Question - 01

This question is about simple test-tube reactions to identify organic liquids.

(a) Silver nitrate solution can be used to distinguish between propanoyl chloride and 1-chloropropane.

Give the observations you would expect when a few drops of silver nitrate solution are added to separate samples of propanoyl chloride and 1-chloropropane.

Observation with propanoyl chloride _____

_____

Observation with 1-chloropropane _____

_____

(2)

(b) Three unlabelled bottles are known to contain either propan-1-ol, propanal, or propanone.

A sample of each liquid is warmed with a few drops of Fehling's solution.

Identify the liquid that reacts with Fehling's solution and give the expected observation.

Suggest a further simple test-tube reaction that can be used to distinguish between the remaining two liquids.

Give the expected observation with the liquid that reacts.

Liquid that reacts with Fehling's solution _____

Observation _____

_____

Further test _____

_____

Observation _____

_____

(3)

(a) **M1** Misty / white / steamy fumes

M1 (immediate) White precipitate forms

M2 No visible change

M2 White precipitate forms slowly

2

(b) **M1** Propanal AND (blue solution gives a brick) red precipitate

If **M1** incorrect, allow ECF for suitable tests on remaining liquids

M1	(Warm with) acidified potassium dichromate (VI)	add Na	warm with a named carboxylic acid with conc H_2SO_4	(Warm with) acidified potassium manganate (VII)
M2	Propan-1-ol/alcohol AND (orange solution) goes green	Propan-1-ol/alcohol AND effervescence	Propan-1-ol/alcohol AND fruity smell	Propan-1-ol/alcohol AND (purple solution) goes colourless

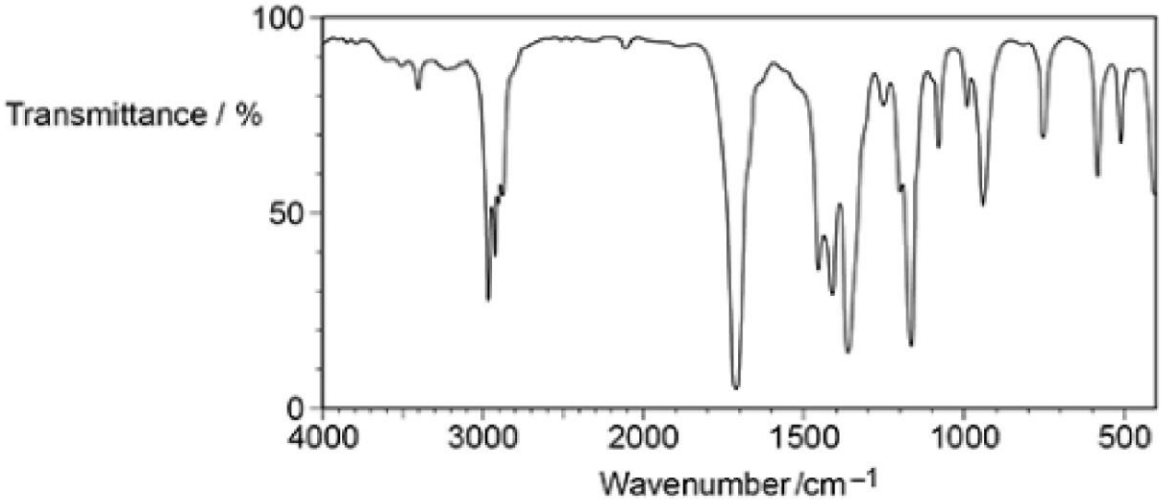
3

Question - 02

This question is about spectroscopy.

(a) Compound **K** has molecular formula C_4H_8O
Figure 1 shows the infrared spectrum of **K**.

Figure 1



Which functional group does **K** contain?

