Victorian Certificate of Education

CHEMISTRY 2026 Unit 4

SAC 4 AOS 2 Outcome 2

Analysis and evaluation of primary and secondary data, including identified assumptions or data limitations, and conclusions

Reading time: 5 minutes

Writing time: 70 minutes

Directions to students

Student's Name: _____

Teacher: _____

Structure of booklet

Section	Question to be answered	Total marks
Short answer	4	62
	Total	62

Materials

- Students are permitted to bring into the examination room: pencils, highlighters, erasers, sharpeners, **rulers**, and an approved scientific calculator.
- Students are NOT permitted to bring into the examination room:
white out liquid/tape, phones or electronic devices, including smart watches.
- Students are provided with the following: Question and answer book of 13 pages and VCAA Data booklet.

The task

- Please ensure that you write your name and teacher's name on this booklet. This paper consists of short answer questions.

- There are a total of 62 marks available.

- Be sure to include states with all chemical equations.

- All numerical answers need to be quoted to the correct number of significant figures.

- All working out must be shown in the space provided.

1. Vitamin C (ascorbic acid) is a vital nutrient commonly found in fruits, where it contributes to their antioxidant properties and nutritional value. Quantitative analysis of vitamin C content in fruits is often performed using titration methods due to their accuracy and simplicity. Alongside vitamin C, fruits also contain various organic compounds responsible for their characteristic aromas and flavors. One such compound is a molecule known for its distinctive fruity scent reminiscent of bananas and pears that will be referred to as compound A. Understanding the concentration of vitamin C and identifying flavor compounds like compound A provides insights into fruit quality, ripeness, and nutritional value.



Figure 1 – the fruits shown have aa unique fruity smell due to a molecule called compound A.

1. A 25.00 mL sample of fresh apple juice was added to a 200 mL volumetric flask and filled to the mark with distilled water. Four 20.00 mL aliquots were then taken and pipetted into four separate 100 mL conical flasks with 2 drops of appropriate starch indicator. Each flask was titrated against a 0.00552 M I_2 solution. The results are shown in table 1 below. (20 marks)

Burette reading	1	2	3	4
Start	1.00	13.25	25.40	2.50
Final	13.25	25.40	37.75	14.70
Titre	12.25	12.15	12.35	12.20

Table 1 – the four titres for each trial of the titration with I_2 solution.

The reaction between vitamin C and I_2 is shown below.

$$\mathbf{C_6H_8O_6\ (ascorbic\ acid) + I_2 \rightarrow C_6H_6O_6\ (dehydroascorbic\ acid) + 2\ I^- + 2\ H^+}$$

a. Find the average titre of the titration. 2 marks

b. Find the mol of I_2 in the average titre. 2 marks

c. Find the concentration of Vitamin C in the volumetric flask in mol/Litre 2 marks

d. Find the concentration of Vitamin C in the sample of apple juice in mol/Litre. 2 marks

e. Express the concentration of Vitamin C (176 g/mol), given in question d. above, in % m/m, given the density of the apple juice is 1.18 g/mL 3 marks

f. The titration results show slight variation between trials (Table 1).

Explain how each of the following may impact the titre delivered.

- The burette was rinsed with the standard I_2 solution.

_____
_____
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_____(2 marks)

- The pipette used to deliver the 25.00 mL aliquot was washed with water but not dried.

_____
_____
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_____
_____
_____
_____
_____(2 marks)

g. A typical commercially available apple juice contains approximately 0.05% m/m Vitamin C.

i. Compare the concentration of vitamin C given as the answer to question e above and justify the discrepancy.

_____
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_____(2 marks)

ii. State one assumption made during this titration and describe how it impacts both the accuracy and validity of the experimental results.

