Neap

Diagnostic Topic Test 2024

VCE Chemistry Units 3&4

Question and Answer Booklet

Test time: 45 minutes
Total marks: 35 marks

Test 6: How are organic compounds analysed and used?

- Laboratory analysis of organic compounds
- Instrumental analysis of organic compounds

Student's Name: _____

Teacher's Name: _____

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page.

A data booklet is provided.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Answer **all** questions in the spaces provided.

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Circle the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
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Question 1

Three organic compounds are listed below.

I 2-methylpropan-2-ol

II 2-propanamine

III propanoic acid

Which of the above would show three peaks in its low-resolution ^{1}H NMR spectrum?

A. I only

B. II only

C. I and III only

D. II and III only

Question 2

Which of the following processes is involved in analysis by infrared spectroscopy?

A. the movement of positively charged particles using electric and magnetic fields

B. the absorption of energy, which changes the vibrational motion of a molecule

C. the absorption of energy by hydrogen nuclei

D. the emission of light as electrons move from higher energy levels to lower energy levels

Question 3

Oxalic acid, $H_2C_2O_4$, reacts readily with strong oxidants such as acidified potassium permanganate, $KMnO_4$, according to the following equation.

$$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

An impure sample of $H_2C_2O_4$ of mass 6.96 g was dissolved in approximately 50 mL of distilled water in a volumetric flask and made up to 250.0 mL. A 20.00 mL aliquot of this solution was then titrated against a freshly prepared 0.105 M acidified $KMnO_4$ solution. The endpoint was reached when an average of 15.6 mL of $KMnO_4$ had been added and the solution retained a pink colour.

Which one of the following identifies the liquids that should be used to rinse each piece of glassware immediately prior to their use in the volumetric analysis?

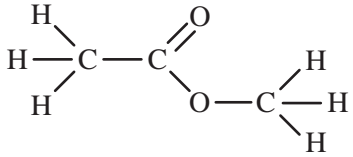
	Volumetric flask	Pipette	Burette	Conical flask
A.	distilled water	$H_2C_2O_4$ solution	acidifed $KMnO_4$ solution	distilled water
B.	distilled water	distilled water	distilled water	distilled water
C.	$H_2C_2O_4$ solution	$H_2C_2O_4$ solution	acidifed $KMnO_4$ solution	$H_2C_2O_4$ solution
D.	distilled water	acidifed $KMnO_4$ solution	$H_2C_2O_4$ solution	distilled water

Question 4

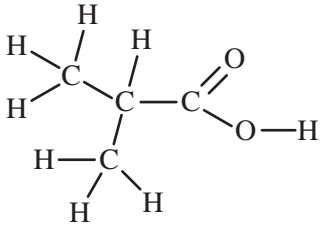
The infrared spectrum of an unknown compound shows distinct absorption peaks in the 1700–1750 cm^{-1} and 2500–3000 cm^{-1} regions. The ^1H NMR spectrum of the compound shows three peaks, a triplet, a quartet and a single peak.

Which of the following molecules is consistent with the spectral data provided?

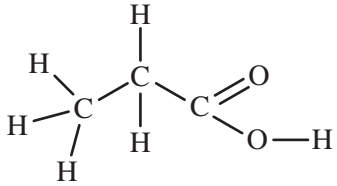
A.



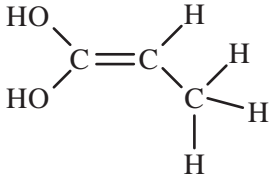
B.



C.



D.



Question 5

0.200 g of a hydrocarbon of molar mass 82 g mol^{-1} reacts exactly with 1.24 g of iodine.

Which one of the following could describe the hydrocarbon?

A. saturated

B. unsaturated with one carbon–carbon double bond

C. unsaturated with two carbon–carbon double bonds

D. unsaturated with three carbon–carbon double bond

Question 6

Glucocorticoid is a member of a class of compounds known as corticosteroids and is used in the treatment of itching, swelling and redness of the skin. It is a large and complex molecule of formula $C_{22}H_{29}FO_4$.

