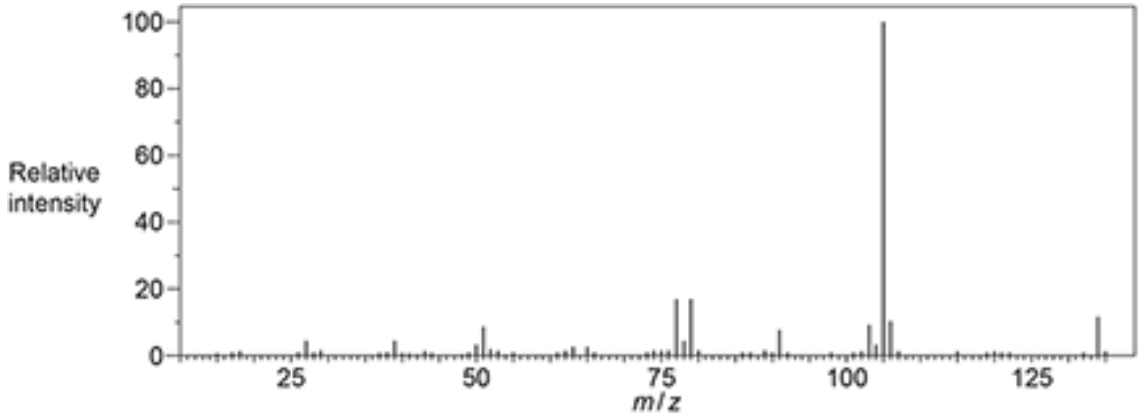
1. Analysis of an unknown organic compound **J** produces the following results.

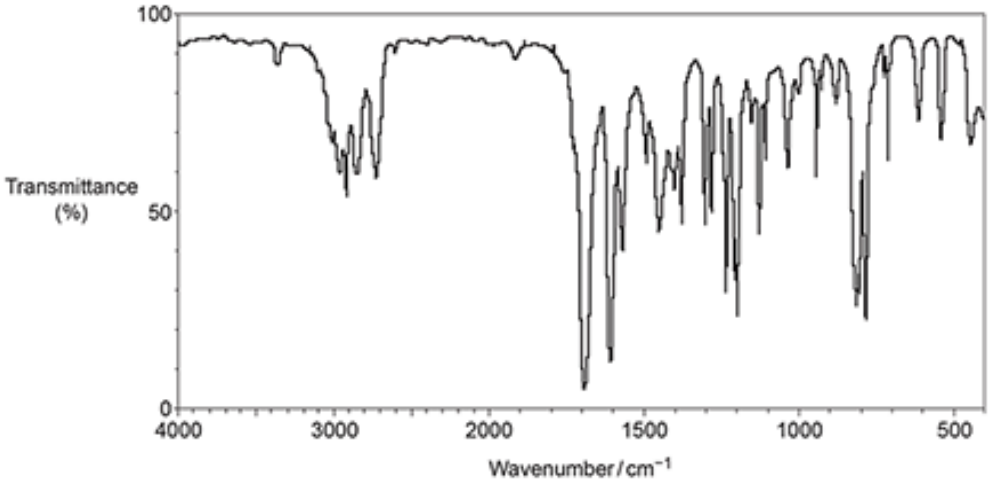
Elemental analysis by mass of compound J