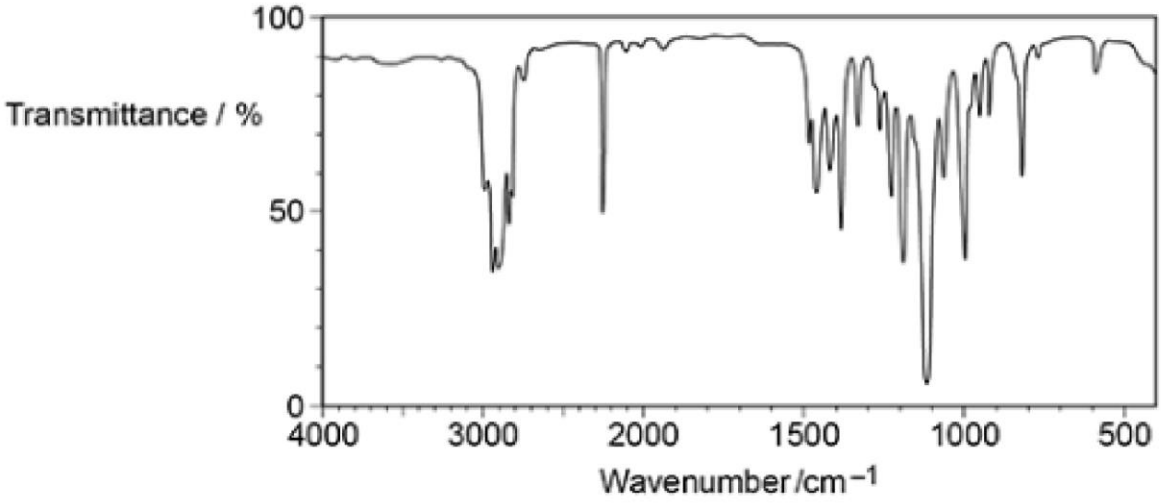
Tick (✓) **one** box.

Functional Group				
alcohol	alkene	amine	carbonyl	nitrile

(1)

(b) Compound **L** has molecular formula C_4H_7NO
Figure 2 shows the infrared spectrum of **L**.

Figure 2



L reacts with H_2 in the presence of a nickel catalyst to give compound **M**.

Suggest **three** ways in which the infrared spectrum of **M** is different from the infrared spectrum of **L**.

1 _____

_____

2 _____

_____

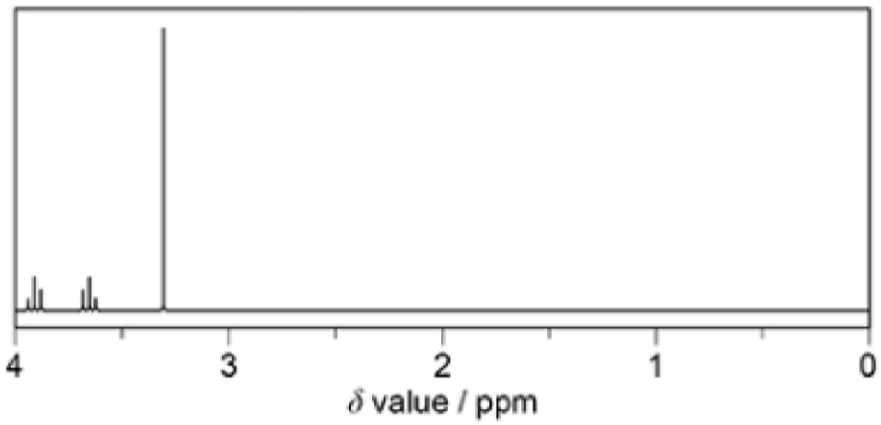
3 _____

_____

(3)

(c) **Figure 3** shows the ^{1}H NMR spectrum of **Q**, C_3H_7ClO

Figure 3



The table below shows the chemical shifts (δ values) and integration values for each peak.

δ value / ppm	3.95	3.65	3.35
Integration value	0.6	0.6	0.9

Deduce the structure of **Q**.

Explain your answer.

_____

_____

_____

_____

_____

(a) Tick in carbonyl box only

1

(b) Peak at 2220-2260 cm^{-1} (for C≡N) disappears

If both C≡N disappears and N-H appears without wavenumbers scores 1

M1

Peak at 3300-3500 cm^{-1} (for N-H) appears

M2

Fingerprint region different

M3

(c) Integration ratio 2:2:3

If no link between delta value and oxygen and chlorine, then can award 1 mark for correct explanation of splitting of all 3 peaks

M1

Peak at 3.95 triplet (integration 2) Cl-CH_2 next to CH_2

M2

Peak at 3.65 triplet (integration 2) O-CH_2 next to CH_2

If no explanation of splitting, then can award 1 mark for 3 correct links between delta value and oxygen and chlorine M1

M3

Peak at 3.35 singlet (integration 3) O-CH_3 no adjacent H

M4

Structure CH_3-O-CH_2CH_2Cl

M5

This question is about compound **X** with the empirical formula C_2H_4O

Figure 1 shows the infrared spectrum of **X**.