The analytical instrument **least** useful in determining the structure of glucocorticoid is the

A. infrared spectrometer.

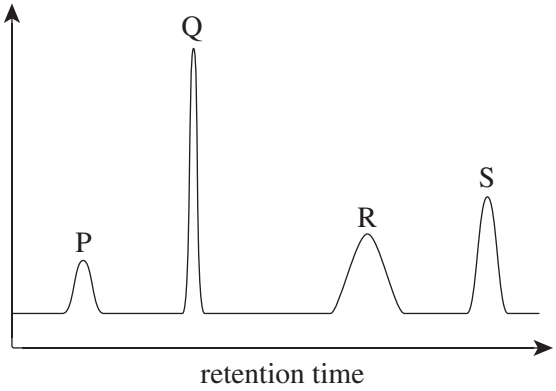
B. high-performance liquid chromatograph.

C. mass spectrometer.

D. ^1H nuclear magnetic resonance spectrometer.

Question 7

The chromatogram below shows the amino acid components of a mixture separated by high-performance liquid chromatography (HPLC).



Which of the following is a reasonable conclusion from the data presented in the chromatogram above?

A. The amount of each component in the mixture is given by the height of each peak.

B. Component P has the lowest concentration and would be eluted last from the column.

C. Component S is the least strongly adsorbed to the stationary phase in the column.

D. Component Q has a greater attraction to the mobile phase than component S.

Question 8

An unknown compound X reacted completely with acidified potassium dichromate solution to produce compound Y. Compound Y does not react when solid sodium carbonate is added to it.

Which of the following is compound X most likely to be?

A. propanal

B. butan-1-ol

C. 2-methylpropan-2-ol

D. 3-methylbutan-2-ol

Question 9

When solutions of $AgNO_3$ and NaCl react, the balanced equation is as follows.

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

When 3.10 g of $AgNO_3$ ($M = 169.9$ g mol^{-1}) and 0.600 g of NaCl ($M = 58.5$ g mol^{-1}) react, the amount of which reactant should be used to calculate the expected mass of AgCl that will form?

A. either reactant

B. $AgNO_3$

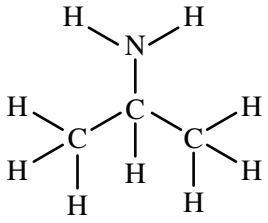
C. NaCl

D. neither, because the expected mass of AgCl can only be determined by an experiment

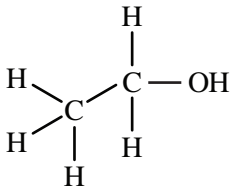
Question 10

Which of the following compounds would have a major peak in its mass spectrum at a mass/charge (m/z) ratio of 44?

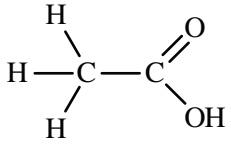
A.



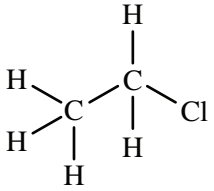
B.



C.



D.



END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

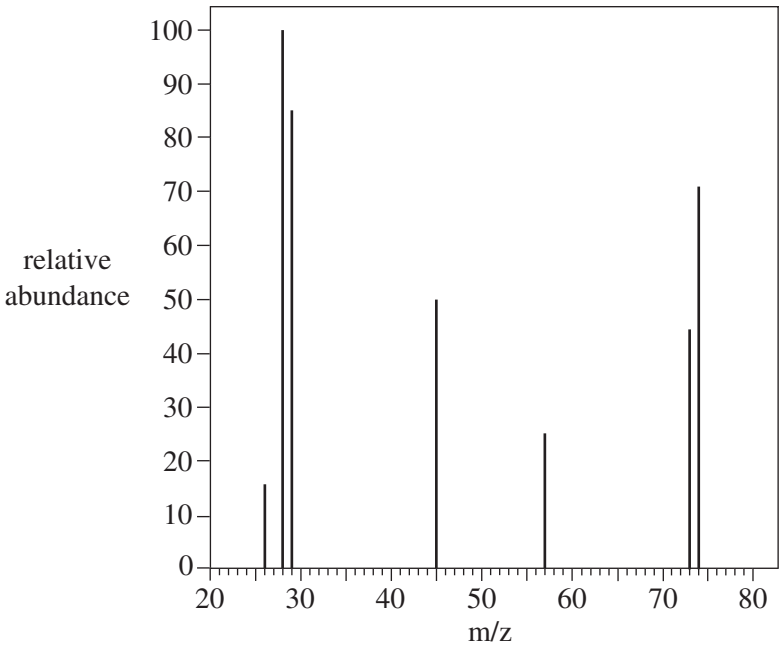
Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, NaCl(s).

