# Chemistry Stage 6 – Module 8: Analysis of organic compounds



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## Overview

**Stage and Learning Area**: Chemistry Stage 6

**Description**: this resource has been designed to address the Module 8 inquiry question: How is information about the reactivity and structure of organic compounds obtained?

This learning sequence builds understanding of the processes used to analyse the structure of simple organic compounds addressed in the course, including but not limited to:

* proton and carbon-13 NMR
* mass spectrometry
* infrared spectroscopy.

**Duration**: while timing will vary based on the mode of delivery, differentiation strategies employed and class or school context, this series of activities should take approximately 2 hours to complete.

## Information for teachers

This learning activity revises and consolidates the use and application of the spectroscopic techniques studied in Module 8 to identify organic substances studied in Module 7.

Identifying and analysing chemicals are essential in scientific research, medicine, environmental management, quality control, mining, and many other fields. Students deduce or confirm the structure and identity of organic compounds by interpreting data from:

* qualitative tests of chemical reactivity
* proton 1H nuclear magnetic resonance (NMR)
* 13C nuclear magnetic resonance (NMR) spectroscopy
* infrared spectroscopy (IR)
* mass spectroscopy (MS).

This learning activity is designed to develop students’ understanding of the processes used to analyse simple organic compounds.

This content also links with other sections of the Stage 6 course, including the Module 7 Inquiry question: How do we systematically name organic chemical compounds?

### Outcomes

A student:

* **CH11/12-4** selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
* **CH11/12**-**7** communicates scientific understanding using suitable language and terminology for a specific audience or purpose
* **CH12-15 describes and evaluates chemical systems used to design and analyse chemical processes**

[Chemistry Stage 6 Syllabus](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/chemistry-2017) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2017.

### Learning intention and success criteria

Students:

* understand the processes used to analyse the structure of simple organic compounds.

Students can/will:

* describe the steps in the analysis of organic compounds for the following techniques using specific key terms and characteristics
* 1H NMR spectroscopy
* 13C NMR spectroscopy
* Infrared spectroscopy
* Mass spectroscopy
* use the Infrared absorption and 13C NMR chemical shift data to identify functional groups and types of carbons present in an organic compound
* explain features of a specific spectrum used to identify simple organic compounds
* apply knowledge of a variety of spectra to identify an unknown organic compound.

**Differentiation consideration**: learning intentions should not be differentiated. All students need access to the same core content, big ideas and concepts. Differentiation should be evident in the success criteria, or the activities/support needed to achieve the success criteria (Wiliam and Leahy 2015). Teachers may co-construct the success criteria with students or adjust them to suit their class context, for example using the strategies and resources for curriculum planning on the [Planning programming and assessing K-12](https://education.nsw.gov.au/teaching-and-learning/curriculum/planning-programming-and-assessing-k-12/planning-programming-and-assessing-7-12) webpage.

## Teaching and learning activities

Learning activities are sequenced into a series of 8 parts as outlined below. Details of each activity are included in the student resource section.

### Components of the class activity

**Teacher note:** to meet the learning requirements of your students, the activities outlined below can be completed in sequence or as stand-alone components. The summary and key ideas parts (1, 4 and 6) are cloze activities designed to build student vocabulary and use of precise terminology. These parts can be completed as a pre-test to revise the key concepts of each technology studied in class. A word list is provided for the completion of these parts.

Students should be given access to resource materials such as textbooks, course notes and online resources and guided through the completion of part 2, part 3, part 5 and part 7. The teacher should refer to the 13C NMR and Infrared data provided in the activities to assist the students in identifying the types of carbons and functional groups present. All diagrams should be drawn in pencil and fully labelled. A word list is provided in part 3. These parts can be completed in a group work setting and students should share their answers in a class discussion.

* Part 1 – proton and carbon-13 NMR – Summary and key ideas
* Part 2 – the components of a typical 13C NMR spectrum
* Part 3 – the components of a typical 1H NMR spectrum
* Part 4 – infrared spectroscopy – Summary and key ideas
* Part 5 – getting to know the IR spectrum
* Part 6 – mass spectroscopy – Summary and key ideas
* Part 7 – getting to know the mass spectrum
* Part 8 – applying your knowledge and understanding

**Teacher note:** students should complete part 8 individually as an in-class assessment. This part is where students apply their knowledge and understanding by completing an HSC style question. Approximately 20 minutes should be used to complete this part. At the conclusion of part 8 the teacher should collect student work and check their answers. Time should be allocated in the following lesson to go through the answers with the class and reinforce any concepts.

**Differentiation consideration:** students may work through the activity independently. If students require more guidance, provide targeted support, and use class discussion to consolidate learning. Teachers could consider using the 'Think aloud' technique which is outlined in [Using context to infer the meaning of unfamiliar vocabulary.](https://resources.education.nsw.gov.au/api/v1/blob-store/dXJoX3JlYWRpbmdhbmRudW1lcmFjeV9GWWR2TElVQkZHVURld2kwSl9fSA===/VXNpbmcgY29udGV4dCB0byBpbmZlciB0aGUgbWVhbmluZyBvZiB1bmZhbWlsaWFyIHZvY2FidWxhcnkuZG9jeA===?versionid=)

All students need to be challenged and engaged to develop their potential fully. A culture of high expectations needs to be supported by strategies that both challenge and support student learning needs, such as through appropriate curriculum differentiation.

