorial 5?

To raise our scientific capital and be able to form opinions on current scientific affairs, giving your own opinion is necessary when evaluating anything after careful consideration of views for or against an argument.

The law currently allows animals to be used in biomedical research and product testing. However, after 1998 the law stated that animal testing was banned for cosmetics, toiletries, and banned for testing of household products after 2015.



Using the thalidomide disaster and the class reader as points of reference, are you **for or against** animal testing?

List points for why we need a model for testing new drugs and why animal testing is, therefore, needed.

List points against animal testing.

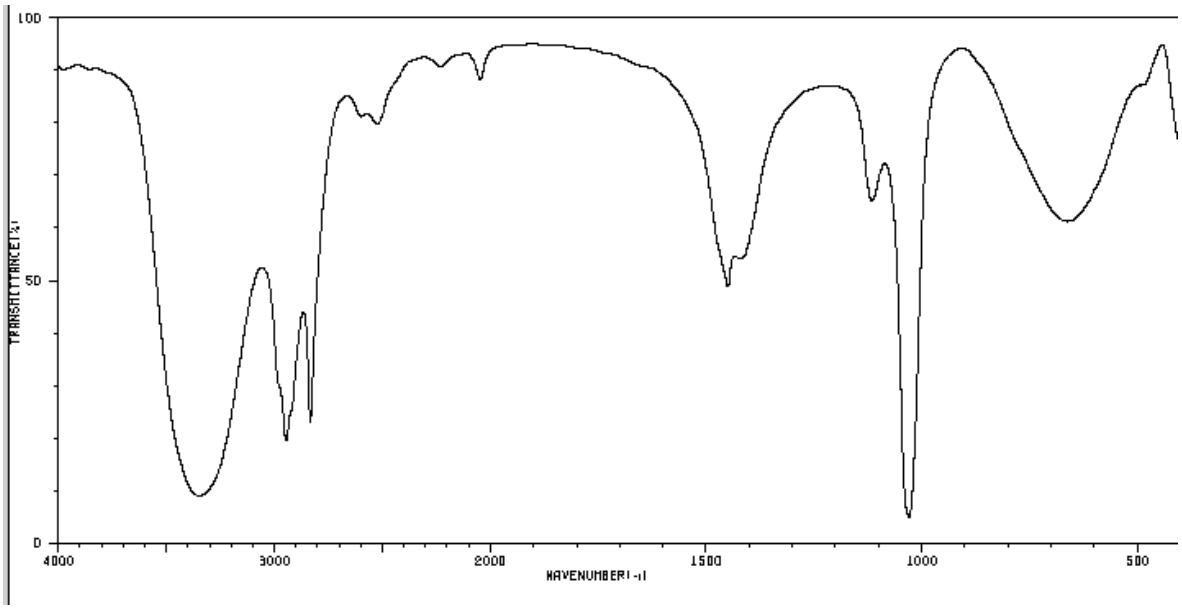
What is your opinion on this matter?
Which group resonates with you more, and why?

