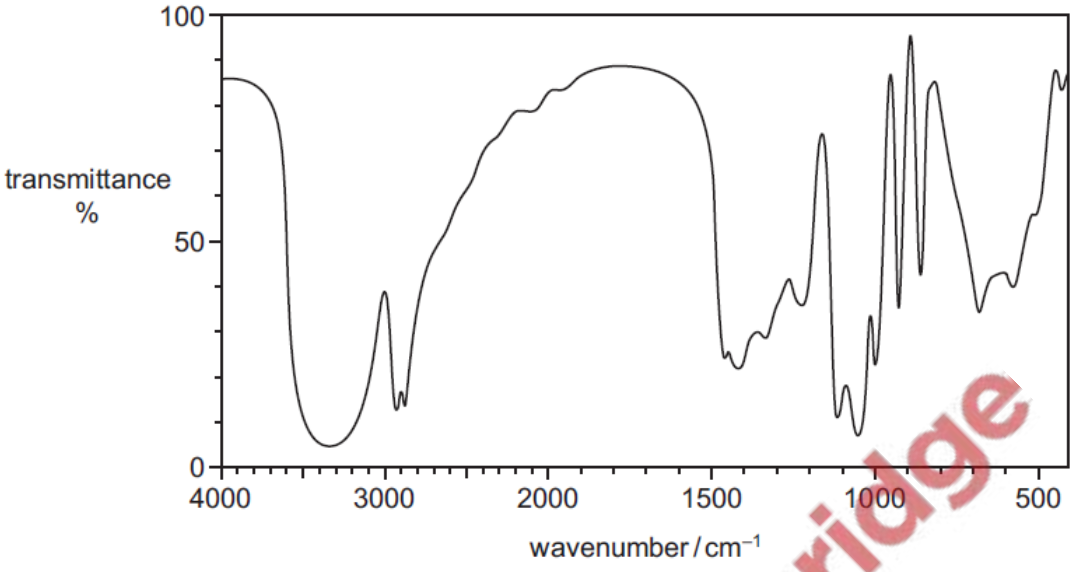
Analytical techniques – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.39

The infrared spectrum of compound L is shown.



bond	functional groups 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 the structure of L?

A $HOCH_2COCH_2OH$

B $HOCH_2CH(OH)CHO$

C $HOCH_2CH(OH)CH_2OH$

D $HOCH_2CH_2COOH$

2. Nov/2023/Paper_ 9701/11/No.40

In the mass spectrum of compound J, the ratio of the height of the M +1 ion peak to the height of the M + ion peak is 4 : 91.

Compound J forms a carboxylic acid when heated with acidified $K_2Cr_2O_7$.

What is compound J?

A butanal

B butanone

C propan-1-ol

D propanenitrile

3. Nov/2023/Paper_ 9701/12/No.40

Oxygen has three stable isotopes, ^{16}O, ^{17}O and ^{18}O. All three isotopes are present in a sample of oxygen gas, O_2, which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

A 3 **B** 5 **C** 6 **D** 9

4. Nov/2023/Paper_ 9701/21/No.4(b)

(b) The mass spectrum of **C** shows a molecular ion peak at *m/e* = 70. This peak has a relative intensity of 48.7.

The relative intensity of the [M+1] peak is 2.7.

Show that this information is consistent with the molecular formula of **C**.

[2]

5. Nov/2023/Paper_ 9701/22/No.3c(iv)

(iv) Reaction 3 is monitored using infrared spectroscopy. It is not possible to use the O—H absorption frequency to monitor the reaction.

Use Table 3.2 to identify a suitable bond whose absorption frequency can be used to monitor the progress of reaction 3.

State the change you would see in the infrared spectrum during reaction 3.

bond .....

change in infrared spectrum .....

.....

[2]

Table 3.2

bond	functional groups 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–H	alkane	2850–2950

6. June/2023/Paper_9701/11/No.40

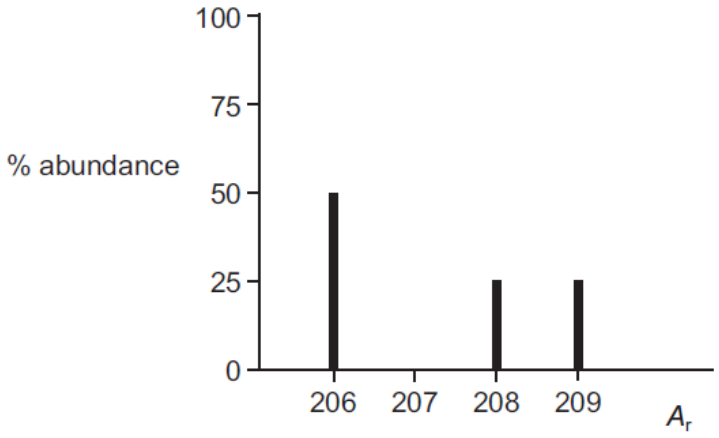
There are two naturally occuring isotopes of bromine. One isotope has 44 neutrons. The other isotope has 46 neutrons.

