Neap

Diagnostic Topic Test 2024

VCE Chemistry Units 3&4

Suggested Solutions

Test 6: How are organic compounds analysed and used?

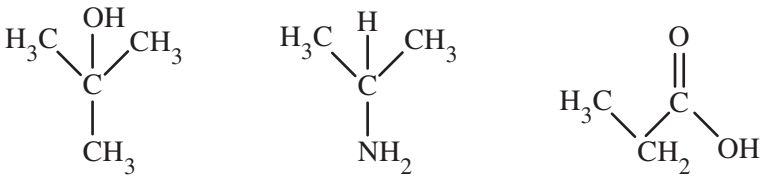
- Laboratory analysis of organic compounds
- Instrumental analysis of organic compounds

SECTION A – MULTIPLE-CHOICE QUESTIONS

Question 1 D

It is helpful to draw the structures.

I **II** **III**



Option I would show two peaks only because the nine methyl hydrogens are equivalent. Option II would show three peaks (CH_3, H, NH_2), and option III would also show three peaks (CH_3, CH_2, OH).

Question 2 B

B is correct. Infrared spectroscopy involves the absorption of infrared radiation. Absorption of energy of this radiation causes bending, stretching and vibration of bonds within molecules.

A is incorrect. The movement of positively charged particles using electric and magnetic fields is a feature of mass spectrometry.

C is incorrect. The absorption of low-energy radiation by hydrogen nuclei placed in a magnetic field occurs in NMR spectroscopy.

D is incorrect. The emission of light as electrons move occurs in atomic emission spectroscopy.

Question 3 A

Flasks are always rinsed with distilled water. Pipettes and burettes are rinsed with the solution that they will contain. In this volumetric analysis, the pipette delivers the aliquot of oxalic acid ($H_2C_2O_4$) solution, so it is rinsed with the $H_2C_2O_4$ solution. The burette delivers the acidified permanganate ($KMnO_4$) solution, so it is rinsed with the $KMnO_4$ solution.

Question 4 C

C is correct and **D** is incorrect. The characteristic peak at 1700 cm^{-1} suggests the presence of the carbonyl (C=O) group. A peak in the 2500–3000 cm^{-1} region could be the OH group of an acid (a broad peak), or simply a CH (smaller, sharper peak).

A is incorrect. This structure would have only two peaks on the ^1H NMR spectrum.

B is incorrect. This structure would have three peaks on the ^1H NMR spectrum, but the splitting pattern would be a singlet, a doublet and a septet.

Question 5 C

$$n(\text{hydrocarbon}) = \frac{m}{M} = \frac{0.200}{82} = 2.44 \times 10^{-3} \text{ mol}$$

$$n(I_2) = \frac{m}{M} = \frac{1.24}{253.8} = 4.89 \times 10^{-3} \text{ mol}$$

The ratio of hydrocarbon to iodine is 1 : 2, indicating that the molecule contains two carbon–carbon double bonds.

Question 6 B

B is correct. High-performance liquid chromatography (HPLC) is useful for the separation and identification of organic compounds, but not for the determination of the structure.

A is incorrect. Infrared spectroscopy provides information about functional groups present in the molecule.

C is incorrect. The fragmentation pattern from the mass spectrometer provides structural information.

D is incorrect. ^1H NMR spectroscopy provides information about the arrangement of the hydrogen atoms within the molecule.

Question 7 D

D is correct. Component Q is eluted before component S and thus would be less attracted to the stationary phase and more attracted to the mobile phase.

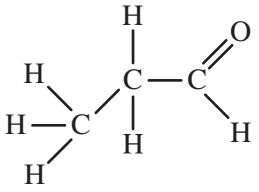
A is incorrect. The area under the peak indicates the amount of each component.

B is incorrect. Component P possibly has the smallest peak area and thus the lowest concentration, but it has the shortest retention time (it is eluted first).

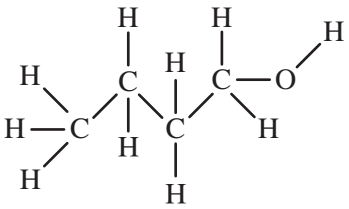
C is incorrect. The most strongly adsorbed component is the one with the longest retention time.