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_____(3 marks)

2. Analysis of Compound A was undertaken. Several spectra of the compound are shown below. (26 marks)

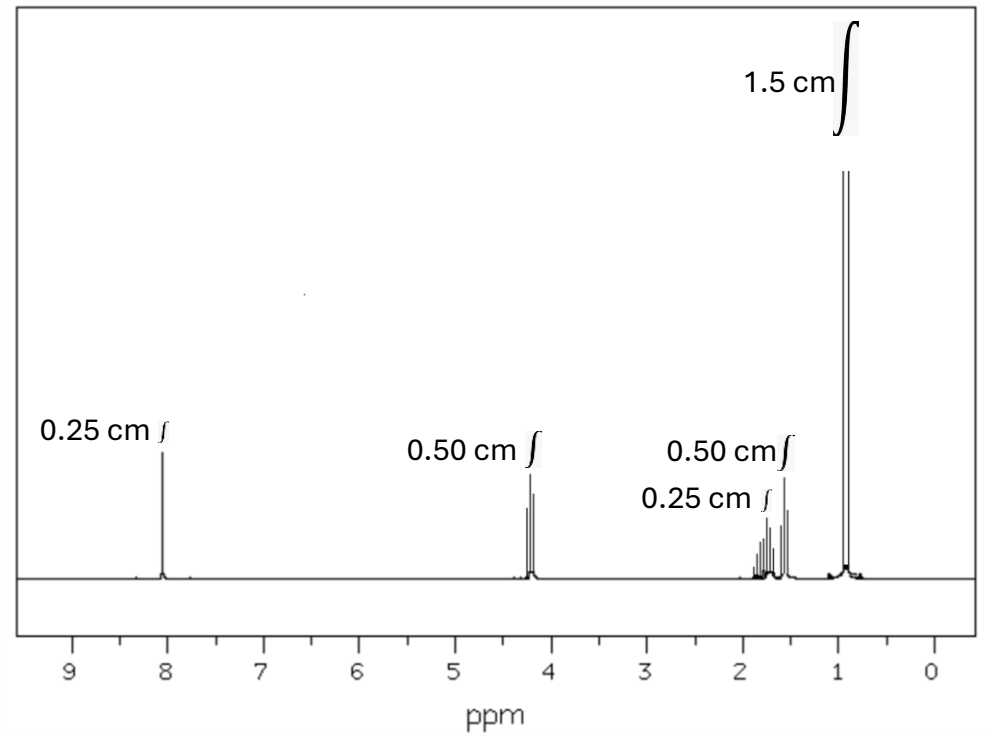


Figure 2 – ^{1}H-NMR of compound A ($C_6H_{12}O_2$) with integrations shown.

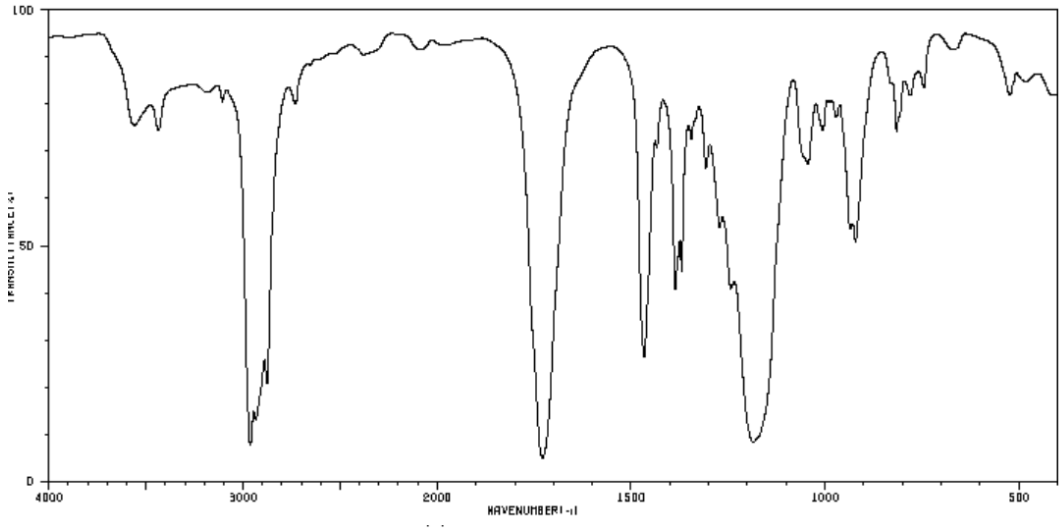


Figure 3 -IR spectrum of compound A ($C_6H_{12}O_2$)