Figure 2 shows the ^{13}C NMR spectrum of **X**.

The ^{1}H NMR spectrum of **X** shows four peaks with different chemical shift values.
The table below gives data for these peaks.

Figure 1

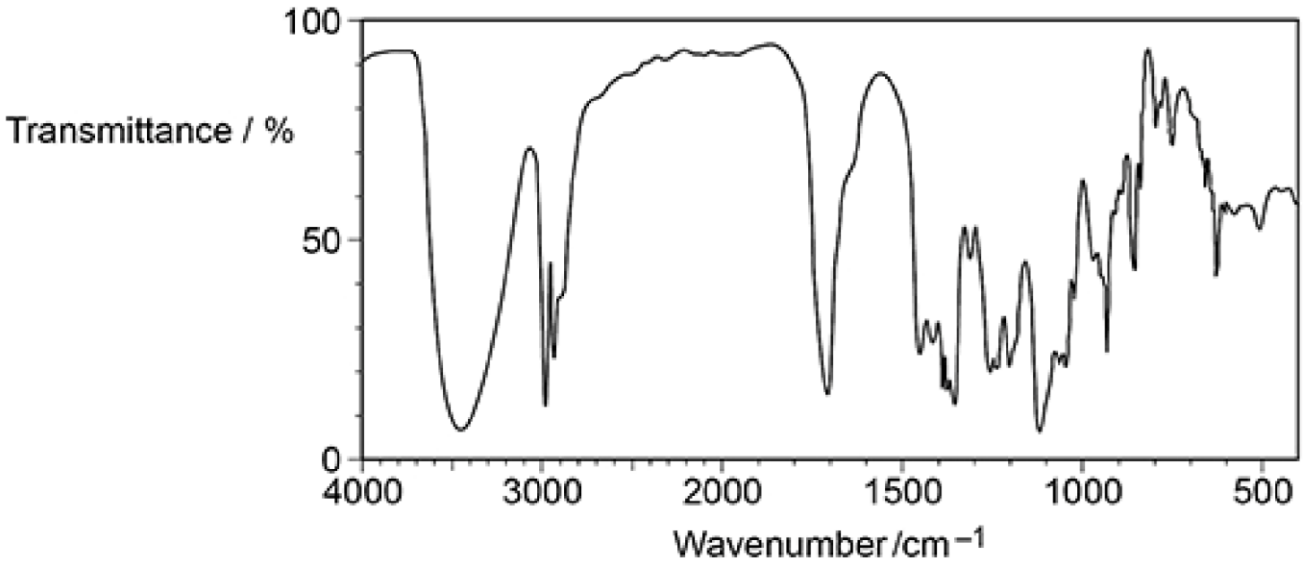
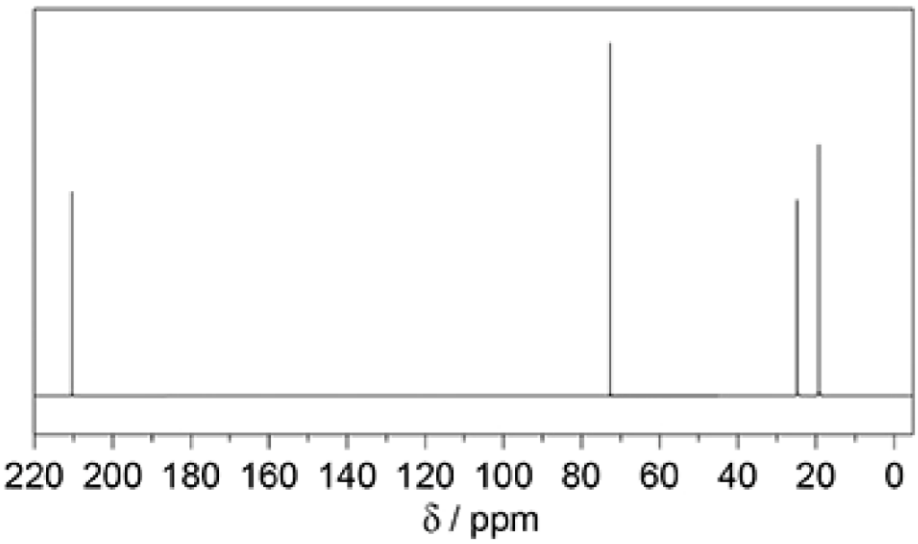


Figure 2



Chemical shift δ / ppm	3.9	3.7	2.1	1.2
Splitting pattern	quartet	singlet	singlet	doublet
Integration value	1	1	3	3

Show how information from **Figure 1**, **Figure 2** and the table can be used to deduce the structure of compound **X**.