Ignoring fragments, how many peaks are there in the mass spectrum of tribromomethane, $^{12}C^{1}HBr_3$?

A 2 **B** 3 **C** 4 **D** 6

7. June/2023/Paper_9701/12/No.40

The diagram shows the relative abundance of different isotopes of lead in a sample of lead ore. The abundance of 208 is half that of 206. The abundances of 208 and 209 are equal.



What is the relative atomic mass of the lead in the sample?

A 207.00 **B** 207.25 **C** 207.50 **D** 207.67

8. June/2023/Paper_9701/13/No.40

The mass spectrum of compound X has M, M+1 and M+2 peaks. Other peaks are also present.

Peak M is the molecular ion peak, M^+. Peak M has a relative abundance fifteen times that of peak M+1.

Peaks M and M+2 are of equal height.

What could be compound X?

A 1-chloro-2,2-dimethylpentane

B 2-chloro-3-methylpentane

C 2-bromo-2-methylhexane

D 3-bromo-2,2-dimethylbutane

9. June/2023/Paper_9701/22/No.5(d)

(d) **D** reacts in the presence of a sulfuric acid catalyst to form **E** and water.

The structure of **E** is shown in Fig. 5.1.

E

Fig. 5.1

(i) Name the functional group present in **E**.

..... [1]

(ii) Identify the type of reaction that occurs when **D** reacts to form **E**.

..... [1]

(iii) Draw the structure of **D** in the box.

D

[1]

(iv) The infrared spectrum of **E** is shown in Fig. 5.2.

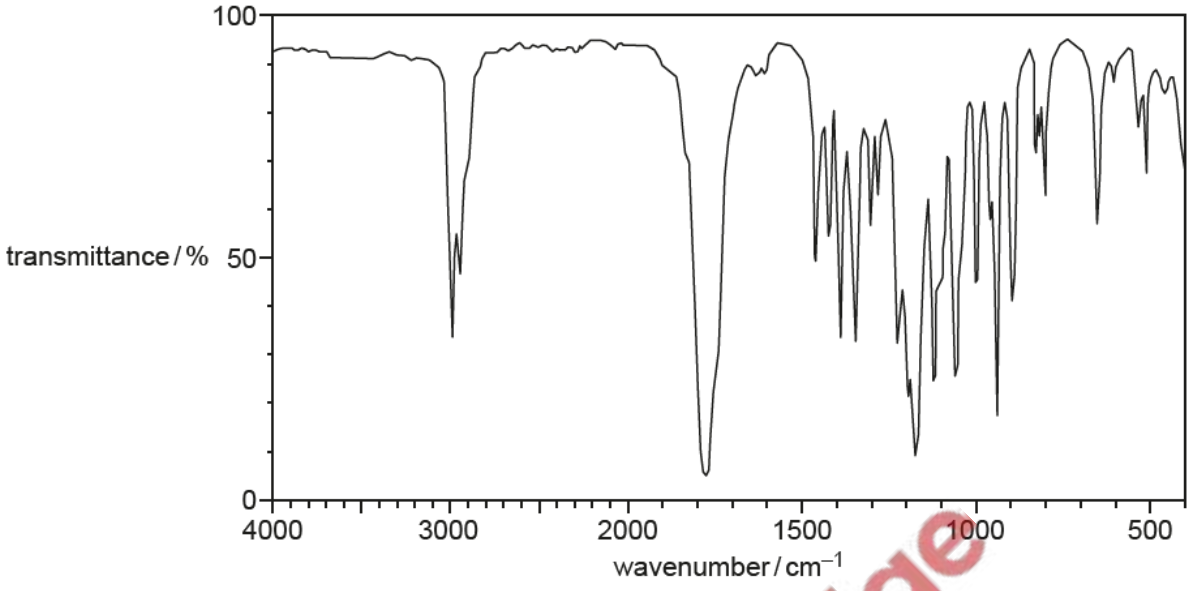


Fig. 5.2

Table 5.3

bond	functional groups 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

Use Fig. 5.2 and Table 5.3 to predict **two** differences in the absorptions above 1500 cm^{-1} of the infrared spectrum of **D** compared to **E**. Explain your answer.

.....

.....

..... [2]

10. June/2023/Paper_9701/23/No.5b(I _ ii)

(b) The formation of **Y** from **X** requires the addition of a suitable reducing agent.

(i) Construct an equation using molecular formulae and [H] for the reaction in Fig. 5.1. Use [H] to represent one atom of hydrogen from the reducing agent.