[CESE What works best 2020 update](https://education.nsw.gov.au/about-us/education-data-and-research/cese/publications/research-reports/what-works-best-2020-update)

## Student resources

### Part 1 – proton and carbon-13 NMR

Table – summary of proton and carbon-13 NMR properties

|  |  |  |
| --- | --- | --- |
| Spectroscopic techniques | 1H NMR | 13C NMR |
| Stands for | Proton Nuclear Magnetic Resonance | Carbon Nuclear Magnetic Resonance |
| Use | 1H NMR is a spectroscopic technique used to determine the types and number of hydrogen atoms present in a molecule | 13C NMR is a spectroscopic method used to determine the types and number of carbon atoms present in a molecule |
| Detection | Proton nuclei | Carbon nuclei |
| Chemical shift range  relative position of absorption in the NMR spectrum | 0-14 ppm | 0-240 ppm |
| Progression | Slow | Fast |
| Solvent peak | Absent | Present |

Table – nuclear and magnetic resonance (NMR) including 1H and 13C NMR

|  |  |
| --- | --- |
| Analysis | Details |
| Basis of analysis | Nuclei of a compound are bombarded with **radio waves.**  The way that these **nuclei** **interact** with radio waves tells us about the **chemical environment** of these atoms which allows us to then build information about how these atoms are bonded **together** and ultimately form the **structure** of that compound. |
| Steps in analysis  Word list:  larger  lower  line up  peaks  different  deshielding  radio waves  spin  chemical shifts  dissolved  decrease  environments  higher  absorbed  magnetic field | 1. The sample is \_\_\_\_\_\_\_\_\_\_\_\_\_\_ in a suitable solvent and placed inside the NMR spectrometer. 2. A strong \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_ is applied causing the positively charged nuclei to \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ with the external field (lower energy) or against the external field (higher energy). 3. These nuclei are then bombarded with \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ of the appropriate frequency that matches that change in energy. This energy is \_\_\_\_\_\_\_\_\_\_\_\_ causing the nuclei to flip to a \_\_\_\_\_\_\_\_\_\_\_\_ energy state (excited state). 4. As nuclei return to their \_\_\_\_\_\_\_\_\_\_\_\_ energy state (ground state) energy is released, and an NMR spectrum is produced which shows this absorption. 5. Absorptions appear as sharp \_\_\_\_\_\_\_\_\_\_\_\_ or signals on the spectrum at different \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ characteristic of their chemical environment.   Electron withdrawing (electronegative) groups can \_\_\_\_\_\_\_\_\_\_\_\_ the electron density at the nucleus, \_\_\_\_\_\_\_\_\_\_\_\_ the nucleus and result in a \_\_\_\_\_\_\_\_\_\_\_\_ chemical shift. This means that H atoms which have \_\_\_\_\_\_\_\_\_\_\_ chemical \_\_\_\_\_\_\_\_\_\_\_\_ will have different chemical shifts. |

### Part 2 – the components of a typical 13C NMR spectrum

13C NMR spectrum – ethanal

Solvent CDCl3

Figure – 13C NMR spectrum – ethanal

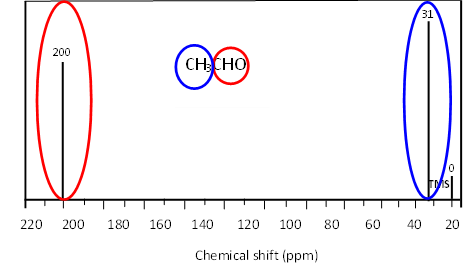
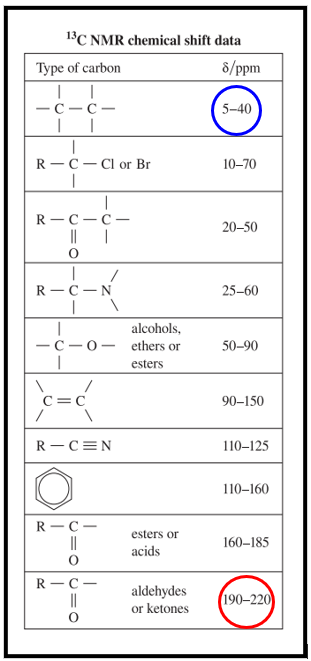


Figure – 13C NMR chemical shift data

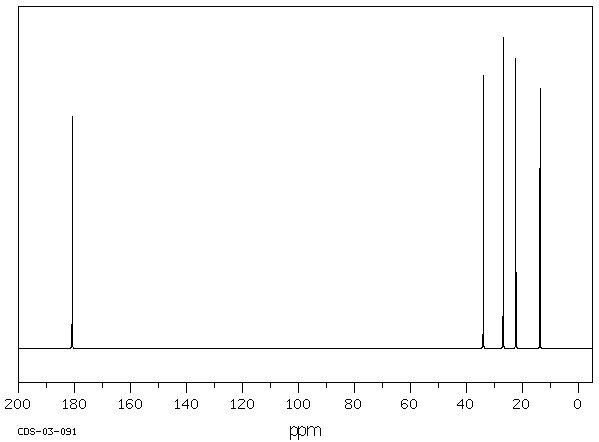


1. Why is the CHO group further downfield and the CH3 group more upfield?

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1. Analyse the spectrum for pentanoic acid below.