C, 80.60%; H, 7.46%; O, 11.94%

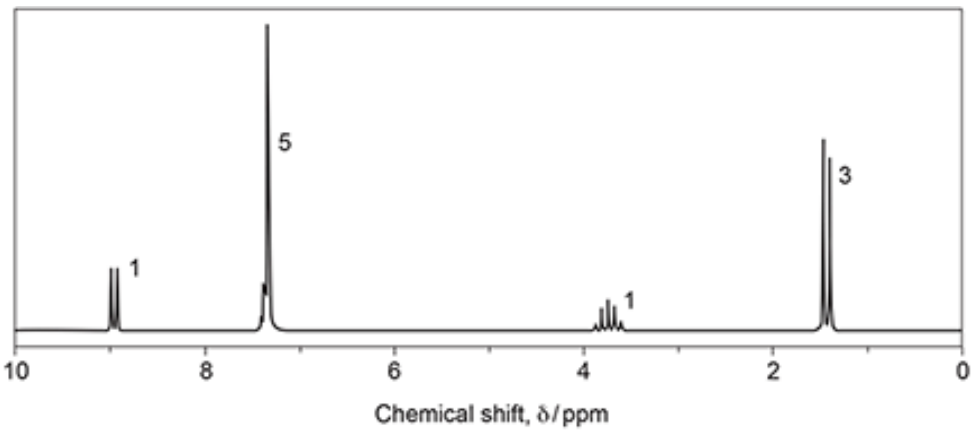
Mass spectrum of compound J



IR spectrum of compound J



Proton NMR spectrum of compound J



The numbers by the peaks are the relative peak areas.

Determine the structure of compound **J**, showing **all** your reasoning.

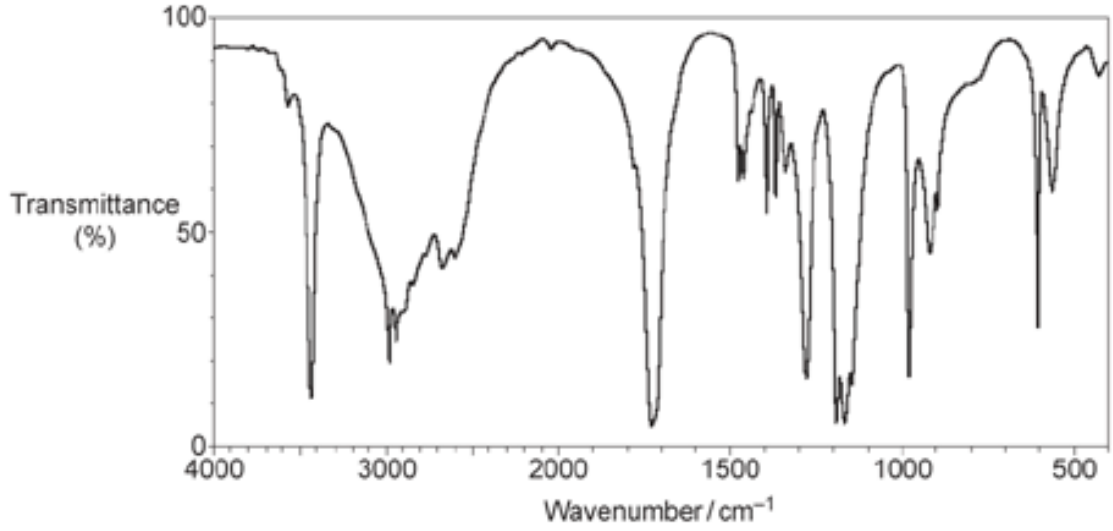
[6]

2. Which statement gives a valid scientific reason for global warming?

A Infrared radiation causes bonds in CH_4 molecules to vibrate more.
B Infrared radiation causes O_2 molecules to vibrate more.
C Ultraviolet radiation causes bonds in CO_2 to vibrate more.
D Ultraviolet radiation causes bonds in CFC molecules to break.

Your answer ☐ **[1]**

3. Which compound could have produced the IR spectrum shown below?



A $HOCH_2CHO$
B CH_3CH_2COOH
C $CH_3CH_2COOCH_3$
D $(CH_3)_2C(OH)COOH$

Your answer ☐ **[1]**

4. Which statement about infrared radiation (IR) is **not** correct?

A Absorption of IR by molecules such as CO_2, H_2O and CH_4 has been linked to global warming.
B IR causes CFC molecules to produce chlorine radicals that initiate ozone breakdown in the upper atmosphere.
C IR causes some covalent bonds to vibrate more and absorb energy.
D IR is used in modern breathalysers to detect ethanol.

Your answer ☐ **[1]**

5. An alcohol $CH_3CH_2CH(CH_3)OH$ produces a mass spectrum.

The mass spectrum contains a large fragment ion at $m/z = 45$.