Question 8 D

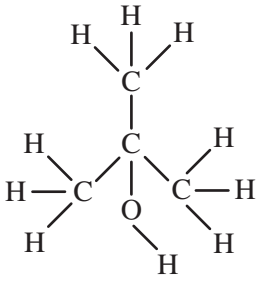
D is correct. The relevant structures are shown below.



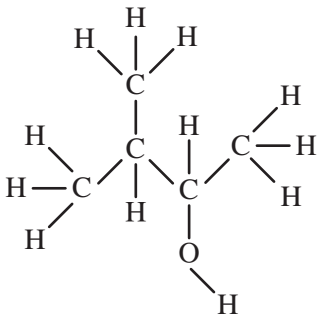
propanal



butan-1-ol



2-methylpropan-2-ol



3-methylbutan-2-ol

3-methylbutan-2-ol is a secondary alcohol that will be oxidised to the ketone, 3-methylbutan-2-one. Ketones are not acidic and so do not react when solid sodium carbonate is added.

A and **B** are incorrect. Propanal (aldehyde) and butan-1-ol (primary alcohol) will both be oxidised by a dichromate solution to form a carboxylic acid, propanoic and butanoic respectively. These acids would react with solid sodium carbonate to produce carbon dioxide, water and a salt.

C is incorrect. 2-methylpropan-2-ol is a tertiary alcohol and will not be oxidised easily by a dichromate solution. Complete oxidation of this alcohol would produce carbon dioxide and water.

Question 9 C

$$n(\text{AgNO}_3) = \frac{m}{M} = \frac{3.10}{169.9} = 0.01824 \text{ mol}$$

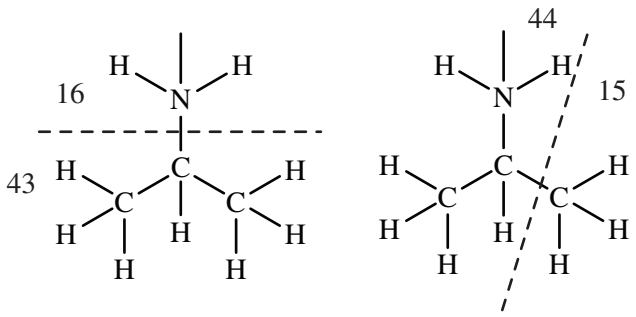
$$n(\text{NaCl}) = \frac{m}{M} = \frac{0.600}{58.5} = 0.01026 \text{ mol}$$

There is a 1 : 1 mole ratio; hence, the NaCl is the limiting reagent and should be used in calculating the expected mass of AgCl.

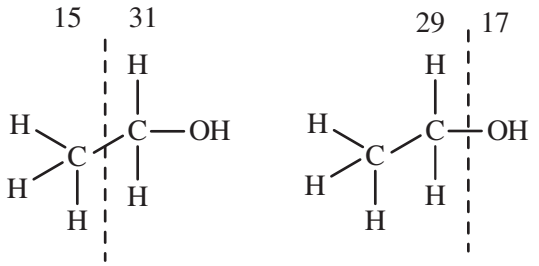
Question 10 A

Typical fragments are shown below.

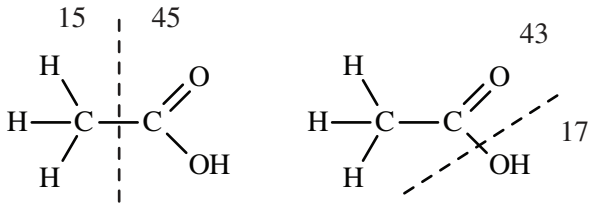
A.



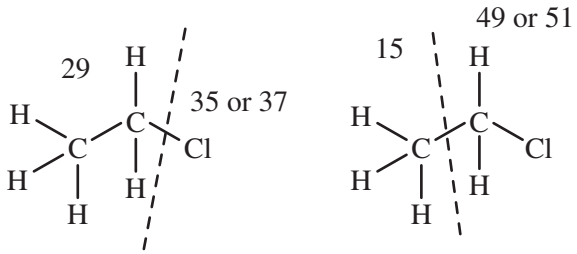
B.



C.



D.



