EXAM PAPERS PRACTICE

Boost your performance and confidence with these topic-based exam questions

Practice questions created by actual examiners and assessment experts

Detailed mark scheme

Suitable for all boards

Designed to test your ability and thoroughly prepare you

Time allowed
103 Minutes

Score /86

Percentage %

CHEMISTRY

OCR AS & A LEVEL

Mark Scheme

Module 6: Organic chemistry and analysis

F324: Rings, Polymers & Analysis
4.3.2 – Spectroscopy MARK SCHEME

1. (a) **infrared – 1 mark only**

shows (very broad) peak between 2500–3300 (cm^{-1})
(due to O–H bond) ✓

ALLOW *(very broad) peak around 3000 (cm^{-1})* ***OR*** *any stated value between 2500 and 3300 (cm^{-1}) for O–H*
DO NOT ALLOW *peak in range 3200–3550 (cm^{-1})*
IGNORE *any reference to C=O or C–O as both are also present in an ester* ***OR*** *to fingerprint region*

^{13}C NMR – 2 marks

$(CH_3)_2CHCH_2COOH$ has 4 peaks (due to 4 different C environments) ✓
$(CH_3)_3CCOOH$ has 3 peaks (due to 3 different C environments) ✓

ALLOW *'^{13}C NMR detects the number of/different C environments' for 1* ✓*, suitable example for the 2nd mark 3*

3

(b) **splitting pattern**

explains any two in terms of '*n* + 1 rule' for two marks ✓✓
Explains any one peak for 1 mark ✓

1 mark *for correct ester*

if two splitting patterns are correctly analysed ***ignore*** *the third*

- *singlet* therefore adjacent C (if any) has no Hs

  ALLOW *singlet because next or bonded to an O*

- *multiplet* **OR** split into 7 therefore adjacent Cs have lots of/6 Hs

  ALLOW *multiplet/heptet because next to 2 CH_3s*

- *doublet* therefore adjacent C is bonded to 1H

  ALLOW *doublet because next to a CH*

must spell ***one*** *of multiplet / heptet, singlet, doublet correctly*

max = 2 marks

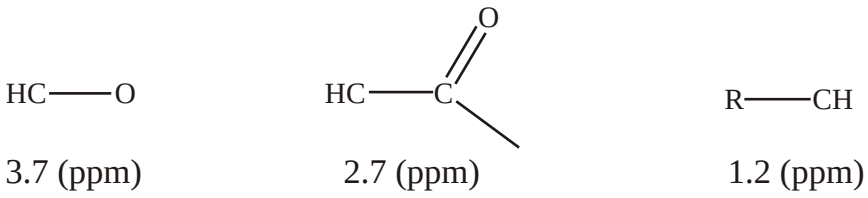
chemical shifts
two marks if any two absorptions are identified correctly ✓✓
one mark if any one absorption is identified correctly ✓

ALLOW *tolerance on δ values; 3.6–3.8, 2.6–2.8 and 1.1–1.3 (ppm)*

- peak ~3.7 (ppm) – bonded to an O
- peak ~2.7 (ppm) – indicates it is next to a C=O
- peak ~1.2 (ppm) – bonded to other Cs **OR** part of a chain

max = 2 marks

ALLOW *any two gets 2 marks, any one scores 1 mark*



ALLOW *peaks labelled on the spectrum*
ALLOW *singlet must be bonded to O, multiplet to C=O and doublet to CH or R for both chemical shift marks*
if two chemical shifts are correctly identified ***IGNORE*** *the third*

