



HSC Chemistry

Student Workbook

Student name: _____



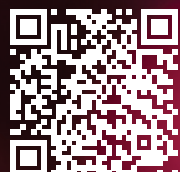


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- B Education (Primary)
- B Education (Secondary)
- B Arts
- B Arts (Interpreting and Translation)
- B Laws
- B Performing Arts (Acting)
- B Music
- B Design (Visual Communication)
- B Music
- B International Studies

YOU LOVE STUDIES OF RELIGION? *WHY NOT STUDY:*

- B Arts
- B Social Science
- B Education (Primary)
- B Education (Secondary)

YOU LOVE HISTORY? *WHY NOT STUDY:*

- B Arts
- B International Studies
- B Social Science
- B Education (Primary)
- B Education (Secondary)
- B Tourism and Event Management
- B Planning (Pathway to M Urban Management and Planning)

YOU LOVE VISUAL ARTS? *WHY NOT STUDY:*

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- B of Design
- B of Design and Technology
- B of Industrial Design (Honours)

YOU LOVE BUSINESS STUDIES? *WHY NOT STUDY:*

- B Business
- B Accounting
- B Education (Primary)
- B Education (Secondary)
- B Tourism and Event Management
- B Construction Management (Honours)

YOU LOVE LEGAL STUDIES? *WHY NOT STUDY:*

- B Criminology
- B Criminal and Community Justice
- B Cyber Security and Behaviour
- B Policing
- B Laws
- B Social Science
- B Humanitarian and Development Studies
- B Education (Primary)
- B Education (Secondary)
- B Construction Management (Honours)
- B Social Work
- B Youth Work

YOU LOVE COMMUNITY AND FAMILY STUDIES STUDIES? *WHY NOT STUDY:*

- B Arts
- B Criminology
- B Nursing
- B Midwifery
- B Psychology (Honours)
- B Psychological and Social Sciences
- B Social Science
- B Youth Work
- B Social Work
- B Humanitarian and Development Studies
- B Education (Early Childhood)
- B Education (Primary)
- B Education (Secondary)

YOU LOVE PHYSICS? *WHY NOT STUDY:*

- B Science
- B Education (Primary)
- B Education (Secondary)
- B Engineering
- B Architectural Design
- B Industrial Design (Honours)
- B Design and Technology

YOU LOVE CHEMISTRY? *WHY NOT STUDY:*

- B Science
- B Medical Science
- B Education (Primary)
- B Education (Secondary)

YOU LOVE HEALTH AND MOVEMENT SCIENCE? *WHY NOT STUDY:*

- B Health Science
- B Health, Physical Education and Sport
- B Exercise Physiology
- B Exercise Science
- B Sport and Performance Science
- B Occupational Therapy
- B Paramedicine
- B Physiotherapy
- B Podiatric Medicine
- B Speech Pathology
- B Traditional Chinese Medicine
- B Nursing
- B Midwifery
- B Education (Primary)

YOU LOVE MATHEMATICS? *WHY NOT STUDY:*

- B Computer Science
- B Data Science
- B Information and Communication Technology
- B Information Systems
- B Mathematics
- B Engineering
- B Education (Primary)
- B Education (Secondary)
- B Planning (Pathway to M Urban Management and Planning)
- B Accounting

YOU LOVE BIOLOGY? *WHY NOT STUDY:*

- B Health Science
- B Health, Physical Education and Sport
- B Occupational Therapy
- B Paramedicine
- B Physiotherapy
- B Podiatric Medicine
- B Speech Pathology
- B Sport and Performance Science
- B Traditional Chinese Medicine
- B Science
- B Medical Science
- B Nursing
- B Midwifery
- B Education (Primary)
- B Education (Secondary)
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- Programs to help you settle into uni life as well as your studies
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- Counselling and mental health and wellbeing services
- Disability services