This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.

Level 3 **5-6 marks**	All stages are covered and each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3 Covers at least 1 point for stage 1, 3 for stage 2 and 3 for stage 3.
Level 2 **3-4 marks**	All stages are covered but stage(s) may be incomplete or may contain inaccuracies Covers at least 1 point for stage 1 stage 2 and stage 3. OR two stages are covered and are generally correct and virtually complete. Covers at least 1 point for stage 1, and 3 for stage 2 or stage 3 OR 3 for stage 2 and 3 for stage 3 Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3.
Level 1 **1-2 marks**	Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR only one stage is covered but is generally correct and virtually complete. Answer includes isolated statements but these are not presented in a logical order.
0 marks	Insufficient correct chemistry to gain a mark.

Indicative Chemistry content

Stage 1: infrared

1a) (broad peak) at 3400 cm^{-1} (any value from 3230-3550) indicates OH in alcohols

1b) peak at 1720 cm^{-1} (any value from 1680-1750) indicates C=O

Stage 2: ^{1}H nmr

2a) peak at 3.9 ppm integration 1 so 1 **H**-C-O AND quartet so adjacent to CH_3 (stated or shown)

2b) peak at 3.7 ppm integration 1 so **H**O-C-(stated or shown)

2c) peak at 2.1 ppm integration 3 so $\mathbf{H_3}$C-C=O AND singlet so no adjacent H (stated or shown)

2d) peak at 1.2 ppm integration 3 so $\mathbf{H_3}$C- AND doublet so adjacent to CH (stated or shown)

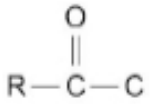
2e) sum of integration values = 8 Hence $C_4H_8O_2$

Stage 3: ^{13}C nmr

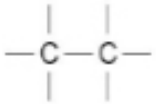
3a) peak at 210 ppm C=O aldehydes or ketones

3b) peak at 75 ppm C−O (alcohols, ethers or esters)

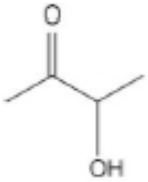
3c) peak at 25 ppm



3d) peak at 20 ppm



3e) structure



Question - 04

The skeletal formulas of two compounds are shown.

Which method would distinguish between samples of these compounds?

A comparing fingerprint regions of their infrared spectra ○

B obtaining molecular masses from their high resolution mass spectra ○

C warming with acidified potassium dichromate(VI) solution ○

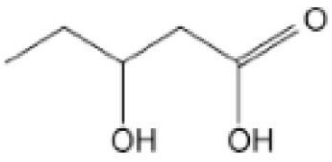
D warming with Tollens' reagent ○

A

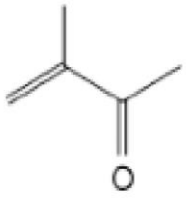
comparing fingerprint regions of their infrared spectra

Question - 05

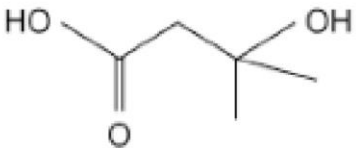
A student plans a series of chemical tests to confirm the identities of four organic liquids.



Liquid **J**



Liquid **K**



Liquid **L**

Liquid **M**

This is the student's method.

To separate test tubes containing samples of each liquid:

Test 1 add potassium dichromate(VI) solution and warm gently

Test 2 add Fehling's solution and cool in iced water

Test 3 add sodium hydrogencarbonate solution and test any gas produced with a lighted splint

Test 4 add bromine water and shake at room temperature.

(a) Identify the missing reagent needed in **Test 1**.

_____

(1)

(b) In addition to the missing reagent in **Test 1**, there is a mistake in the method for **two** of the other tests.

State the **two** mistakes.

Suggest how each of the mistakes should be corrected.

Mistake 1 _____

Suggestion _____

_____

Mistake 2 _____

Suggestion _____

_____

(2)

(c) The missing reagent is added and the mistakes are corrected.

Identify the liquid(s), **J**, **K**, **L** and **M**, that would react in each test.

State the expected observation for each reaction.