compound identified as $(CH_3)_2CHCOOCH_3$ ✓✓

compound identified as $CH_3COOCH(CH_3)_2$ ✓

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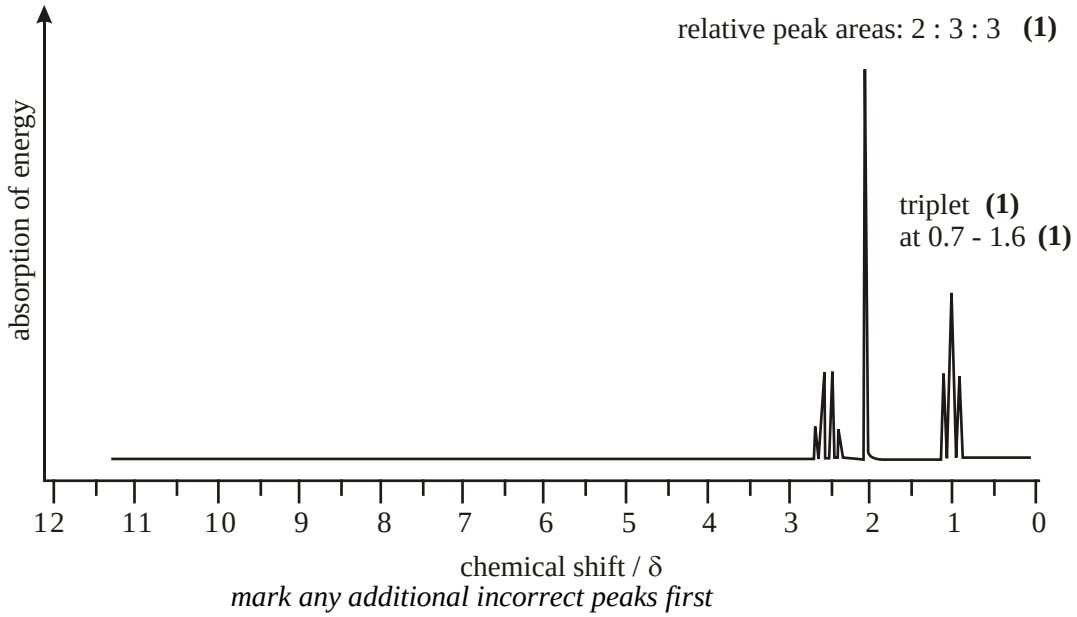
[9]

2. (i) the peak is due to the CH_3CO- group **(1)**

not split, so next to a C with no protons / has no neighbouring proton / δ value is in the range 2.0 – 2.9 **(1)** 2

(ii) adjacent to a C with three protons / to a CH_3 **(1)** 1

(iii) and (iv) 3



mark any additional incorrect peaks first

[6]

3. IR

Similarities
Any 2 of the following three peaks (must give the quoted range)
peak corresponding to OH in all three(3230 – 3550 cm^{-1}) **(1)**
peak corresponding to NH in all three(3100 – 3500 cm^{-1}) **(1)**
peak corresponding to CO in all three (1000 – 1300 cm^{-1}) **(1)** 2 max

Differences
only shown in the fingerprint region **(1)** 1

Mass Spec

similarities
M_r (75)/ base peak will be the same **(1)** 1
M + 1 peak same **(1)** 1

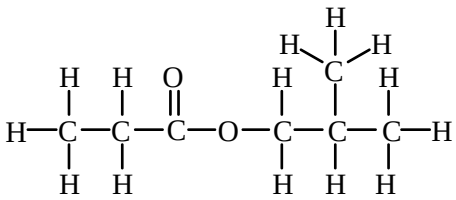
Differences
Fragmentation pattern may show differences between isomers / specific example, eg CH_3+ at m/e 15 **(1)** 1

(MAX 5)

QWC
Use of any two terms from: functional group / amino group / hydroxy group / fingerprint / fragmentation / fragment ion(s) / base peak or molecular ion / M + 1 peak / m/e 1

[6]

4. (a)



propanoate and ester group **(1)** 2-methyl propyl **(1)** 2

(b) propanoic acid **(1)**
(2-)methylpropan-1-ol **(1)**

heat **(1)**
conc. H_2SO_4 **(1)**
(allow ecf from part (a) for the equation)

$CH_3CH_2COOH + CH_3)_2CHCH_2OH \rightarrow CH_3CH_2COOCH_2CH(CH_3)_2 + H_2O$
reactants **(1)** products **(1)** 6

(c) mass spectrum / spectrometry **(1)**

molecular ion peak /
m/e or mass of the peak furthest right **(1) AW** 2

[10]

5. ***δ* value / chemical shift** gives the 'type' of proton /
chemical environment **(1) AW**
example quoted from data sheet **(1)**

number of peaks gives the number of different types of proton /
chemical environments **(1)**

relative / ratio of **(1)**
peak areas gives the number of protons (of each type) **(1)**

splitting gives number of neighbouring / adjacent protons **(1)**

description of *n* + 1 rule / example of doublet, triplet or quadruplet
showing 1, 2 and 3 protons neighbouring (carbon) atom **(1) AW**

D_2O can be used to identify OH groups **(1)**
ANY 7 marks out of 8 7

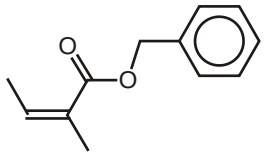
Quality of written communication mark for correct use and
organisation of at least two of the following technical terms:
proton, environment, singlet (doublet *etc*.), ppm, equivalent,
chemical shift, splitting, labile, integration 1

[8]

6. (a) (i) alkene **(1)**
ester **(1)** 2

allow "C=C double bond"

i.