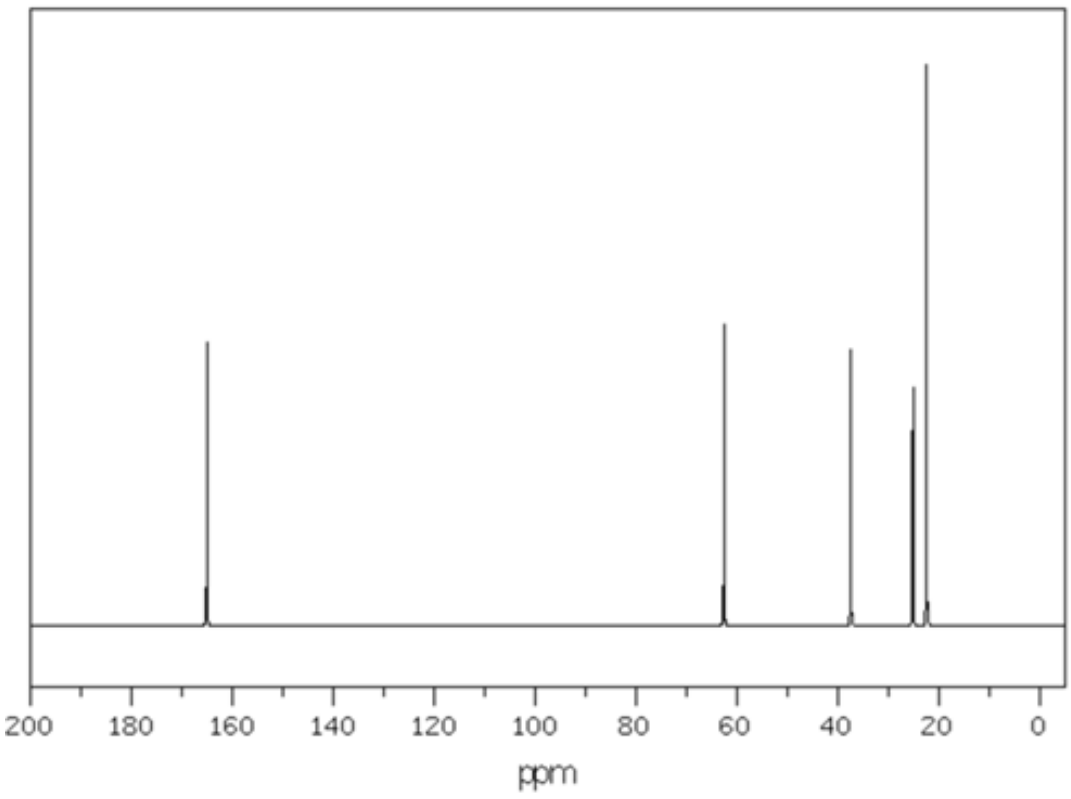


Figure 4 – ^{13}C-NMR of compound A($C_6H_{12}O_2$)