Figure – 13C NMR spectrum



[Spectral Database for Organic Compounds](https://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi) image by the National Institute of Advanced Industrial Science and Technology (AIST).

|  |
| --- |
| 1. How many carbon environments are present in the spectrum above? |
|  |
| 1. What functional group is most likely to be present an approximately 180ppm? |
|  |

### Part 3 – the components of a typical 1H NMR spectrum

Figure – 1H NMR spectrum

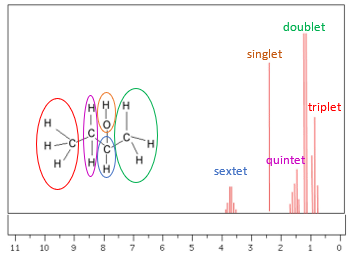


Image adapted from [Socratic](https://socratic.org/questions/599f0f7db72cff6f49804461).

1. The explanation for the splitting patterns for triplet and doublet peaks is outlined below. Use this information to complete the explanations for the quintet, singlet and sextet peaks.

The peak at ~ 1ppm is split into a triplet (three peaks), indicating this hydrogen environment is adjacent to a neighbouring carbon with two hydrogens. The **terminal CH3 group**, marked in red, is adjacent to the **CH2 group**. It produces a triplet peak and is normally a very low shift as it is a terminal hydrogen environment and furthest away from the electron-withdrawing OH group.

The peak at ~ 1.3ppm is split into a doublet (two peaks), indicating this hydrogen environment is adjacent to a neighbouring carbon with one hydrogen, CH group. The spectrum above shows the **terminal CH3 group** in green connected to the **CH group** marked in blue. The doublet has a slightly higher chemical shift than the triplet as it is closer to the electron-withdrawing OH group.

1. The peak at ~ 1.5ppm is split into a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (\_\_\_\_\_\_\_ peaks), indicating this hydrogen environment is the CH2 group marked in purple is adjacent to one neighbouring carbon group \_\_\_\_\_\_\_ attached to \_\_\_\_ H atom and another neighbouring carbon group \_\_\_\_\_\_\_ attached to \_\_\_\_\_\_\_ hydrogen atoms. This gives a total of \_\_\_\_\_\_\_ hydrogen atoms. The quintet has a slightly higher chemical shift than the doublet as it is attached to the electron-withdrawing OH group.
2. The peak at ~ 2.5ppm is split into a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ (\_\_\_\_\_\_\_ peak), indicating that the hydrogen is attached to a non-carbon. The spectrum above shows the H attached to the \_\_\_\_\_\_\_\_\_\_\_ atom (non-carbon). The has a slightly higher chemical shift than the quintet.
3. The peak at ~ 3.5ppm is split into a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ (\_\_\_\_\_\_\_ peaks), indicating this hydrogen environment is the CH group marked in blue and is attached to one neighbouring carbon group \_\_\_\_\_\_\_ attached to \_\_\_\_ H atoms and another neighbouring carbon group \_\_\_\_\_\_\_ attached to \_\_\_\_\_\_\_ hydrogen atoms. This gives a total of \_\_\_\_\_\_\_ hydrogen atoms. The sextet has the greatest chemical shift, as it is directly attached to the electron-withdrawing OH group.