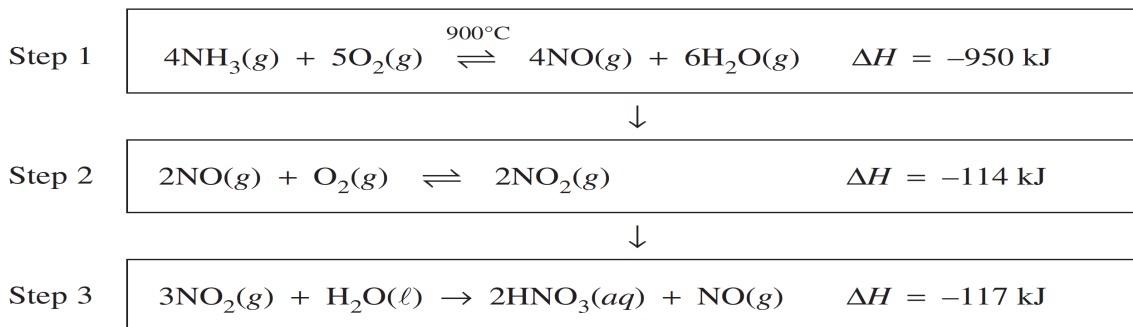
- Members of the ADF – Student Veteran Program
 - Elite athletes and performers support
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Chemistry - Content Analysis and Syllabus review

Module 5 - Equilibrium

The flowchart outlines the sequence of steps in the Ostwald process for the manufacture of nitric acid.

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Explain the reaction conditions required at each step of the Ostwald process to maximise the yield and production rate of nitric acid.

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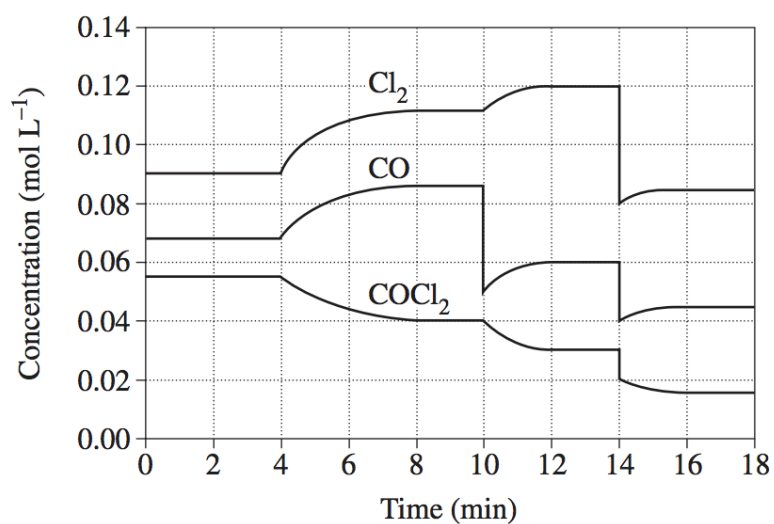
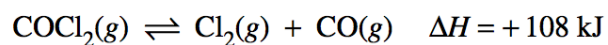
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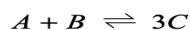
The graph shows the variation in concentration of reactant and products as a function of time for the following system.



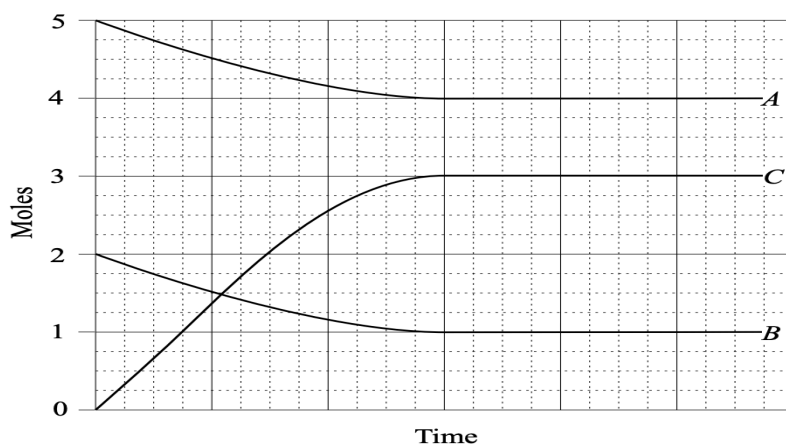
Identify and explain each of the changes in conditions that have shaped the curves during the time the system was observed.

[illegible]

Two substances A and B react according to the equation:



5 moles of A and 2 moles of B are mixed in a 2 L closed container. The reaction is allowed to come to equilibrium at temperature T . The graph below shows the variation in moles of A , B , and C over time.