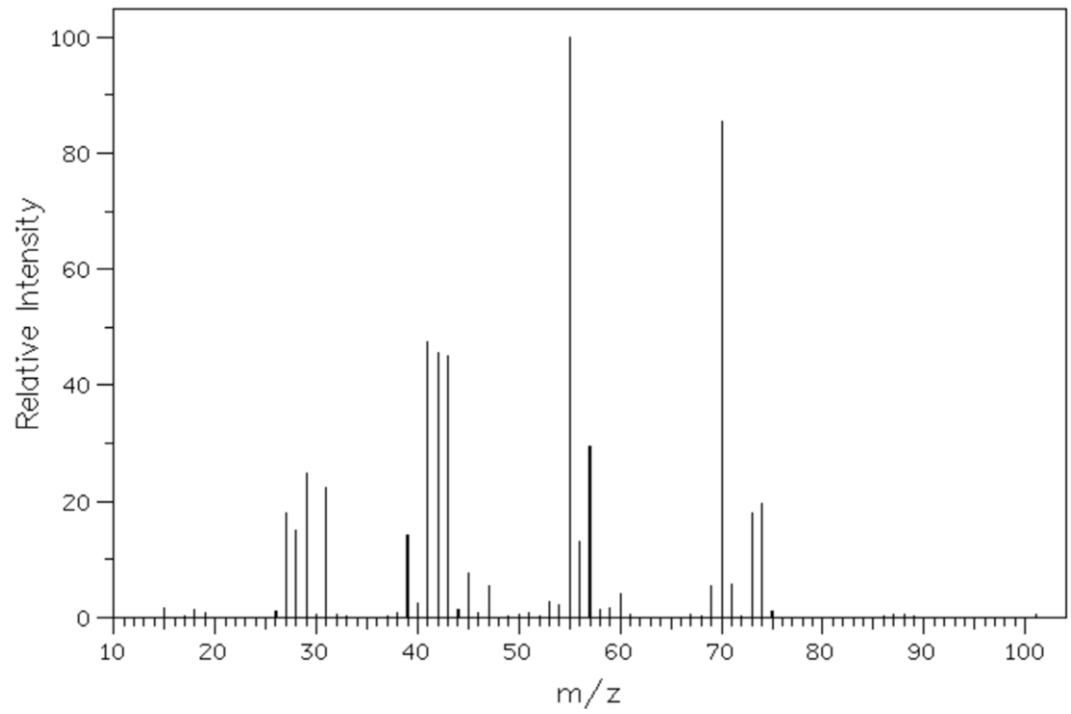


Figure 5 – Mass spectrum of compound A ($C_6H_{12}O_2$)

a. A student was unsure about which family of organic compounds compound A belongs to. Upon analysing its IR spectrum, the student noticed a strong absorption at **1190 cm^{-1}**, indicative of a C–O bond.
Using **item 21** of the 2026 VCAA Data Booklet and the IR spectrum provided, complete the table below by either:

- providing **two pieces of evidence** supporting the classification of compound A to the class of compounds you think it belongs to.
  or
- Providing **two pieces of evidence** that dismiss each of the other classes.
  Note: The "Acid" row is completed as an example. This shows that only one column needs to be filled per class (either support or dismiss), and in this example, the evidence dismisses compound A as an acid. (6 marks)

Class of compound	Evidence for choosing this class.	Evidence for dismissing this class
Alcohol		
Ketone		
Acid		***- no broad absorption between 2500-3500 cm^{-} suggesting an acidic OH.*** ***- no absorption of an acidic C=O bond between 1680-1740.***
Ester		

b. Describe why different bonds in a molecule absorb infrared radiation at different wavenumbers (cm^{-1}). In your answer suggest what might cause variations in absorption frequencies.

3 marks

c. Explain why a molecule such as CO_2 can absorb infrared radiation, but Cl_2 cannot.

3 marks

d. Consider the ^{1}H-NMR and ^{13}C-NMR spectra of compound A ($C_6H_{12}O_2$), shown above.

i. Compound A contains six carbon atoms in its molecular structure. Based on the ^{13}C-NMR spectrum, how many chemically unique carbon environments are present in each molecule?

_____ 1 mark

ii. Explain why the number of chemically unique carbons shown in the ^{13}C-NMR differs from the total number of carbon atoms in the molecule.

