

Practice Question Set For A-Level

Subject : Chemistry

Paper-2 Topic: Nuclear Magnetic Resonance Spectroscopy

Name of the Student: _____

Max. Marks : 21 Marks

Time : 21 Minutes

Mark Schemes

Q1.
C

[1]

Q2.

IR

Extended response

Absorption at 3360 cm^{-1} shows OH alcohol present

Deduction of correct structure without explanation scores maximum of 4 marks as this does not show a clear, coherent line of reasoning.

M1

1

NMR

There are 4 peaks which indicates 4 different environments of hydrogen

Maximum of 6 marks if no structure given OR if coherent logic not displayed in the explanations of how two of OH, CH_3 and CH_2CH_3 are identified.

M2

1

The integration ratio = $1.6 : 0.4 : 1.2 : 2.4$

The simplest whole number ratio is $4 : 1 : 3 : 6$

M3

1

The singlet (integ 1) must be caused by H in OH alcohol

M4

1

The singlet (integ 3) must be due to a CH_3 group with no adjacent H

M5

1

Quartet + triplet suggest CH_2CH_3 group

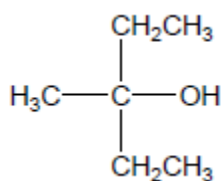
M6

1

Integration 4 and integration 6 indicates two equivalent CH_2CH_3 groups

M7

1



M8

1

[8]

Q3.

(a) Method 1

$$M1 \text{ \%O} = 27.1$$

$$\begin{array}{ccc} \frac{61.0}{12.0} & \frac{11.9}{1.0} & \frac{27.1}{16.0} \\ = 5.08 & = 11.9 & = 1.69 \end{array}$$

$$M2 \quad 3 \quad 7 \quad 1$$

$$M3 \quad C_3H_7O = 59 \text{ which is half of } M_r \text{ so } MF = 2EF$$

OR

Method 2

$$M1 \quad 61\% \text{ of } 118 = 72.0 \text{ and } 11.9\% \text{ of } 118 = 14.0$$

$$M2 \quad 72 + 14 = 86 \text{ so oxygen} = 32 \text{ out of } 118$$

$$\text{OR } 27.1\% \text{ of } 118 = 32.0$$

$$\begin{array}{ccc} \frac{72.0}{12.0} & \frac{14.0}{1.0} & \frac{32.0}{16.0} \\ = 6 & = 14 & = 2 \end{array}$$

M3

Method 3

Alternative using given molecular formula

$$M1 \quad C = \frac{12 \times 6}{118} \times 100 = 61.0\%$$

$$M2 \quad H = \frac{14 \times 1}{118} \times 100 = 11.9\%$$

$$M3 \quad O = \frac{16 \times 2}{118} \times 100 = 27.1\%$$

3

- (b) For this question, marks can be awarded either for a description of how the structure is derived or from the given structure itself. The maximum mark to be awarded is nine from the ten marks listed.

Marks fall into three sections:

- Infrared evidence : two marks are available for use of the infrared evidence, (M1 and M10)
- Chemical evidence: one mark is available for use of the chemical evidence (M2)
- N.m.r. evidence: six marks are available for use of the n.m.r. evidence (M3 – M8 inclusive)

plus one mark (M9) for a completely correct structure.

Suggested procedure for marking

First look at the infrared spectrum: marks M1 and M10 may be scored there or in the written answer.

Then look for use of the acidified potassium dichromate(VI) evidence, (M2).

Then look at the final structure: this may lead to the award of marks M3 to M9 as shown on the structures below.

Beware contradictions, e.g. using the chemical evidence they may state that **R** is a primary or secondary alcohol but then draw a tertiary alcohol. This will lose M2 but may score M3.

The written 'evidence' frequently simply contains extracts from the Table **B** on the Data Sheet and, if only this is given, is unlikely to score many marks.

Described

Or drawn

M1 Infrared peak/absorbance at 3400 cm^{-1} = O-H alcohol
(reference to ir spectrum needed)

Note: please check the spectrum

*If peak at 3000 cm^{-1} is identified as acid then cannot score M1
(contradiction)*

M10 **Either** no peak between $1680\text{--}1750\text{ cm}^{-1}$ so no C=O or not aldehyde/acid
OR peak at $1000\text{--}1300\text{ cm}^{-1}$ so C-O present

Apply list principle to IR analysis for M10

M2 (Acidified potassium dichromate(VI) turns green) so primary alcohol or secondary alcohol or not tertiary alcohol

Ignore aldehyde here

Lose M2 if just tertiary alcohol in structure

M3 $\delta = 3.1$ singlet or integration = 1 is O-H

Award M3 if structure has 1 O-H group only (can be primary, secondary or tertiary)

Lose M3 if more than one OH group shown

M4 two triplets at 1.4 & 3.8 = $\text{--CH}_2\text{--CH}_2\text{--}$

Allow $\text{--CH}_2\text{--CH}_2\text{--CH}_2\text{--}$

M5 $\delta = 3.8$ means CH_2 attached to O (in ether NOT ester)

Allow $\text{O--CH}_2\text{--CH}_2\text{--CH}_2\text{--C}$

$\delta = 1.4$ means CH_2 attached to C (but not to C=O)

M6 $\delta = 1.1$ (singlet) integration 6 = $2 \times$ equivalent CH_3 on same C

$\text{--C(CH}_3)_2\text{--}$

M7 $\delta = 1.1$ singlet so no H attached to $\text{--C(CH}_3)_2\text{--}$

$\text{R--C(CH}_3)_2\text{--R}$

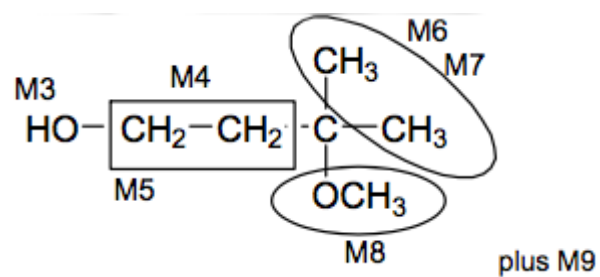
M8 $\delta = 3.2$ singlet integration 3 = --OCH_3

--OCH_3

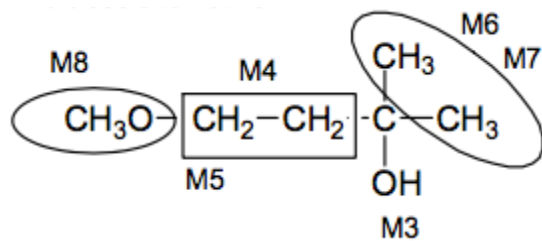
M9 For completely correct

If no structure given then Max 8

R is



This close alternative



would not score M9, but could score up to 8 marks

[12]