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1 (12 marks)

A sweet-smelling liquid, X, undergoes hydrolysis in acidic conditions to give two organic products, Y and Z. Product Y was found to be a water-soluble carboxylic acid. The mass spectrum of Y is shown below.



a. **i.** Determine the molar mass of Y. 1 mark

ii. Suggest a fragment ion responsible for the peak at the m/z value of 29. 1 mark

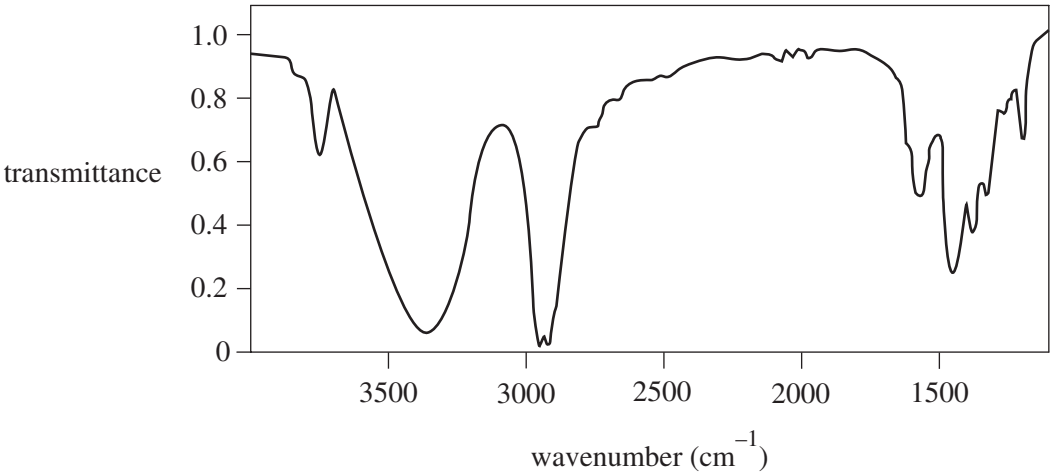
iii. Draw the structural formula of compound Y, showing all bonds. 1 mark

b. Product Z was found to have a relative molecular mass of 60, and contained 60.0% carbon, 13.3% hydrogen and 26.7% oxygen by mass.

i. Determine the empirical formula of Z. 2 marks

ii. Determine the molecular formula of Z. 1 mark

iii. The infrared spectrum of compound Z is shown below.



Draw **two** possible structural formulas for the isomers of compound Z. 2 marks

iv. The low-resolution ^{1}H NMR spectrum of compound Z shows four peaks.
Give the IUPAC name of compound Z. 1 mark

c. Draw a structural formula for compound X (the original sweet-smelling liquid). 1 mark

d. Describe a simple chemical test, including the expected results, that could distinguish between compound X and compound Y. 2 marks

Question 2 (7 marks)

Vitamin C is found in citrus fruits and vegetables such as spinach. The level of vitamin C (ascorbic acid) in citrus fruits can be determined using a redox titration with iodine. The reaction produces dehydroascorbic acid and iodide ions as its products, and starch is used as an indicator. The equation for the reaction is as follows.

$$C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2I^-(aq) + 2H^+(aq)$$

In an experiment to determine the level of vitamin C in oranges, the juice from 200.0 g of oranges was collected and strained into a 100.0 mL volumetric flask, then made up to the mark with deionised water. 20.0 mL aliquots of this solution were titrated against a standardised 0.00498 M iodine solution. The average titre required was 25.1 mL.