Calculate the value of the equilibrium constant, K , for the reaction at temperature T .
Show your working.

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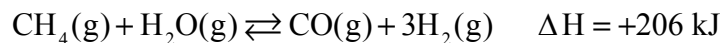
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Methane and water vapour react to form carbon monoxide and hydrogen in a closed container as shown.



Compare the impact on the equilibrium system of a decrease in volume of the container to the impact of a decrease in temperature. Refer to the equilibrium constant in your answer.

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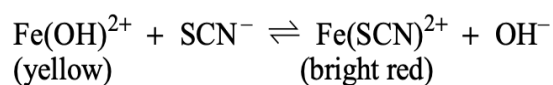
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A stage show requiring a frothing ‘blood-like’ liquid used dry ice ($\text{CO}_2(s)$) and iron complexes to produce this effect.

One such iron complex consists of an alkaline solution containing iron (III) chloride and sodium thiocyanate. This produces the following equilibrium reaction:



- (a) The numerical value of K at 25°C for this reaction was found to be 2.3×10^{-4} .
- (i) What does the value of K tell us about the equilibrium concentrations of the $\text{Fe}(\text{SCN})^{2+}$ and OH^{-} ions?
- (ii) Predict the colour of the solution at 25°C .
- (b) If dry ice is added to this solution, the pH changes from about pH 10 to pH 4. What causes this pH change?
- (c) Explain how the addition of dry ice achieves the effect of the blood-like liquid.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Solid ammonium hydrogen sulfide (NH_4HS) decomposes to form ammonia gas and hydrogen sulfide gas (H_2S).

2.00 moles of ammonium hydrogen sulfide were placed in a sealed 3.00 L container and the system was allowed to reach equilibrium. At equilibrium, there were 0.0328 moles of ammonia gas.

Calculate the equilibrium constant for this reaction.

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The value of the solubility product for Ba(OH)_2 is 2.55×10^{-4} at 25°C .

Calculate the solubility of Ba(OH)_2 in mol L^{-1} at 25°C .

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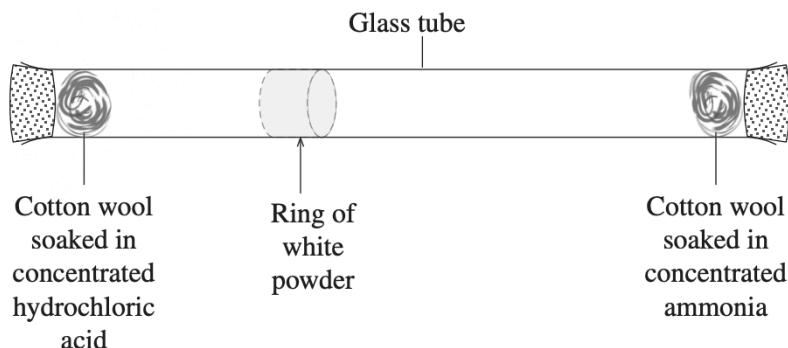
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Module 6 – Acid/Base Reactions

The equipment shown is set up. After some time a ring of white powder is seen to form on the inside of the glass tube.



- a) Why would this NOT be an acid-base reaction according to Arrhenius?
- b) Explain why this would be considered a Brønsted-Lowry acid-base reaction. Include an equation in your answer.

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Using relevant chemical equations, describe the properties of an amphoteric species.

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A 0.001 mol L^{-1} solution of hydrochloric acid and a 0.056 mol L^{-1} solution of acetic acid both have a pH of 3.0.

Why do both solutions have the same pH?

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Calculate the pH of a $0.0010 \text{ mol L}^{-1}$ solution of acetic acid. $K_a = 1.8 \times 10^{-5}$.

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A standard solution was prepared by dissolving 1.314 g of sodium carbonate in water. A solution was made up to a final volume of 250.0 mL.

- a) Calculate the concentration of the sodium carbonate solution.

This solution was used to determine the concentration of a solution of hydrochloric acid. Four 25.00 mL samples of the acid were titrated with the sodium carbonate solution. The average titration volume required to reach the end point was 23.45 mL.