Liquid(s) that react in **Test 1** _____

Expected observation _____

_____

Liquid(s) that react in **Test 2** _____

Expected observation _____

_____

Liquid(s) that react in **Test 3** _____

Expected observation _____

_____

Liquid(s) that react in **Test 4** _____

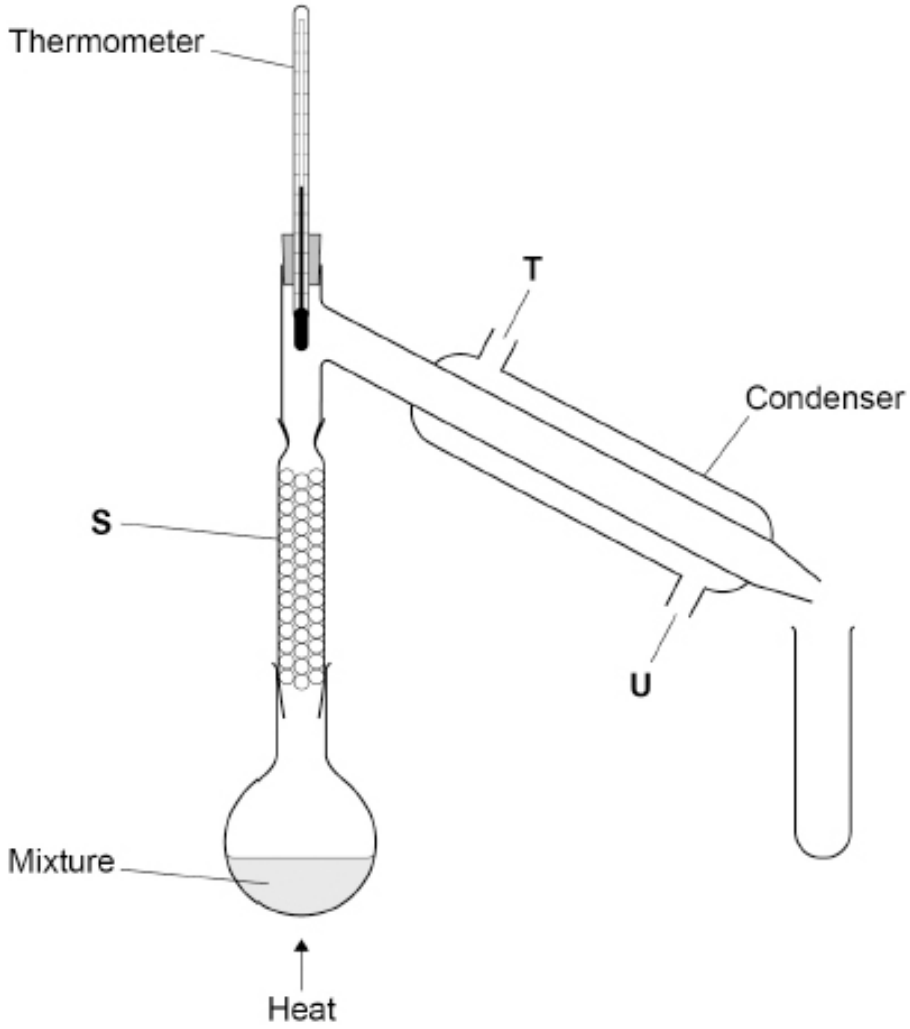
Expected observation _____

(8)

(d) The figure below shows the apparatus that is used to separate a mixture of liquids **K** and **M** using fractional distillation.

Suggest labels that should be added to positions **S**, **T** and **U** in the figure.

Explain why fractional distillation is preferred to simple distillation to separate liquids **K** and **M**.



Label **S** _____

Label **T** _____

Label **U** _____

Explanation _____

_____

(3)

(a) Use H_2SO_4

Allow HCl / H_3PO_4

Ignore conc / dilute

1

(b) M1 Cool test 2

warm (water bath)

Allow heat / hot

M2 Gas is tested with lighted splint in test 3

Bubble into limewater

Allow no test on gas needed

2

(c) M1 J and M

M2 Test 1 (Orange solution goes) green

M3 M

M4 Test 2 (Blue solution gives a brick) red precipitate

Allow (Brown-red/orange/orange-red)

M5 J and L

M6 Test 3 (Colourless gas that turns) limewater cloudy

Allow M6 Test 3 fizz / effervescence

M7 K

M8 Test 4 (Orange solution goes) colourless

Allow (Brown/Brown-red/yellow/yellow-orange)