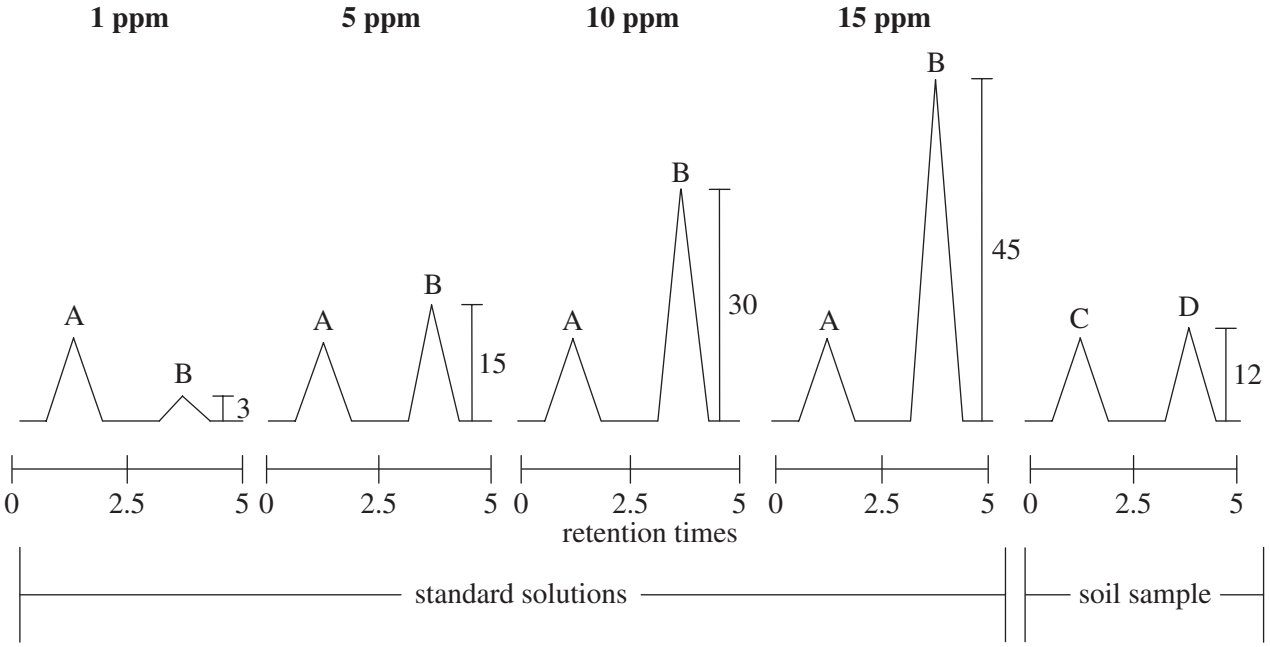
a. **i.** Calculate the concentration, in M, of vitamin C in the diluted orange juice. 3 marks

ii. Calculate the mass of vitamin C in the 200.0 g of oranges. 2 marks

b. Suggest why a redox titration , rather than an acid–base titration, was used to determine the ascorbic acid level. 2 marks

Question 3 (6 marks)

Atrazine is a herbicide commonly used in agriculture. A sample of soil has been analysed for atrazine using HPLC. To determine the amount of atrazine in the soil sample, a number of solutions of atrazine in methanol (solvent) of known concentrations (1 ppm–15 ppm) were injected into the column. After leaving the column, the solution passes through an ultraviolet spectrometer, where the atrazine is detected and peak height recorded. The results of each run are shown below.



a. Explain why components of a mixture take different times to pass through the HPLC column. 3 marks

b. There are two peaks, A and B, represented in the standard solution runs. One corresponds to the solvent, the other to atrazine.

Identify A and B, giving reasons for your choices. 2 marks

c. Determine the concentration, in ppm, of atrazine in the soil sample. 1 mark

END OF TEST