- b) Write a balanced equation for the titration reaction.
c) Calculate the concentration of the hydrochloric acid solution.

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Explain how a buffer solution is able to resist sudden changes in pH.
Make use of a relevant chemical equation in your response.

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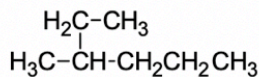
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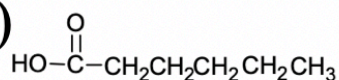
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Module 7 - Organic Chemistry

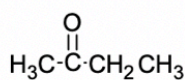
i)



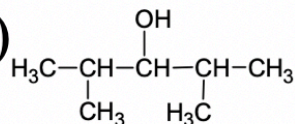
iv)



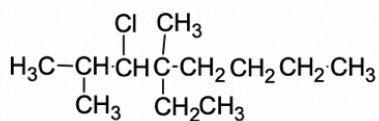
ii)



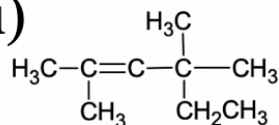
v)



iii)

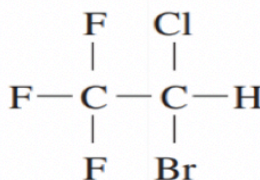


vi)



- i)
- ii)
- iii)
- iv)
- v)
- vi)

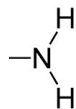
What is the IUPAC name of the following compound?



- (A) 1-bromo-1-chloro-2,2,2-trifluoroethane
- (B) 1-chloro-1-bromo-2,2,2-trifluoroethane
- (C) 2-chloro-2-bromo-1,1,1-trifluoroethane
- (D) 2-bromo-2-chloro-1,1,1-trifluoroethane

NAMING AMINES

Remember that amines have the following functional group.

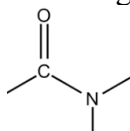


Carbon chains could replace the hydrogens in this structure as well.

The YouTube clip <https://www.youtube.com/watch?v=J00-e0p2c5E> explains how to name amines quite well (sorry that he sounds so boring!!) Stop after about 4.13 minutes when he starts talking about aniline - way beyond the scope of the course.

NAMING AMIDES

Remember that amides have the following functional group.



The YouTube clip <https://www.youtube.com/watch?v=EzjyF2qvtLs> explains how to name amides very well. Apologies for the ads that might come into it. Stop after about 5.10 minutes. I can't see you having to name amides with ring structures hanging off them.

In which of the following pairs are the substances isomers of each other?

- A. 1-pentene and cyclopentane
- B. Pentane and 2,3-dimethylbutane
- C. Butanoic acid and 1,2-butanediol
- D. Dichloromethane and trichloromethane

Which of the following isomeric alkanes has the lowest boiling temperature?

- A. 2-methylpentane
- B. 2,2-dimethylbutane
- C. 3-methylpentane
- D. Hexane

Explain your answer.

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Within a homologous series such as the alkanes, boiling points

- A. are all approximately the same.
- B. increase as the molar masses increase.
- C. are independent of intermolecular forces.
- D. decrease as the molecules become larger.

Explain your answer.

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Explain why alkanes and their corresponding alkenes have similar physical properties but very different chemical properties.

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Why is ethene insoluble in water?

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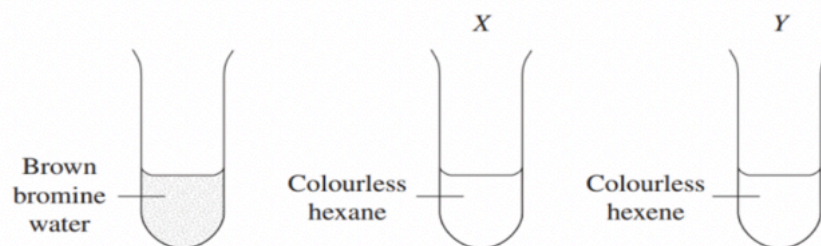
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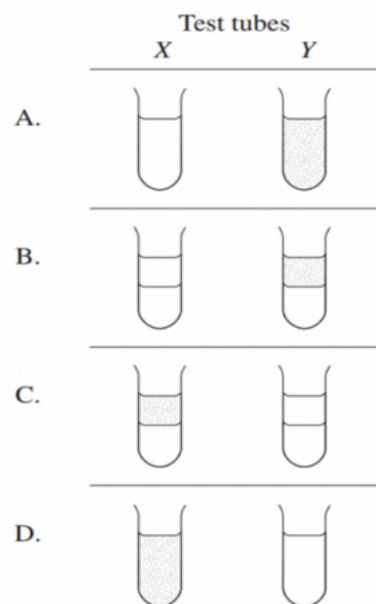
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Three test tubes were set up as shown.