Allow decolorises bromine

8

(d) M1 S - Fractionating column

M1 Allow beads

M2 Both T - Water out AND U - Water in

M3 Liquids K and M are likely to have similar boiling points

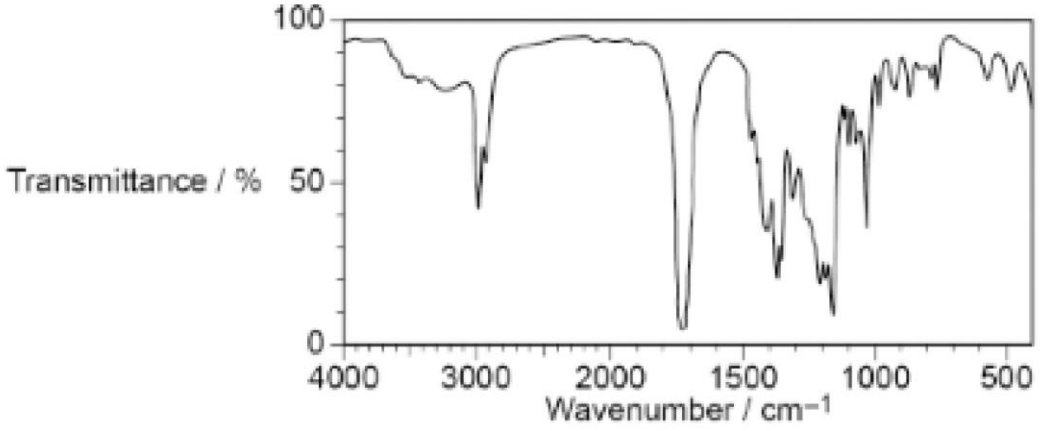
3

Question - 06

This question is about compound **Z**, with molecular formula $C_7H_{12}O_3$

Figure 1 shows the infrared spectrum of **Z**.

Figure 1

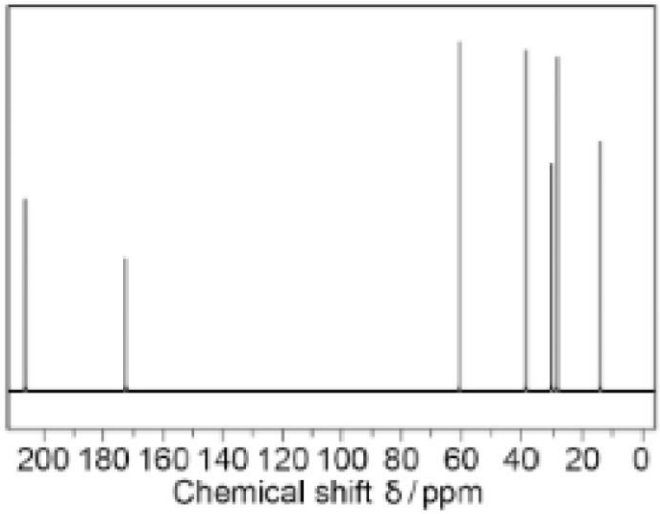


(a) Identify the bond that causes the absorption at 1725 cm^{-1}

_____

Figure 2 shows the ^{13}C NMR spectrum of **Z**.

Figure 2



(1)

(b) How many different carbon environments are there in a molecule of **Z**?

	5	6	7	8
Tick ✓ **one** box				

(1)

(c) State the type of carbon environment that causes the peak at δ = 174 ppm

Use **Table C** in the Data Booklet to help you answer this question.

_____

(1)

(d) the table below shows data from the ^{1}H NMR spectrum for compound **Z**.

Chemical shift δ / ppm	4.10	2.60	2.56	2.19	1.26
Integration ratio	2	2	2	3	3
Splitting pattern	quartet	triplet	triplet	singlet	triplet

Explain what can be deduced from the splitting patterns and chemical shift values for the peaks at δ = 4.10 ppm and at δ = 1.26 ppm

Deduce the part of the structure of **Z** that causes the peaks at δ = 4.10 ppm and δ = 1.26 ppm

Use **Table B** in the Data Booklet to help you answer this question.