What is the possible identity of this fragment ion?

A CH_2CHOH^+
B $CH_2CH_2OH^+$
C CH_3CHOH^+
D $CH_3CH_2CH^+$

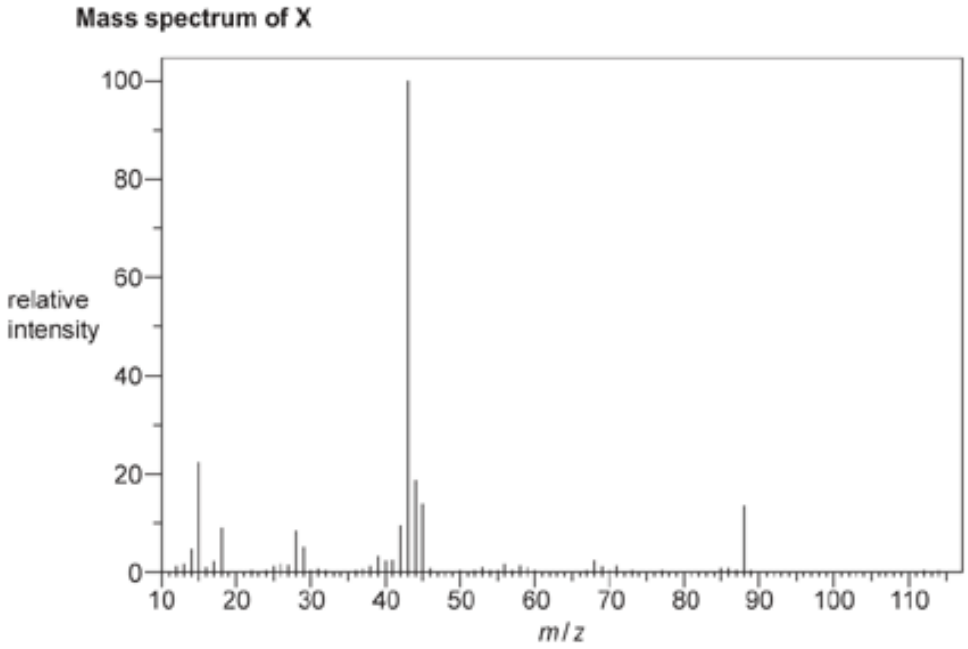
Your answer ☐ **[1]**

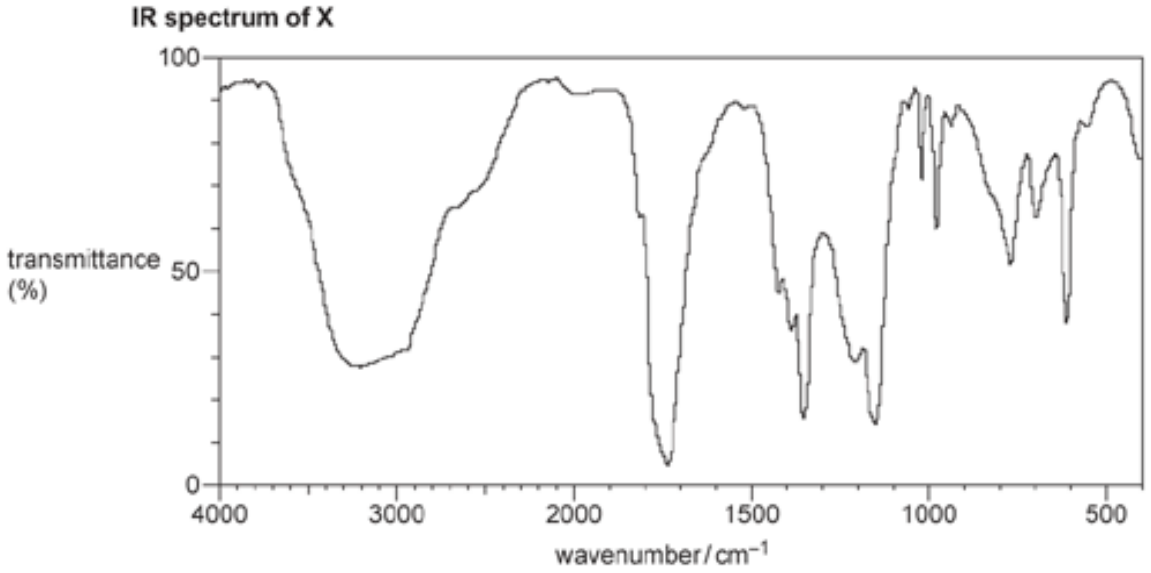
6. Compound **X** is an organic compound with **two** functional groups.