**Word list:** quintet, five, CH, CH3, one, three, four, sextet, six, CH2, CH3, two, three, five, singlet, one, oxygen.

1. Study the 1H NMR spectrum and the proton NMR peak data for propanoic acid below

Figure – 1H NMR spectrum

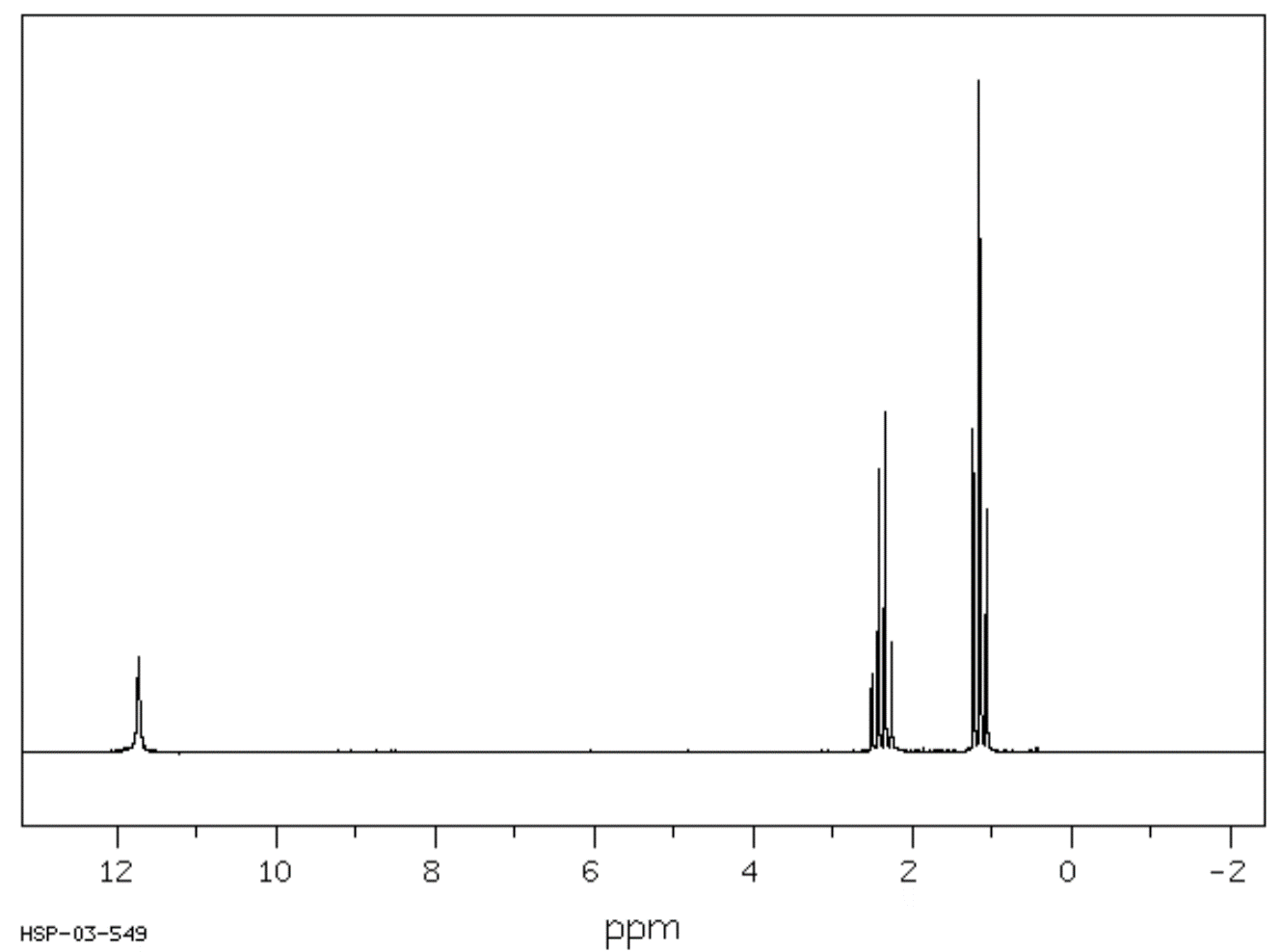


Table – spectral database for organic compounds

|  |  |  |
| --- | --- | --- |
| Shift (ppm) | Number of peaks | Peak area ratio |
| 11.73 | 1 | 1 |
| 2.38 | 4 | 2 |
| 1.16 | 3 | 3 |

Explain how this spectrum is representative of propanoic acid.

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### Part 4 – infrared spectroscopy – summary and key ideas

Read through the key ideas and complete the steps in the analysis section of the table. A word list has been provided.

Table – Infrared (IR) spectroscopy applications and analysis

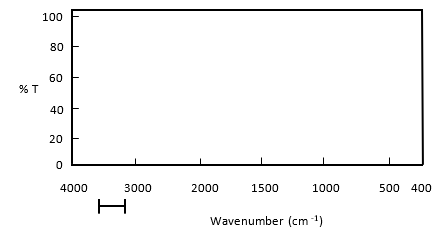
|  |  |
| --- | --- |
| Infrared (IR) | spectroscopy |
| Use | Analytical technique used to determine and **identify the structure of organic compounds** by utilising electromagnetic radiation in the **infrared range**. |
| Basis of analysis | Molecules are identified based on their **interaction** and **absorption** of **infrared** radiation characteristic of their **molecular** **vibration** |
| Steps in analysis  Word list:  absorption data  matches  functional groups  absorption  molecular vibration  irradiated  absorbed | 1. A sample is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with infrared electromagnetic radiation consisting of a range of wavelengths. 2. Energy is either transmitted or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. 3. Energy is absorbed if the frequency of the radiation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the frequency of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ causing the molecule in the sample to vibrate in a unique way (stretching/bending). 4. An \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ spectrum is produced and interpreted. 5. Patterns are compared to infrared \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_, and the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the molecule are determined. |
| Wavenumber Range | 4000–500. |

### Part 5 – getting to know the IR spectrum

Draw the peak absorbance (dip in transmittance) for the examples below. The Infrared absorption data table is provided, and the marker is placed below the X axis to guide you.

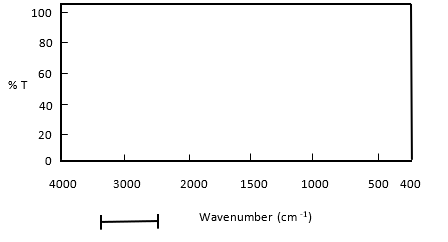
#### Hydroxyl group in alcohols

Figure – IR template



#### Hydroxyl group in carboxylic acids

Figure – IR template



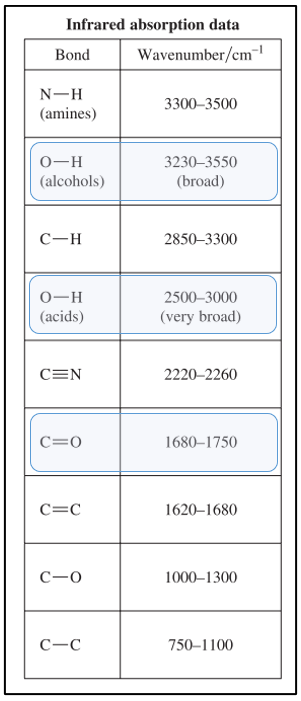
#### A carbonyl group

Figure – IR template

Blank transmittance graph



Figure – infrared absorption data



Use Figure 9 to conduct Quick check 1 and 2.

**Quick check 1**

Consider the classes of organic substances listed in the Chemistry syllabus.