Bromine water was added to *X* and *Y* in the absence of UV light.

Which of the following best represents the changes in test tubes *X* and *Y*?



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Which of the equations correctly describes incomplete combustion?

- (A) $\text{C}_2\text{H}_5\text{OH}(l) + 2\text{O}_2(g) \rightarrow 2\text{CO}(g) + 3\text{H}_2\text{O}(l)$
- (B) $\text{C}_2\text{H}_5\text{OH}(l) + \frac{7}{2}\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$
- (C) $\text{C}_2\text{H}_5\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 3\text{H}_2\text{O}(l)$
- (D) $\text{C}_2\text{H}_5\text{OH}(l) + 2\text{O}_2(g) \rightarrow \text{C}(s) + \text{CO}(g) + 3\text{H}_2\text{O}(l)$

Two compounds X and Y have the molecular formula C_4H_8 . On reaction with HBr , compound X gives a single product, while compound Y gives two products.

- (a) Give a structural formula for compound Y .
- (b) Give the systematic name of compound X .
- (c) Give the structural formula of the product formed by the reaction of X with HBr .

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This apparatus was set up to produce methyl butanoate.



- (a) Identify a safety issue in this experiment.

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- (b) Using structural formulae, write the equation for the production of methyl butanoate.

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- (c) Explain the purpose in using the equipment shown.

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The table shows information about three carbon compounds.

Compound	Structural formula	Molecular weight	Boiling point
X	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	60	97°C
Y	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{O}-\text{H} \end{array} \\ \\ \text{H} \end{array} $	60	118°C
Z	$ \begin{array}{c} \text{H} \quad \quad \text{O} \\ \quad \quad \\ \text{H}-\text{C}-\text{O}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $	60	?

What is the best estimate for the boiling point of compound Z?

- (A) 31°C
- (B) 101°C
- (C) 114°C
- (D) 156°C

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Module 8 - Applying Chemical Ideas

Compound X shows three signals in its ^{13}C NMR spectrum.

Treatment of X with hot acidified potassium permanganate produces a compound Y.

Compound Y turns blue litmus red.

Compound X produces compound Z upon reaction with hot concentrated sulfuric acid. Which of the following correctly identifies compounds X, Y and Z?

	<i>Compound X</i>	<i>Compound Y</i>	<i>Compound Z</i>
A.	butan-1-ol	butanoic acid	but-1-ene
B.	butan-2-ol	butanone	but-2-ene
C.	methyl ethanoate	methanoic acid	ethene
D.	2-methylpropan-1-ol	2-methylpropanoic acid	2-methylprop-1-ene