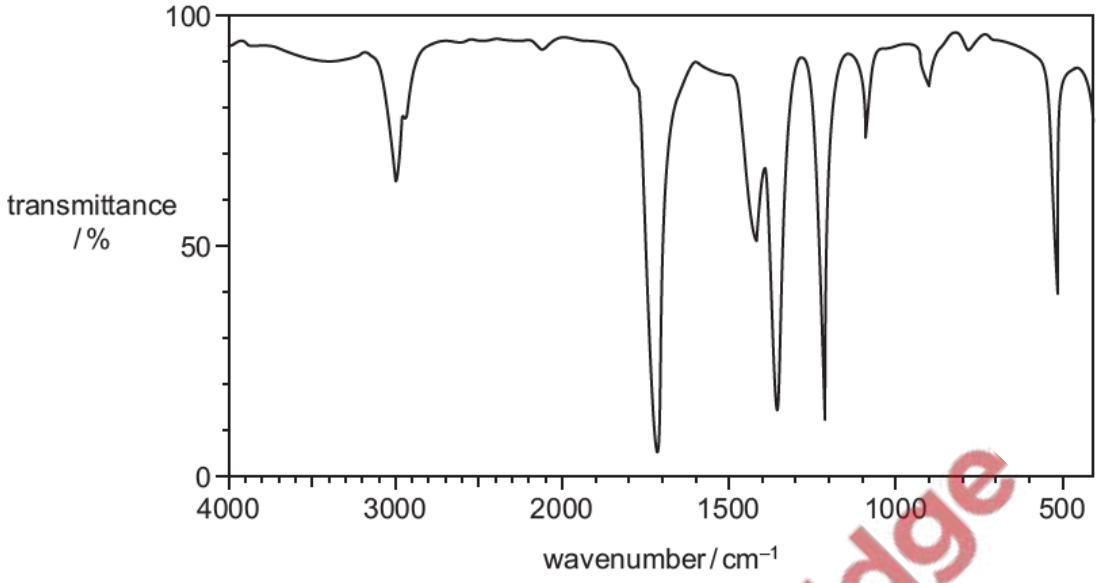
..... [1]

(ii) Identify a suitable non-gaseous reducing agent for the formation of **Y** from **X**.

..... [1]

11. March/2023/Paper_9701/12/No.38

The infrared spectrum of an organic compound is shown.



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

Which compound could give this spectrum?

A $CH_3CH_2CO_2H$

B $CH_3CH(OH)CH_3$

C CH_3COCH_3

D CH_3COCH_2OH

12. March/2023/Paper_9701/22/No.4(d)

(d) (i) Fig. 4.2 shows the infrared spectrum of one of the compounds **D**, **E**, **F**, **G** or **H**.

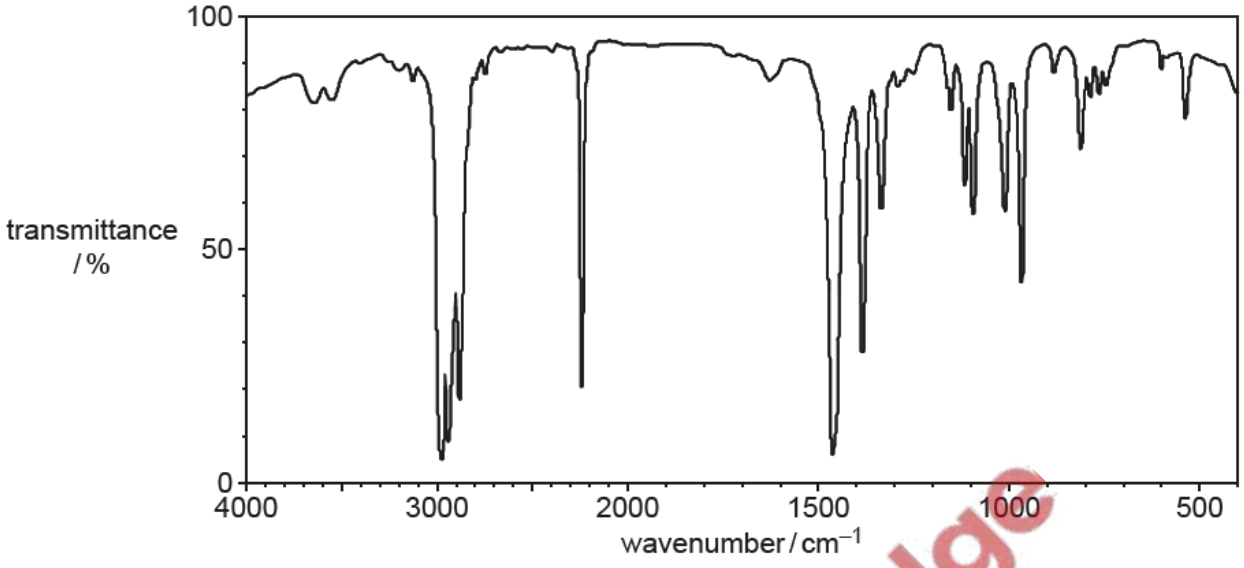

Fig. 4.2

Use information from Table 4.1 (on page 14) to identify which of the compounds **D**, **E**, **F**, **G** or **H** produces the infrared spectrum in Fig. 4.2.

Explain your answer.

.....

.....

..... [2]

Table 4.1

bond	functional groups 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
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C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3600

(ii) In the mass spectrum of **D**, the relative abundance of the molecular ion peak is 3.4.

Predict the relative abundance of the M+2 peak for **D**.

Explain your answer.

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..... [1]