A carbonyl group is found in ketones, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Figure – an amino group

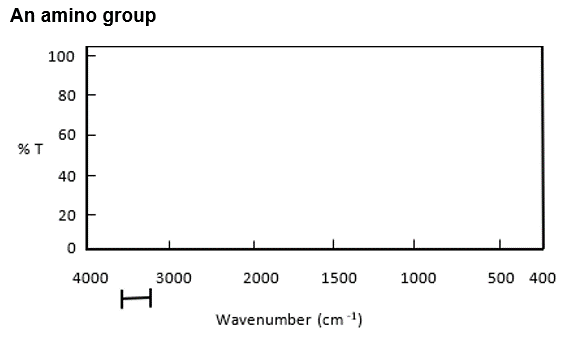
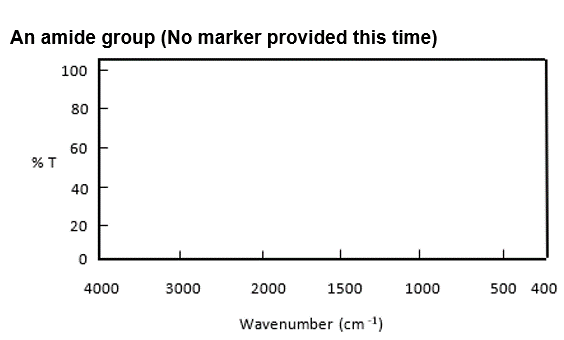


Figure – an amide group



**Quick check 2**

Consider the classes of organic substances listed in the Chemistry syllabus.

An amino group is found in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

### Part 6 – mass spectroscopy – summary and key ideas

Read through the key ideas and complete the steps in the analysis section of the table. A word list is provided.

Table – mass spectroscopy applications and analysis

|  |  |
| --- | --- |
| Mass | spectroscopy (MS) |
| Use | Use to identify the compounds by analysing their **molecular weights** |
| Basis of analysis | Molecular fragments are analysed based on **charge-to-mass** ratio |
| Steps in analysis  Word list:  database  curved  peaks  detector  charge/mass  fragments  vaporised  peak  Ionised  accelerated  magnetic  abundance | 1. The sample is \_\_\_\_\_\_\_\_\_\_\_\_ and then \_\_\_\_\_\_\_\_\_\_\_\_ by bombardment with a stream of high energy electrons. 2. The positive ions are \_\_\_\_\_\_\_\_\_\_\_\_ by an electric field and then passed through a \_\_\_\_\_\_\_\_\_\_\_\_ field, causing the ions to move in \_\_\_\_\_\_\_\_\_\_\_\_ paths in which the deflection (radius of the path) depends on the \_\_\_\_\_\_\_\_\_\_\_\_ ratio. 3. The ions then exit and reach the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. 4. The mass spectrum is produced consisting of a series of \_\_\_\_\_\_\_\_\_\_\_\_ of varying heights. 5. Each peak corresponds to one of the \_\_\_\_\_\_\_\_\_\_\_\_ and the height of the \_\_\_\_\_\_\_\_\_\_\_\_ indicates its \_\_\_\_\_\_\_\_\_\_\_\_. Different chemicals break apart in a distinct way forming a fingerprint spectrum. 6. The spectral pattern is used to identify the original molecule by comparison with a computer \_\_\_\_\_\_\_\_\_\_\_\_ of known compounds. |

Draw a schematic diagram of a mass spectrometer in the space below. Label the following components: ionisation, acceleration, deflection, detection, electromagnet, vaporised sample, to vacuum pump.

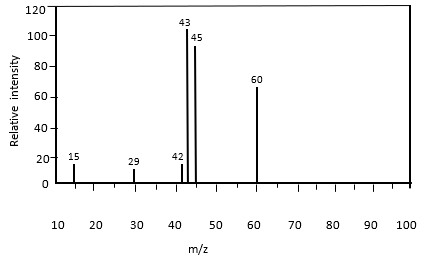
|  |
| --- |
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### Part 7 – getting to know the mass spectrum

Examine the mass spectrum for ethanoic acid below and answer the questions that follow.

#### Mass spectrum for ethanoic acid

Figure – mass spectrum of ethanoic acid



1. Draw the structural formula for ethanoic acid in the box below and use the structure to help you to identify the fragmentation pattern for ethanol in the following questions.

|  |
| --- |
|  |

1. On the mass spectrum above, label the parent molecular ion and the base peak.
2. Draw the structural formula for fragment 43 and fragment 60 in the boxes below.

|  |  |
| --- | --- |
| Fragment 43 | Fragment 60 |
|  |  |

1. The table below shows the common fragmentations that occur in ethanoic acid. The first example is done for you. Complete the rest of the table.

Table – relative mass and fragment size

|  |  |
| --- | --- |
| Relative mass | Fragment |
| 15 | CH3+ |
| 29 |  |
| 43 |  |

### Part 8 – applying your knowledge and understanding

**Question 1**

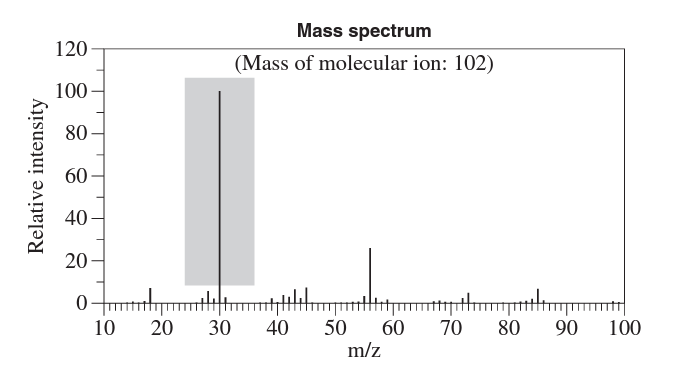
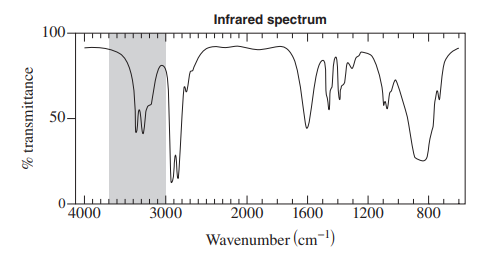
Adapted from [2021 HSC Chemistry Exam](https://educationstandards.nsw.edu.au/wps/portal/nesa/resource-finder/hsc-exam-papers/2021/chemistry-2021-hsc-exam-pack).