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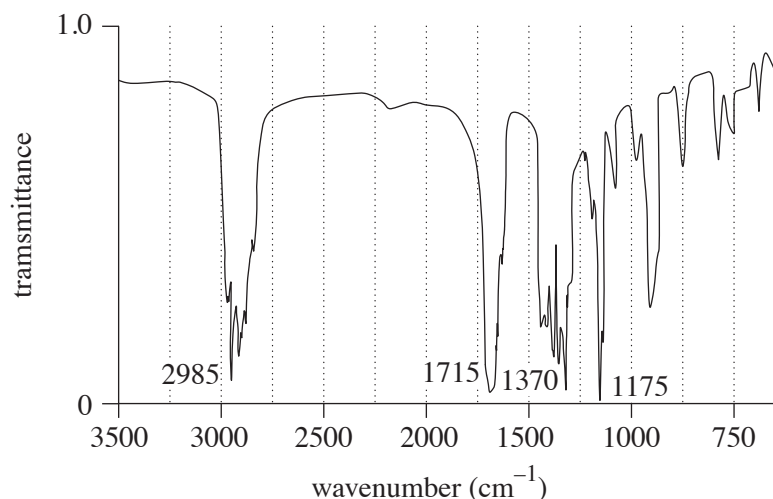
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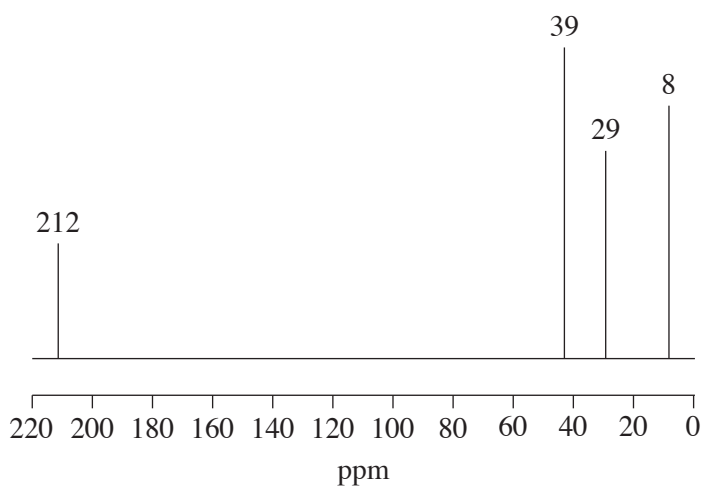
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A student investigating the identity of compound X examined the following spectroscopic data.

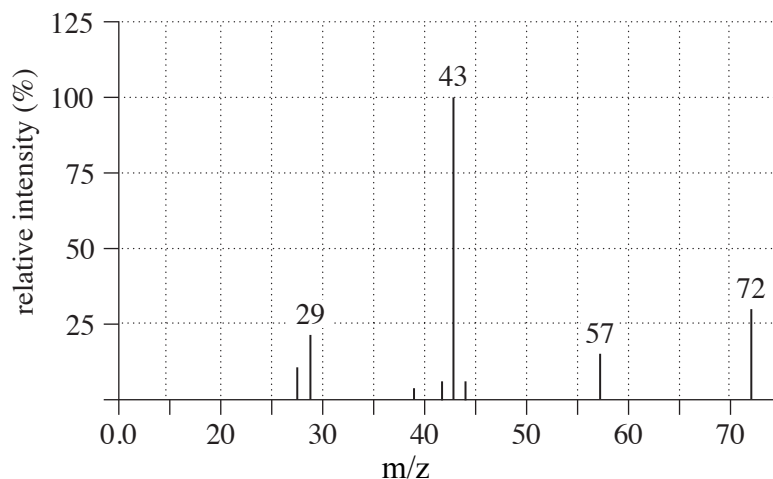
Infrared spectrum of compound X



¹³C NMR spectra of compound X



Mass spectrum of compound X



After narrowing down the identity of compound X to one of two possibilities, the student conducted a final chemical test to identify the compound. The student tested the reaction of compound X with acidified potassium permanganate and no colour change was observed.

Identify compound X. Support your answer with an analysis of the evidence provided.

Infrared absorption data

Bond	Wavenumber/cm ⁻¹
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

¹³C NMR chemical shift data

Type of carbon	δ/ppm
$\begin{array}{c} \quad \\ -C - C- \\ \quad \end{array}$	5–40
$\begin{array}{c} \\ R - C - Cl \text{ or } Br \\ \end{array}$	10–70
$\begin{array}{c} \\ R - C - C - \\ \quad \\ O \end{array}$	20–50
$\begin{array}{c} \\ R - C - N \\ \quad \diagup \end{array}$	25–60
$\begin{array}{c} \\ -C - O - \\ \end{array}$ alcohols, ethers or esters	50–90
$\begin{array}{c} \diagdown \quad \diagup \\ C = C \\ \diagup \quad \diagdown \end{array}$	90–150
R — C ≡ N	110–125
	110–160
$\begin{array}{c} R - C - \\ \\ O \end{array}$ esters or acids	160–185
$\begin{array}{c} R - C - \\ \\ O \end{array}$ aldehydes or ketones	190–220

UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ _{max} (nm)
C—H	122
C—C	135
C=C	162

Chromophore	λ _{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

[illegible]



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