Analytical techniques – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.40

In the mass spectrum of a compound, Z, the relative abundances of the M and M+1 peaks are in the ratio 13 : 1.

What is compound Z?

A butyl butanoate

B hexan-3-one

C 2,2,3-trimethylhexane

D 3,3-dimethylpentan-1-ol

2. Nov/2022/Paper_12/No.40

A molecule of an organic compound, P, contains three carbon atoms and shows a strong absorption at 1720 cm^{-1} in its infrared spectrum.

P is reacted with an excess of hot acidified potassium dichromate(VI) forming organic product Q.

Q shows a strong absorption at 1700 cm^{-1} and a strong, broad absorption centred at 2800 cm^{-1} in its infrared spectrum.

bond	functional group containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3600

What is P?

A propanal

B propanone

C propan-1-ol

D propan-2-ol

3. Nov/2022/Paper_21/No.5(b, c)

(b) A student monitors the progress of reaction **2** using infrared spectroscopy.

Use Table 5.1 to suggest why it is difficult to distinguish between **N** and 5-hydroxyhexanoic acid using infrared spectroscopy.

.....

..... [2]

Table 5.1

bond	functional group containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–3100
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

(c) Unknown lactone **Q** is analysed using mass spectrometry.
Table 5.2 shows information from the mass spectrum.

Table 5.2

peak	*m/e*	abundance
M+	72	95.5
M+1	73	3.15

Use these data to deduce the structure of **Q**.
Show your working.

Q

.....

.....

[2]

4. Nov/2022/Paper_22/No.3(c)

(c) Organic compound **E** contains three carbon atoms.
E reacts with cold dilute acidified $KMnO_4(aq)$ to form a single compound **F** with M_r = 154.9.
Fig. 3.1 shows the infrared spectrum of **E**.
Fig. 3.2 shows the infrared spectrum of **F**.

E

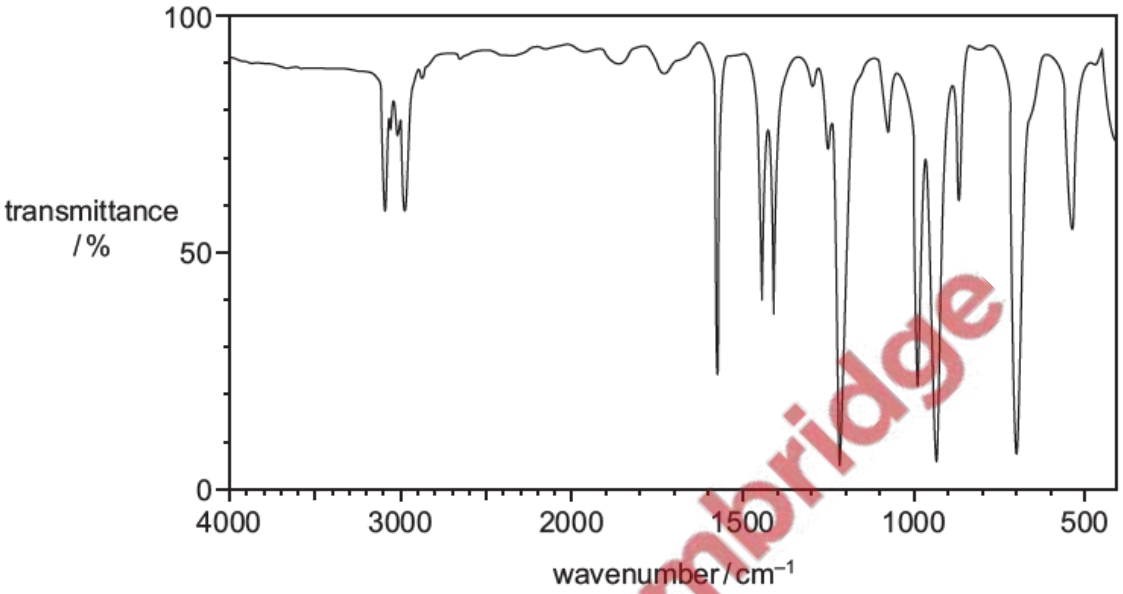

Fig. 3.1

F

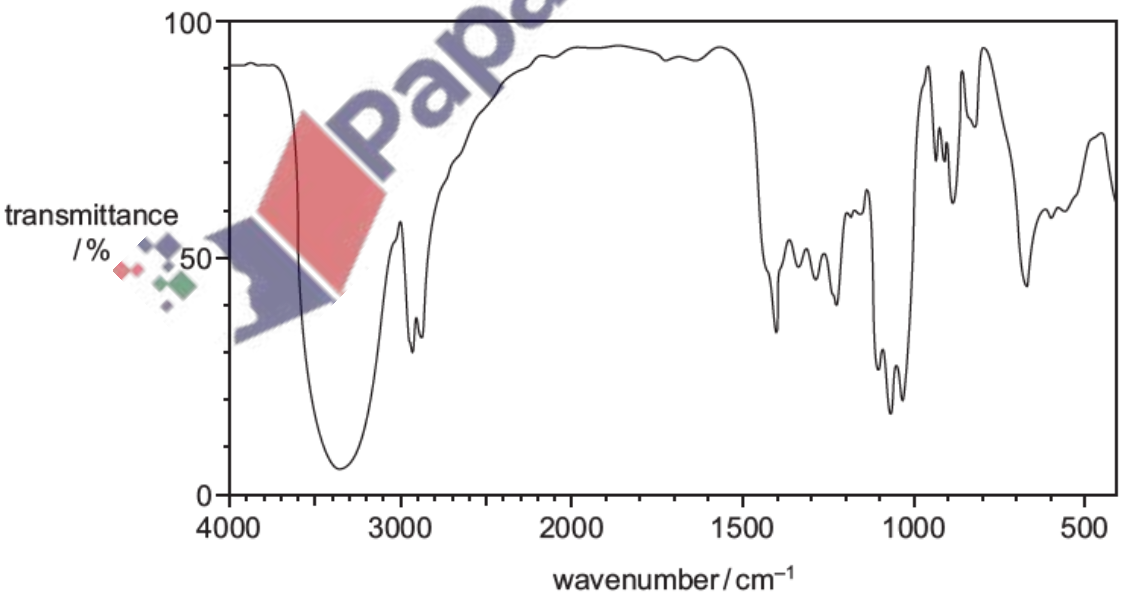

Fig. 3.2

Table 3.2

bond	functional group containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–3100
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

Both spectra show absorptions between 2850 and 2950 cm^{-1} owing to C–H bonds in each molecule.

(i) Use the two infrared spectra and Table 3.2 to identify the functional group present only in **E**.
Explain your answer, referring only to absorptions at frequencies greater than 1500 cm^{-1}.

functional group .....

explanation .....

.....

[1]

(ii) Use the infrared spectrum of **F** to identify the functional group formed when **E** reacts with cold dilute acidified $KMnO_4(aq)$.
Explain your answer, referring only to absorptions at frequencies greater than 1500 cm^{-1}.

functional group .....

explanation .....

.....

[1]

(iii) The mass spectrum of **E** shows a molecular ion peak and an M+2 peak of approximately equal abundance at m/e = 120 and 122.

Deduce the relative molecular mass, M_r, of **E**.

M_r = ... [1]

(iv) Use the information in **3(c)** to suggest a structure for **E**.

[1]

(v) Complete the equation for the reaction of **E** with cold dilute acidified $KMnO_4(aq)$ to form **F**. In the equation, [O] represents cold dilute acidified $KMnO_4(aq)$.

H_2O + [O] + ... → .....

[1]