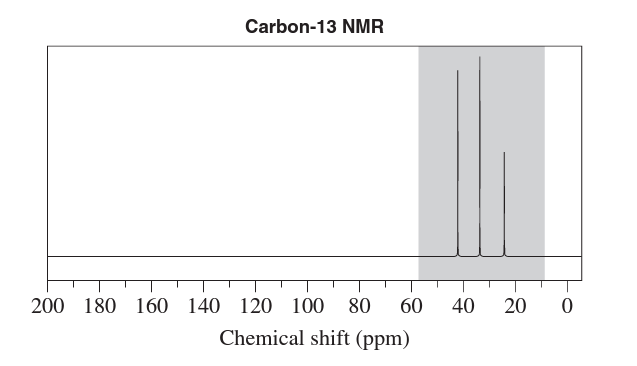
A chemist obtained spectral data of pentane-1,5-diamine (C5H14N2).

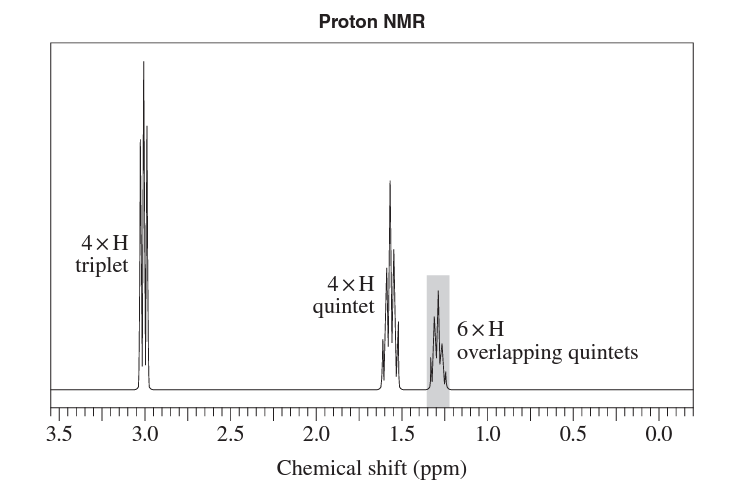
1. Draw the structural or displayed formula for this compound in the box below and highlight/circle the amine functional groups.

|  |
| --- |
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The spectra obtained for pentane-1,5-diamine (C5H14N2) are shown below.







1. Relate the highlighted features of the spectra to the structure of pentane-1,5-diamine.

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## Sample responses

### Part 1 – proton and carbon-13 NMR – summary and key ideas

Steps in analysis

1. dissolved
2. magnetic field, spin, line up
3. radio waves, absorbed, higher
4. lower
5. peaks, chemical shifts
6. decrease, deshielding, larger, different environments.

### Part 2 – The components of a typical 13C NMR spectrum

1. CHO group contains an electronegative oxygen atom. This atom decreases the electron density at the carbon nucleus, deshielding it and resulting in a larger chemical shift (downfield). The CH3 group does not have any electronegative atoms, and thus the electron density at the carbon nucleus is unaffected/nucleus is shielded. This results in a smaller chemical shift (upfield).
2. Five
3. COOH

### Part 3 – The components of a typical 1H NMR spectrum

1. Quintet, five, CH, one, CH3, three, four
2. Singlet, one, oxygen
3. Sextet, six, CH3, three, CH2, two, five
4. Propanoic acid has three different hydrogen environments, as indicated by the three peaks in the spectrum. Peak #1 is a singlet representing the COOH group, as the H atoms are attached to a non-carbon atom. In this case, the electronegative oxygen atom deshields the nucleus causing a larger chemical shift (11.73 from the spectrum). The quartet represents the CH2.

### Part 4 – Infrared spectroscopy – Summary and key ideas

1. irradiated
2. absorbed
3. matches, molecular vibration
4. absorption
5. absorption data, functional groups

### Part 5 – Getting to know the IR spectrum

Table 6 – example spectra

|  |  |  |
| --- | --- | --- |
| Functional group | Description | Example |
| Hydroxyl group in alcohol | As referenced in the IR spectrum, a broad peak (**beard**) is hand-drawn between the 3230–3550 range. | Hydroxyl group transmittance pattern in alcohols |
| Hydroxyl group in carboxylic acid | A very broad peak (**beard**) is hand-drawn between the 2500–3000 range as referenced in the IR spectrum | Hydroxyl group transmittance pattern in carboxylic acids |
| Carbonyl group | A sharp peak (**sword**) is hand-drawn between the 1680–1750 range as referenced in the IR spectrum | A sharp peak representing the carbonyl functional group |
| Amino group | A double prong peak is hand-drawn between the 3300–3500 range. | Amino group transmittance pattern in amines |
| Amide group | A double prong peak is hand-drawn between the 3300–3500 range representative of the amino group and another peak is drawn between the 1680–1750 range representative of the carbonyl group | Amino group transmittance pattern in amides carbonyl group transmittance pattern in amides |