_____

_____

_____

_____ 2 marks

iii. With reference to item 22 of the 2026 VCAA data booklet, suggest to what functional group does the carbon that formed the peak at 165 ppm, of the ^{13}C-NMR, belongs to.

_____ 1 mark

iv. How many chemically unique hydrogen environments exist in the compound A?

_____ 1 mark

v. Using the integration curves shown in Fig. 2, determine the simplest relative ratio of hydrogens in each environment. Show your working clearly. 2 marks

vi. What information can be extracted by analysing the peak at 0.98 ppm of the ^{1}H-NMR spectrum formed.

_____

_____

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_____

_____3 marks

vii. Draw the skeletal structure of compound A in the space provided below.

3 marks

e. The mass spectrum of compound A shows a peak at 57 m/z. With reference to the structure drawn in question d. vii above, give the fragment that produced this peak?

_____ 1 mark

3. A chromatogram of a mixture of unknown plant pigments, shown in fig 9, was developed using reversed phase HPLC. (8 marks)

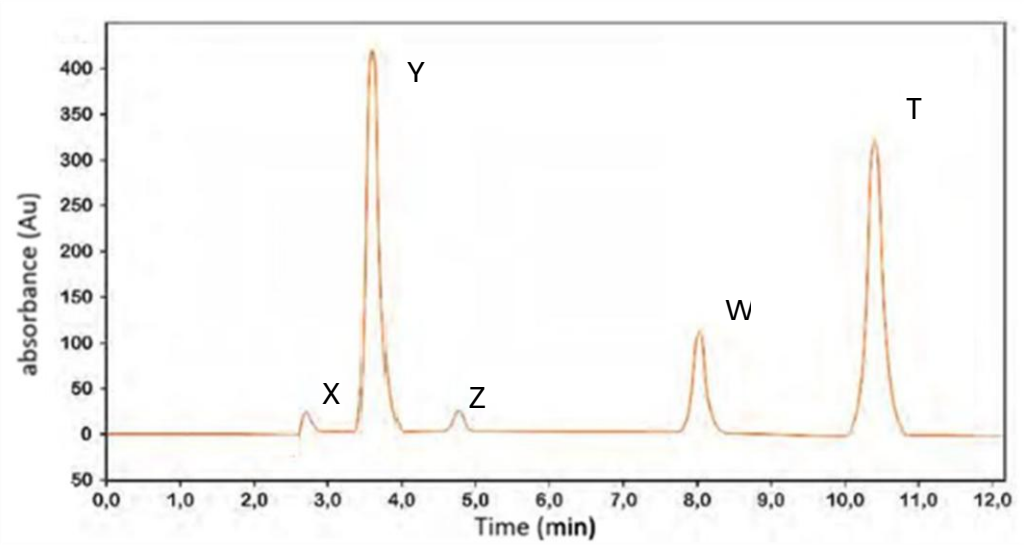


Figure 9 – A reversed phase HPLC chromatogram of a mixture of unknown plant pigments.

a. Explain how the chromatogram can be used to identify the presence of specific plant pigments in the mixture.

_____

_____

_____

_____

_____3 marks

b. Which compound is present in the highest concentration in the mixture? Justify your answer.

_____

_____

_____

_____

_____2 marks

c. Explain how the concentration of a component of the mixture can be accurately calculated?

_____

_____

_____

_____

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_____

_____

_____3 marks

4. A sample of fruit juice was used to obtain pure samples of limolene, ethyl acetate and malic acid. Reversed phase HPLC uses a polar stationary phase with a non-polar mobile phase. The structure of each compound is shown below. (14 marks)