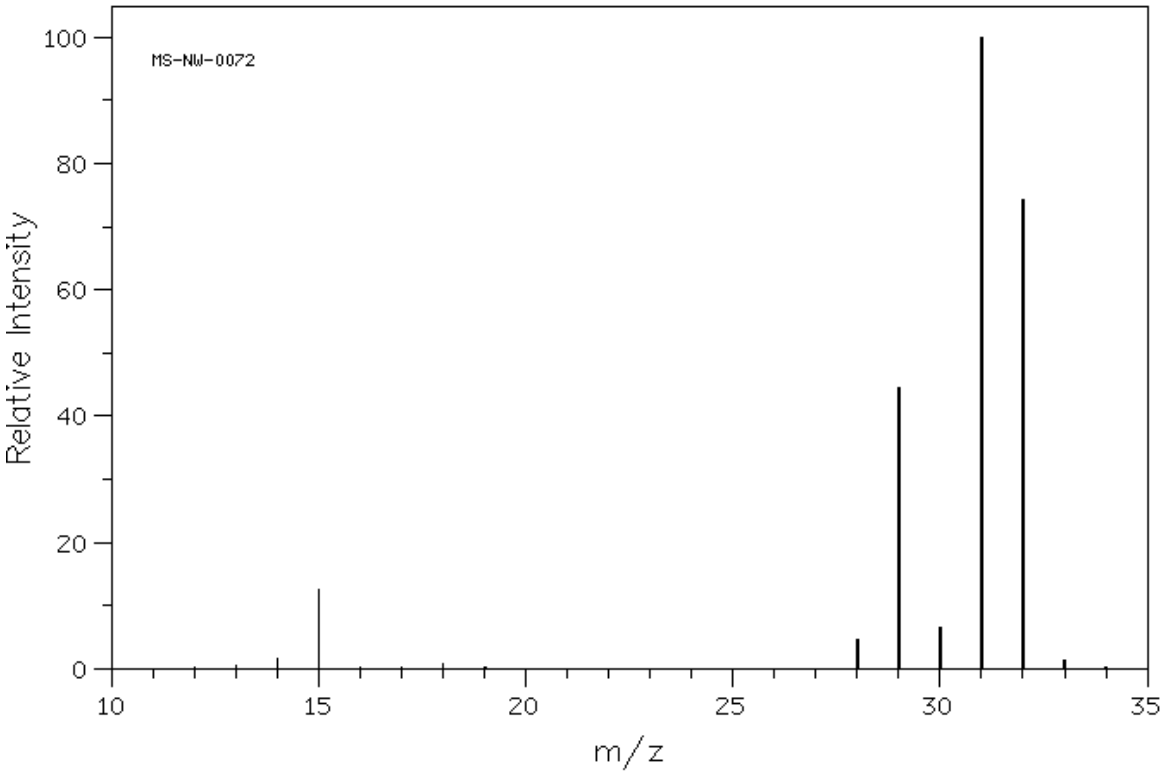
Homework: Final Assignment

The attached spectra is of a simple compound used in anti-freeze. The process used to assign this compound is also needed to assign novel compounds.

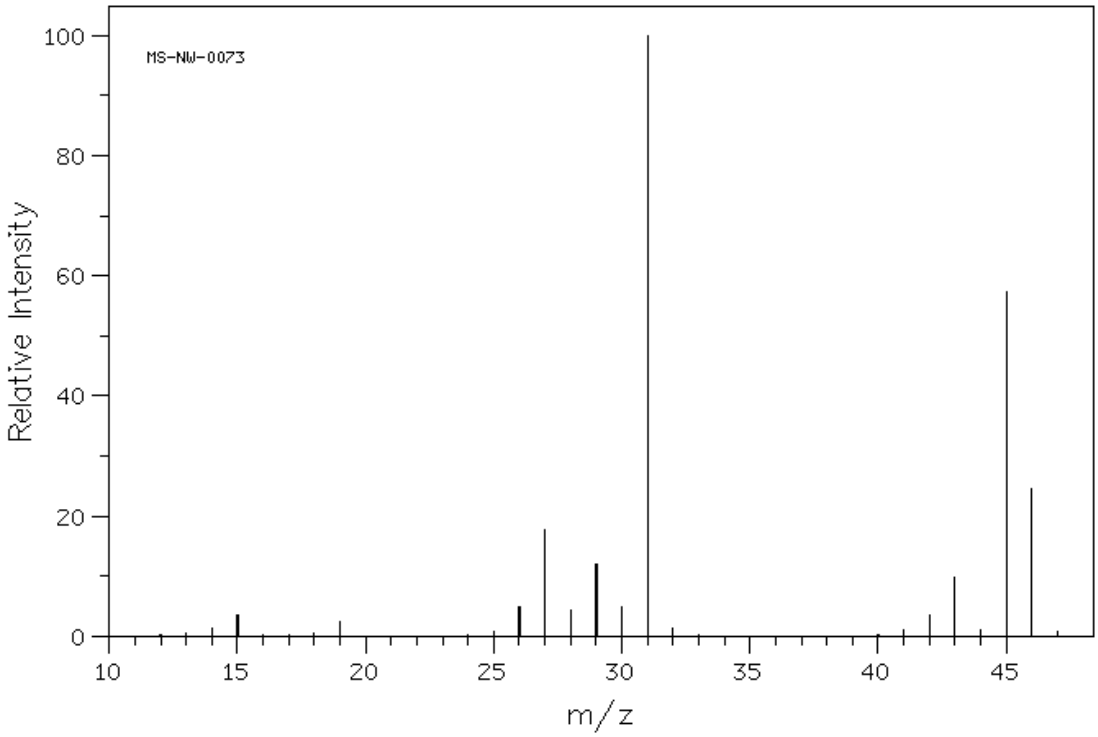
1) Fully characterise the compound using the following spectra and assign a compound.
   In your answer include data tables assigning each peak and how you get to a final structure.