**Teacher tip:** The analogy of ‘beards’ and ‘swords’ is sometimes used to help students recognise the hydroxyl peaks (beards) and the carbonyl peaks (swords)

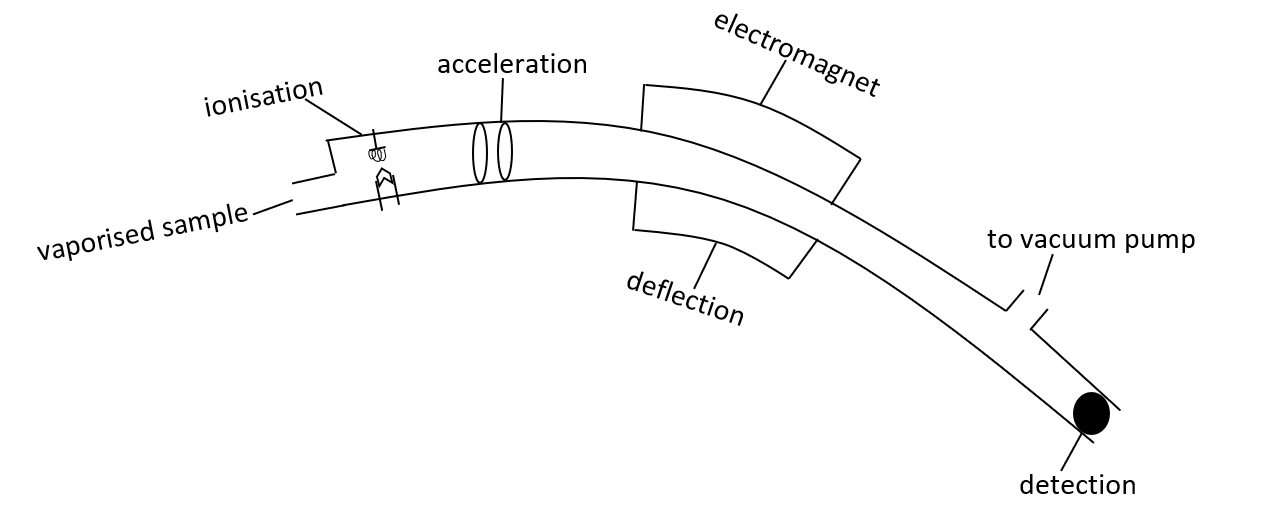
**Quick check 1** – carboxylic acids, esters, aldehydes, and amides.

**Quick check 2** – amines and amides.

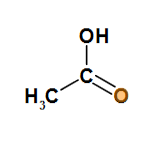
### Part 6 – Mass spectroscopy – Summary and key ideas

1. vaporised, ionised
2. accelerated, magnetic, curved, charge/mass
3. detector
4. peaks
5. fragments, peak, abundance
6. database

Schematic diagram of MS

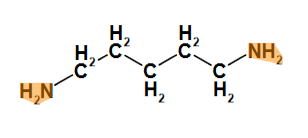


### Part 7 – Getting to know the mass spectrum

1. 
2. Students label molecular peak 60 and base peak 43
3. Students draw a structural diagram for fragment 43, which is CH3CO+ and for fragment 60, which is CH3COOH+
4. Fragment 29 = CH2CH3+, CHO+, Fragment 43 = CH3CO+

### Part 8 – Applying your knowledge and understanding

Question 1

1. 

Infrared spectrum

* The peak at the wavenumber range 3300–3400 cm–1 is due to the N-H group (amino group). The spectrum confirms the presence of the amino group.

Mass spectrum

* The highlighted feature is the fragment CH2NH2+ (12 x 1 + 1.0 x 4 + 14 x 1 = 30)

Carbon-13 NMR spectrum

* There are 5 carbon atoms in the molecule. However, only 3 peaks (3 signals) are shown in the spectrum.
* Due to symmetry, carbon atoms 1 and 5 are in identical environments. The same is true for carbon atoms 2 and 4. However, carbon atom 3 is in a unique environment.
* The signals at 24 and 33 ppm are consistent with –CH2–CH2– carbon atoms (5−40 ppm)
* The signal at 42 ppm is due to the C-N-H groups (25−60 ppm)

Proton NMR

* Quintets arise from H atoms with four H atoms on neighbouring C atoms, for example: the H atoms on C-3 have four neighbouring H atoms on C-2 and C-4.
* The highlighted signal results from similar chemical shifts of protons in two different environments.
* The highlighted signal results from the overlap of a 2H signal and a 4H signal, giving 6H.

## Support and alignment

**Resource evaluation and support:** all curriculum resources are prepared through a rigorous process. Resources are periodically reviewed as part of our ongoing evaluation plan to ensure currency, relevance and effectiveness. For additional support and advice or to provide feedback, contact the Science Curriculum team by emailing [Science7-12@det.nsw.edu.au](mailto:Science7-12@det.nsw.edu.au).

Please complete the following [feedback form](https://forms.office.com/Pages/ResponsePage.aspx?id=muagBYpBwUecJZOHJhv5kYnlAVp34PdDo_Spv__gCQNUM0xER1lEWDkyQjVDMEhWMDlNRjhMSVpIVi4u) to help us improve our resources and support.