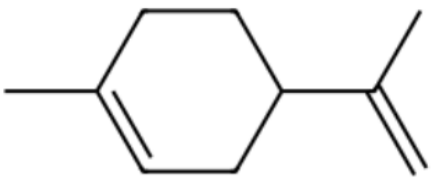


Figure 6 -Limolene

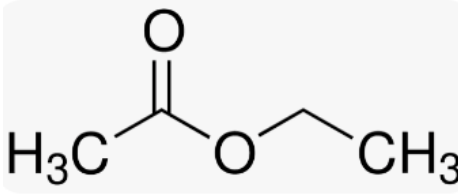


Figure 7 -Ethyl acetate

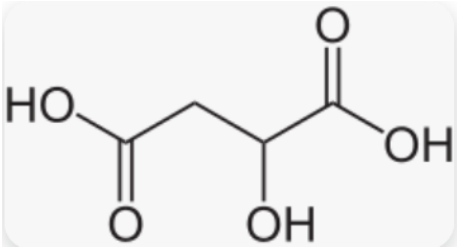


Figure 8 –Malic acid

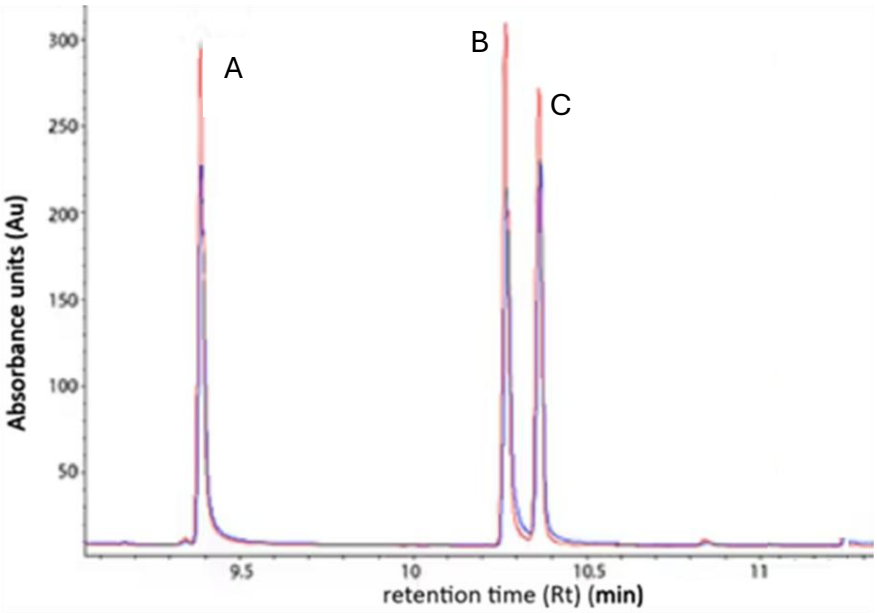


Figure 10 – Reversed phase HPLC chromatogram of a mixture of limolene, malic acid and ethyl acetate.

a. Identify the compound that produced each peak in the chromatogram in fig 10. Justify your answer.

_____

_____

_____

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_____

_____

_____3 marks

b. Peaks B and C in the chromatogram are very close to each other. Suggest two ways to increase the resolution between these peaks and explain how each method improves the separation.

Method 1

_____

_____

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_____2 marks

Method 2

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_____2 marks

c. A biochemical laboratory is investigating the enzyme-catalysed breakdown of malic acid and ascorbic acid in fruit extracts. Ethyl acetate is used as a solvent to extract potential enzyme inhibitors. The laboratory uses steam distillation to purify volatile compounds.

i. Briefly describe the role of the **active site** in enzyme activity and explain how a competitive inhibitor could affect the enzyme's action on malic acid or ascorbic acid.

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_____2 marks

ii. Explain why ethyl acetate is a suitable solvent for extracting enzyme inhibitors, which may be polar or nonpolar, from fruit extracts. Refer to its chemical properties and the principle of solvent extraction.

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_____2 marks

iii. Volatile compounds in fruit often have high boiling points and subject to breakdown at these high temperatures. Explain why steam distillation is preferred over simple distillation for purifying these compounds during extraction. Include the advantages of steam distillation for heat sensitive compounds..

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_____3 marks

End of assessment