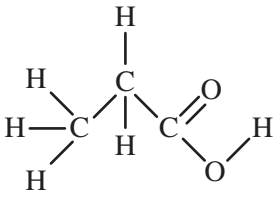
SECTION B

Question 1 (12 marks)

a. **i.** $M = 74 \text{ g mol}^{-1}$ 1 mark

ii. $CH_3CH_2^+$ 1 mark

iii.



1 mark

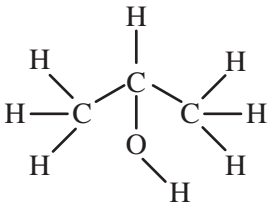
b. **i.** $\text{C} : \text{H} : \text{O} = \frac{60.0}{12.0} = \frac{13.3}{1.0} = \frac{26.7}{16.0} = 5.0 : 13.3 : 1.67 = 3 : 8 : 1$ 1 mark

The empirical formula is C_3H_8O. 1 mark

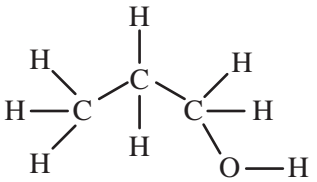
ii. $\text{MF} = (C_3H_8O)_a$, where $a = \frac{\text{RMM}}{\text{EFM}} = \frac{60}{60} = 1$

The molecular formula is C_3H_8O. 1 mark

iii.



(2-propanol)



(1-propanol)

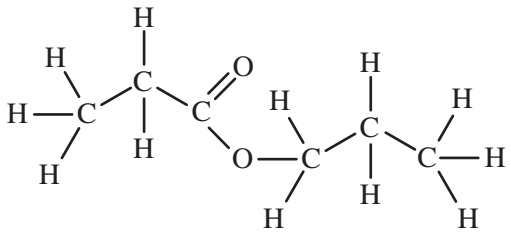
2 marks

1 mark for each correct structure.

iv. 1-propanol 1 mark

(The ^{1}H NMR data shows that compound Z is 1-propanol. 2-propanol would only show three peaks, as the six methyl hydrogens are equivalent.)

c.



1 mark

d. Shake each of compounds X and Y separately with a small quantity of powdered sodium carbonate, Na_2CO_3. Make observations of both solutions. 1 mark

Compound Y, the carboxylic acid, will react vigorously and evolve CO_2 gas quickly and completely. Compound X, the ester, will show no reaction. 1 mark

OR

Add universal indicator to the compounds. 1 mark

Compound Y, the carboxylic acid, will produce a red/yellow colour, whereas compound X, the ester, will remain green. 1 mark

Question 2 (7 marks)

a. **i.** $n(I_2) = c \times V = 0.00498 \times 0.0251$ mol 1 mark

$n(C_6H_8O_6) = n(I_2) = 0.00498 \times 0.0251$ mol 1 mark

$$c(C_6H_8O_6) = \frac{n}{V} = \frac{0.00498 \times 0.0251}{0.0200} = 0.00625 \text{ M}$$ 1 mark

ii. $m(C_6H_8O_6)$ in a 20.0 mL aliquot $= n \times M = 0.00498 \times 0.0251 \times 176.0 = 0.0220$ g 1 mark

$m(C_6H_8O_6)$ in a 100.0 mL solution $= m(C_6H_8O_6)$ in 200.0 g of oranges

$$= 0.0220 \times \frac{100.0}{20.0} = 0.110 \text{ g}$$ 1 mark

b. The oranges may contain other acids in addition to the ascorbic acid (for example, citric acid). An acid–base titration would determine total acid content, not specifically ascorbic acid content. 1 mark

The redox reaction involves only ascorbic acid and so is a specific measure of this acid. 1 mark

Question 3 (6 marks)

a. Each component has a different structure and polarity, and so is attracted differently to the solvent and column. 1 mark

The components will be moved at different rates along the column depending on their relative attractions for the mobile and stationary phases. 1 mark

Components attracted more strongly to the stationary phase will be retained for a longer period of time in the column before being eluted, so will have a longer retention time. 1 mark

b. The solvent concentration will remain relatively consistent so its peak height will not change (A). 1 mark

The atrazine concentrations change from 1 to 15 ppm, so peak heights will increase (B). 1 mark

c. Using the peak heights, each 1 ppm produces a peak height of 3 mm.

The peak height of D is 12 mm, hence the concentration of atrazine = 4 ppm. 1 mark