**Differentiation:** further advice to support Aboriginal and Torres Strait Islander students, EALD students, students with a disability and/or additional needs and High Potential and gifted students can be found on the [Planning programming and assessing 7-12](https://education.nsw.gov.au/teaching-and-learning/curriculum/planning-programming-and-assessing-k-12/planning-programming-and-assessing-7-12) webpage.

**Assessment**: further advice to support formative assessment is available on the [Planning programming and assessing 7-12](https://education.nsw.gov.au/teaching-and-learning/curriculum/planning-programming-and-assessing-k-12/planning-programming-and-assessing-7-12) webpage.

**Professional learning**: relevant professional learning is available on the [Science statewide staffroom](https://education.nsw.gov.au/teaching-and-learning/curriculum/statewide-staffrooms) and [HSC Professional Learning](https://education.nsw.gov.au/teaching-and-learning/professional-learning/hsc-pl). [Stage 6 Literacy in context](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy/teaching-and-learning-resources/literacy/stage-6-literacy-in-context-writing/science) provides further advice to teachers to improve student writing.

**Related resources**: further resources to support Stage 6 Chemistry can be found on the [HSC hub](https://www.hschub.nsw.edu.au/) and the [Science K-12](https://education.nsw.gov.au/teaching-and-learning/curriculum/science) page.

**Consulted with**: Literacy and Numeracy and subject matter experts.

**Alignment to system priorities and/or needs**: [School Excellence Policy](https://education.nsw.gov.au/policy-library/policies/pd-2016-0468), [School Success Model](https://education.nsw.gov.au/public-schools/school-success-model/school-success-model-explained).

**Alignment to the School Excellence Framework**: this resource supports the [School Excellence Framework](https://education.nsw.gov.au/policy-library/policies/pd-2016-0468) elements of curriculum (curriculum provision) and effective classroom practice (lesson planning, explicit teaching).

**Alignment to Australian Professional Teaching Standards**: this resource supports teachers to address [Australian Professional Teaching Standards](https://educationstandards.nsw.edu.au/wps/portal/nesa/teacher-accreditation/meeting-requirements/the-standards/proficient-teacher) 3.2.2, 3.3.2.

**Author**: Science 7-12 Curriculum Team

**Resource**: Classroom resource

**Creation date**: updated 26 October 2022

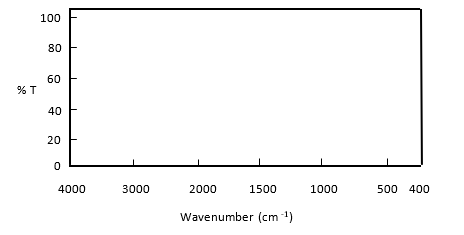
## Appendix

### Spectra templates

The following templates are to support general teaching and learning activities for spectroscopy. They could be used when designing questions or when demonstrating worked examples to a class.

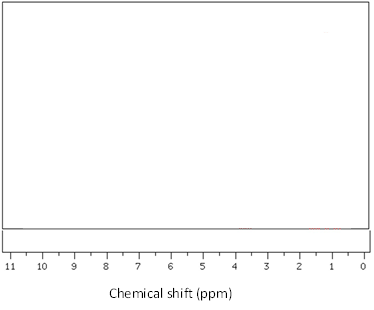
**Teacher tip:** the following templates can be used by teachers to create their own spectra when designing learning materials.

#### Infrared Spectra

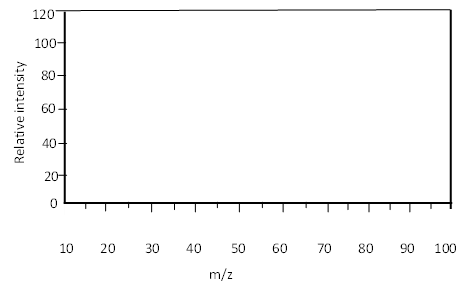


#### 13C NMR SpectraBlank CNMR graph

#### 1H NMR Spectra



#### Mass Spectra



## References

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[Chemistry Stage 6 Syllabus](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/chemistry-2017) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2017.

AIST (National Institute of Advanced Industrial Science and Technology) (2018) [*Spectral Database for Organic Compounds*](https://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi) [website], accessed 29 June 2020.

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NESA (NSW Education Standards Authority) (2022) ‘[Proficient Teacher: Standard descriptors](https://educationstandards.nsw.edu.au/wps/portal/nesa/teacher-accreditation/meeting-requirements/the-standards/proficient-teacher)’, *The Standards*, NESA website, accessed 23 May 2023.

Wiliam D and Leahy S (2015) *Embedding Formative Assessment: Practical Techniques for K-12 Classrooms*, Learning Sciences International, US.

### Acknowledgements

The practice questions in this document are from [Chemistry 2021 HSC exam pack](https://educationstandards.nsw.edu.au/wps/portal/nesa/resource-finder/hsc-exam-papers/2021/chemistry-2021-hsc-exam-pack) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2021.

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### Further reading

State of New South Wales (Department of Education) (n.d.) ‘[Literacy and numeracy](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy)’, *Curriculum*, NSW Department of Education website, accessed 24 February 2023.

State of New South Wales (Department of Education) (n.d.) ‘[Literacy and numeracy priorities](https://education.nsw.gov.au/teaching-and-learning/curriculum/literacy-and-numeracy)’, *Literacy and numeracy*, NSW Department of Education website, accessed 24 February 2023.

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