

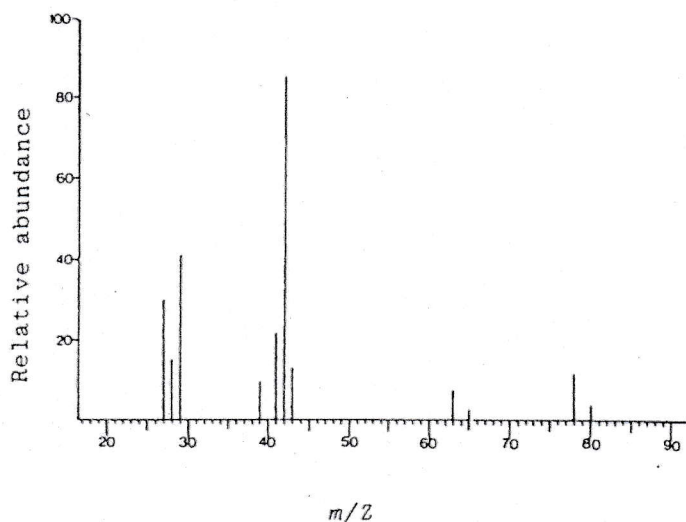
MEASUREMENT AHL (HL only)

Please ensure that you have also completed the Core (SL & HL) questions

1. An unknown organic compound, Z, was investigated using a variety of analytical techniques.

Upon reaction with aqueous silver nitrate, compound Z produced a white precipitate. This suggests that chlorine is present.

(a) The mass spectrum of compound Z is shown below.

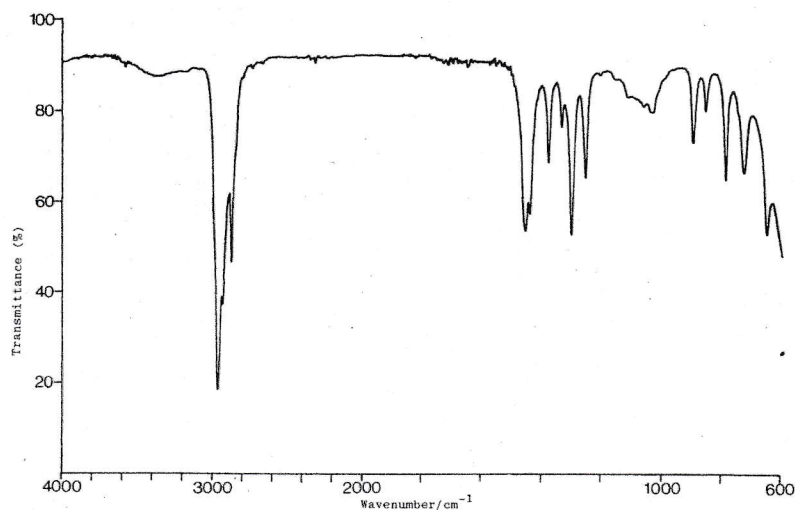


(i) Explain how the peaks at 80 and 78 m/z suggest the presence of a chlorine atom.

[2]

The peaks are 2 mass units apart. ✓
78:80 has a 3:1 ratio. ✓
(or $[R^{35}\text{Cl}]^+$ and $[R^{37}\text{Cl}]^+$) ← this scores 2. or similar in words.

(b) The infrared (IR) spectrum of compound X is shown below.



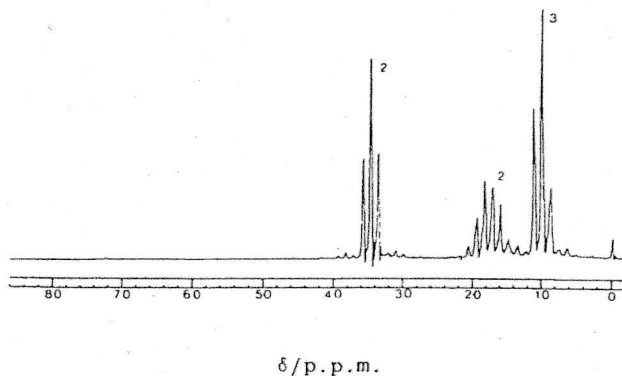
(i) Explain what the IR spectrum tells you about the bonds in compound Z (using section 26 of the data booklet).

[1]

Only shows C-H bonds (at $\sim 3000 \text{ cm}^{-1}$)

allow comment such as "no functional group bonds seen".