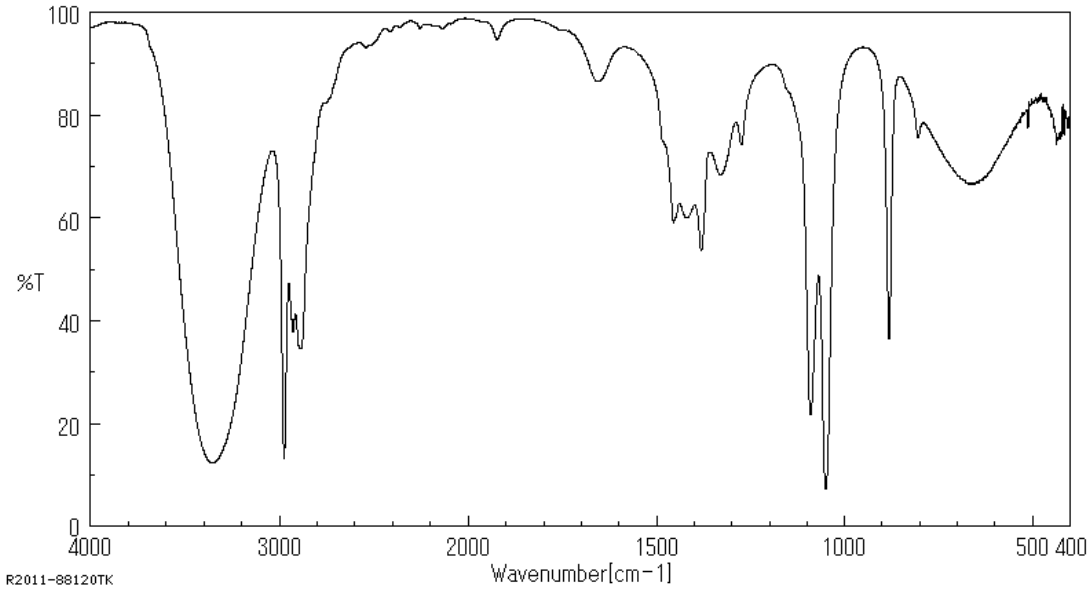
   The compound is one of three:
   A. Methanoic acid B. Methanol C.Ethyl methanoate





2) In industrial methylated spirits, used widely in laboratories, they add a small amount of the compound being analysed in question 1 to pure alcohol to ensure it is not mis-used.





Write a mini essay, including the following points:

a) Compare the two compounds present in industrial methylated spirits.
b) Include in your answer how a slight difference in chemical structure can have a massive impact on a person if consumed and use relevant examples and reference appropriately.

Remember to structure your answer using introduction, main body paragraphs and conclusion. You should also use subject specific vocabulary, and correct spelling and grammar.

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

UNI PATHWAYS

UNI PATHWAYS

thebrilliantclub.org