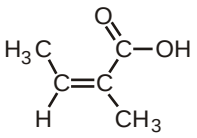
(1) 1

ii. $C_{12}H_{14}O_2$ **(1)** 1

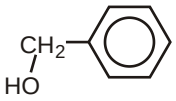
(b) same structural formula/order of bonds,
different spacial arrangement **AW (1)**

description or diagram showing **B** and how it is different from **A (1)** 2

(c)



(1)



(1) 2

(d) (i) peak at 1680-1750 (cm^{-1}) due to C=O **(1)**

peak at 1000-1300 (cm^{-1}) due to C-O / **(1)** 2

(ii) 2500-3300 / 3230-3550 (cm^{-1}) **(1)**

O-H /carboxylic acid/alcohol is **not** present in **A (1)**

allow 1 mark for ~500-1500 (cm^{-1}) which is a unique fingerprint region etc 2

[12]

7. (a) low boiling point / easily turns to a gas **AW (1)** 1

(b) 2,4-dinitrophenylhydrozine / 2,4-DNP(H) / Brady's reagent **(1)**

purify/recrystallise the product/solid (derivative) **(1)**

measure the melting point /mp **(1)**

compare the result with data book/known values **(1)** 4

[5]

8. (a) (i) Molecular ion peak: the peak caused by the unfragmented molecule / the peak with the highest m/e value / the peak that tells you the Mr. 1

Base peak : peak with the greatest (relative) intensity / peak representing most stable/abundant fragment
NOT the tallest / biggest / most common peak 1

(ii) The molecular ion is too unstable / will have been completely fragmented / may not carry a positive charge 1
NOT peak too small to be seen / too little ion present

(b) IR spectrum:
C=O peak at approx 1650 cm^{-1} (1680-1750 cm^{-1}) 1
broad O-H peak at value(s) between 2500-3300 cm^{-1} 1
ignore any references to C-O peak at 1000 – 1300 cm^{-1}

mass spectrum:
Fragment with m/e = 31 is CH_2OH^+ 1
Fragment at m/e = 45 is $COOH^+$ 1

penalise missing + sign once only

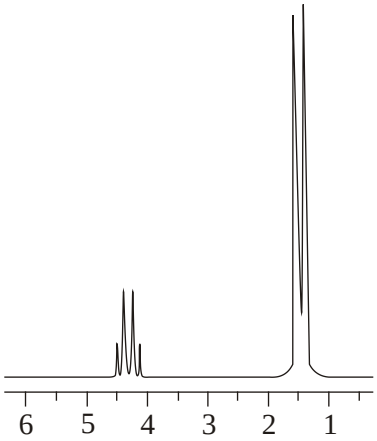
(c) 2 proton peak at δ = 3.3-4.3 – singlet ($-CH_2-$) 1
1 proton peak at δ = 3.5-5.5 – singlet (-OH) 1
1 proton peak at δ = 11.0-11.7 – singlet (-COOH) 1
(ranges of chemical shift (δ) values taken from data sheet)
- penalise each error once only
- ignore peak areas/heights unless incorrectly labelled

Labelled diagram of the structure of G proposed by the student may be used to provide evidence for the positioning of peaks on the sketched spectrum.

Both OH and COOH protons disappear on shaking with D_2O 1

[11]

9. (i)



splitting:
doublet **(1)**
quartet **(1)**
ignore any other peaks

position:
doublet peak is at ~1.4 and
quartet peak is at ~4.3 **(1)**
*allow ecf from **one** incorrect splitting pattern*

areas:
1 and 3 on the correct peaks
(or either way round as ecf if any errors above) **(1)** 4

(ii) 4 **(1)**
OH/labile protons now visible AW **(1)** 2

[6]

10. (a) (i) Find the m /e of …. **(1)**
... the peak furthest to the right / with highest m /e or mass **(1)** 2
allow attempts to cater for the ^{13}C peak

$C_2H_3O_2$ /empirical formula has $M_r = 59$ **(1)**
so M_r of molecular formula is $^{118}/_{59} = 2$ /twice the empirical formula **(1)** 2

(b) (i) OH peak disappears (with D_2O / on the second spectrum) 1

(ii) no of peaks: one **(1)**

splitting: none **(1)**

all four protons equivalent / in the same environment **(1)** 3

if the wrong structure is chosen allow ecf for:
*two peaks **(1)**,*
*splitting **(1)(1)** (as last 2 marks for part (ii))*

[8]

11. (i) **A** C_3H_6 **(1)** **B** C_4H_8 **(1)** 2

(ii) **A** $CH_3CH=CH_2$ (or displayed) ('sticks' penalised once) 1

(iii) $C_3H_5^+$ **(1)** for formula and **(1)** for charge 2

[5]