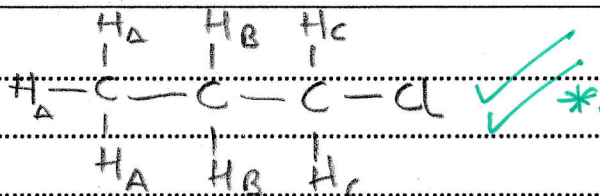
(c) The $^1\text{H-NMR}$ spectrum of compound Z is shown below:



(i) Explain, in detail, the splitting pattern seen in the $^1\text{H-NMR}$ spectrum and deduce the full structural formula of compound Z.

[5]

Full structural formula



Peak at 1.0 ppm is H_A split into 3 by H_B ✓

Peak at ~ 1.75 ppm is H_B split into multiplet by H_A and H_C ✓

Peak at ~ 3.5 ppm is H_C split into 2 by H_B ✓

* If formulae incorrect 1 additional mark can be gained from comment on evidence. e.g NMR proton ratio is 3:2:2.

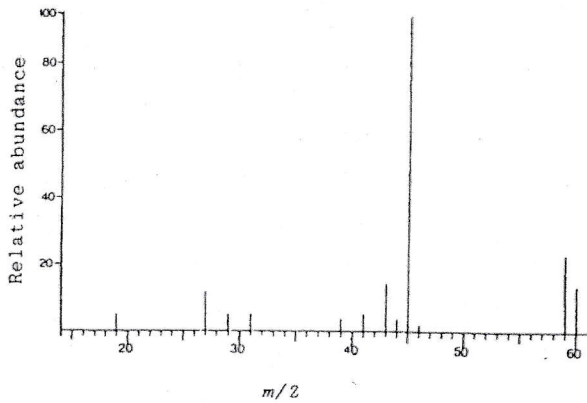
(ii) Return to the mass spectrum in (a) and identify the species responsible for the peaks at 80 and 78 m/z.

[1]

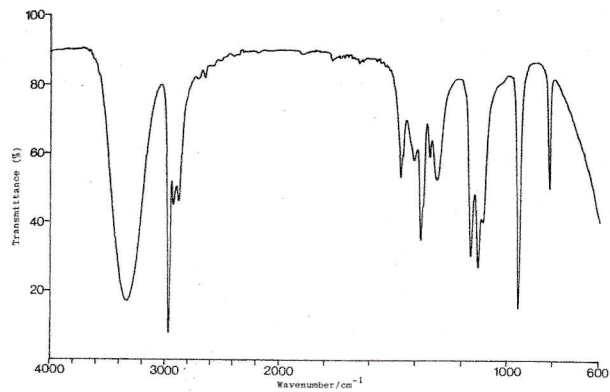
$[\text{C}_2\text{H}_7^{35}\text{Cl}]^+$ and $[\text{C}_2\text{H}_7^{37}\text{Cl}]^+$ ✓ both required.

2. An unknown organic compound, Y, was investigated using a variety of analytical techniques.

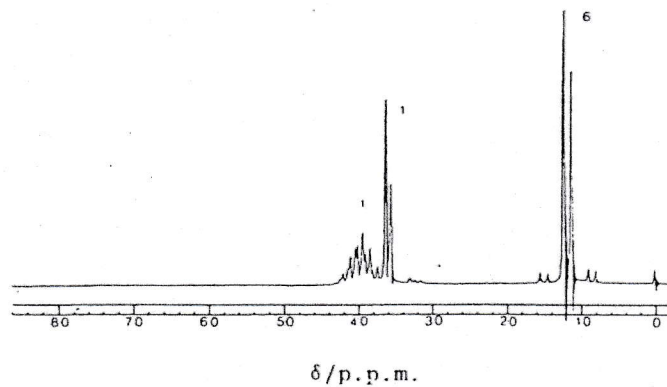
Mass spectrum of Y



IR Spectrum of Y



¹H-NMR spectrum of Y



(a) Deduce the full structural formula of compound Y. Explain the information that you use from each spectrum, including the splitting pattern seen in the ¹H-NMR spectrum.

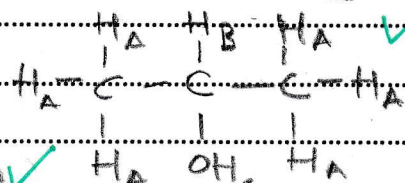
[7]

IR spectrum shows the presence of O-H in an alcohol ✓
as shown by band at $\sim 3200 \text{ cm}^{-1}$ ✓

mass spectrum shows molecular mass in 60 ✓

NMR shows protons in 6:1:1 ratio ✓

Full structure



H_A split into 2 by H_B (1.2 ppm) ✓

H_B split into multiplet by H_A (4.0 ppm) ✓

H_C split into 2 by H_B (3.5 ppm) ✓

any 7. (And allow marks for additional evidence to 7 max ~~if~~ or 6 max if

Total Marks 16 (24 minutes)

Structure is incorrect)