Peak at δ = 4.10 ppm _____

_____

_____

Peak at δ = 1.26 ppm _____

_____

_____

Part of structure

(5)

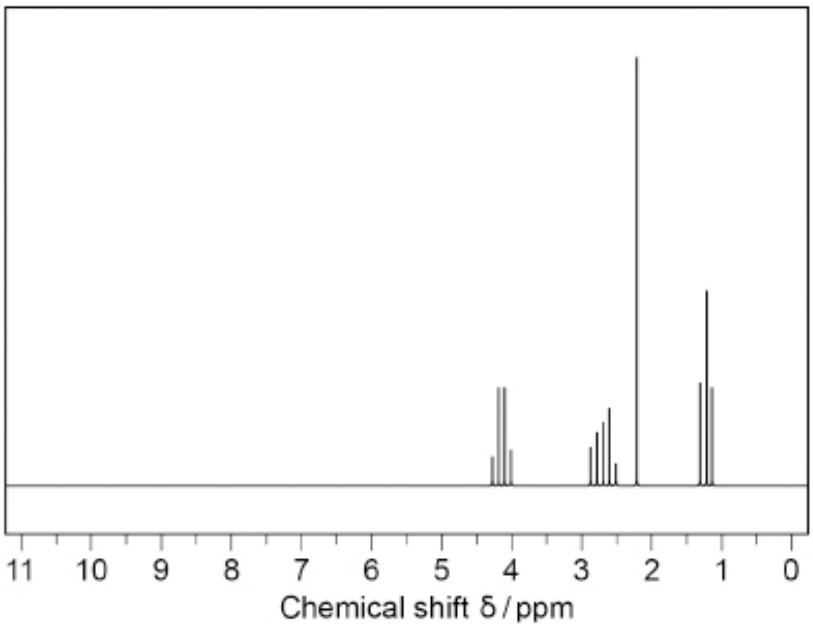
(e) Deduce the part of the structure of **Z** that causes the peak at δ = 2.19 ppm

Part of structure

(1)

Figure 3 shows the ^{1}H NMR spectrum of compound **Z**.

Figure 3



(f) Suggest why it would be difficult to determine the structure of **Z** using the spectrum in **Figure 3**, without the information in the table in part (d).

_____

_____

_____

_____

(1)

(g) Deduce the structure of **Z**.

(1)

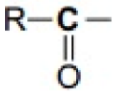
(a) C=O

1

(b) Tick in the box for 7 ONLY

1

(c)



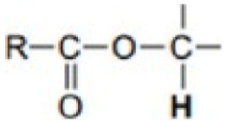
esters

Ignore acids

1

(d) M1 (Quartet) because neighbouring C has 3H

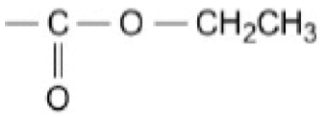
M2 (At δ = 4.1 ppm) because connected to single bonded O of ester or



M3 (Triplet) because neighbouring C has 2H

M4 (At δ = 1.26 ppm) because R_2CH_2 or RCH_3

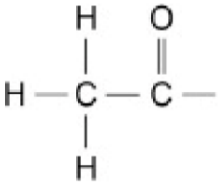
M5



Ignore use of integration

5

(e)



1

(f) Cannot deduce splitting patterns of peaks (at about δ = 2.60)

Or

No integration values

Allow

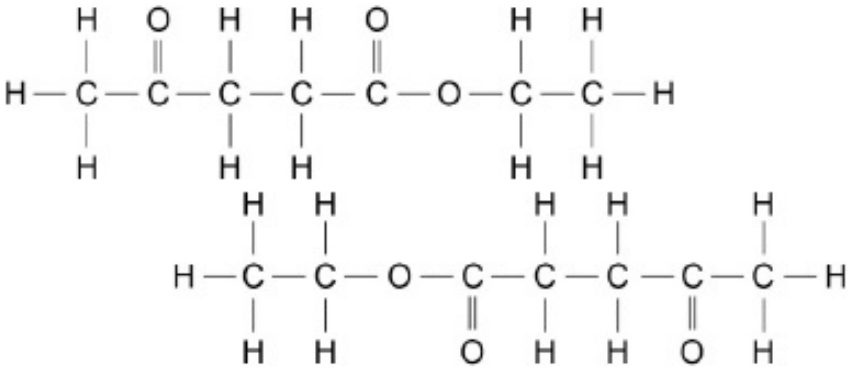
Peaks at δ = 2.60 and δ = 2.56 ppm overlap

OR

spectrum at δ = 2.60 is second order

1

(g)



1