Compound **X** has the percentage composition by mass:
C, 40.91%; H, 4.54%; O, 54.55%.

Compound **X** does **not** decolourise bromine water.

A scientist analyses compound **X** using mass spectrometry and infrared spectroscopy.



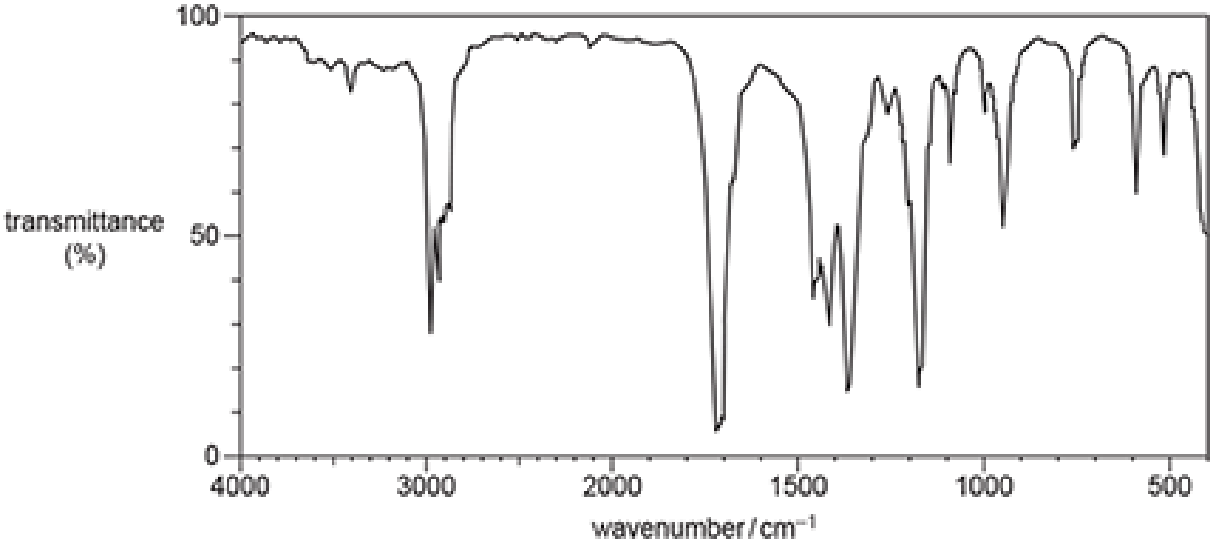


Use all the information to determine a possible structure of compound **X**.

In your answer, make it clear how your conclusions are linked to the evidence.

[6]

7. An organic compound produces the infrared spectrum below.



Which compound could have produced this IR spectrum?

A $CH_3CH_2CH=CH_2$
B $CH_3CHOHCH_2CH_3$
C $CH_3CH_2COCH_3$
D $(CH_3)_2CHCOOH$

Your answer ☐ **[1]**

8. Pentan-2-ol and pentan-3-ol are structural isomers with the molecular formula $C_5H_{12}O$ and M_r = 88.

The isomers can be distinguished from the fragment ions in their mass spectra.

Which fragment ion would you expect to be present in only **one** of these isomers?

A *m/z* = 29
B *m/z* = 45
C *m/z* = 59
D *m/z* = 73

Your answer ☐ **[1]**

9. An unknown organic compound is analysed.

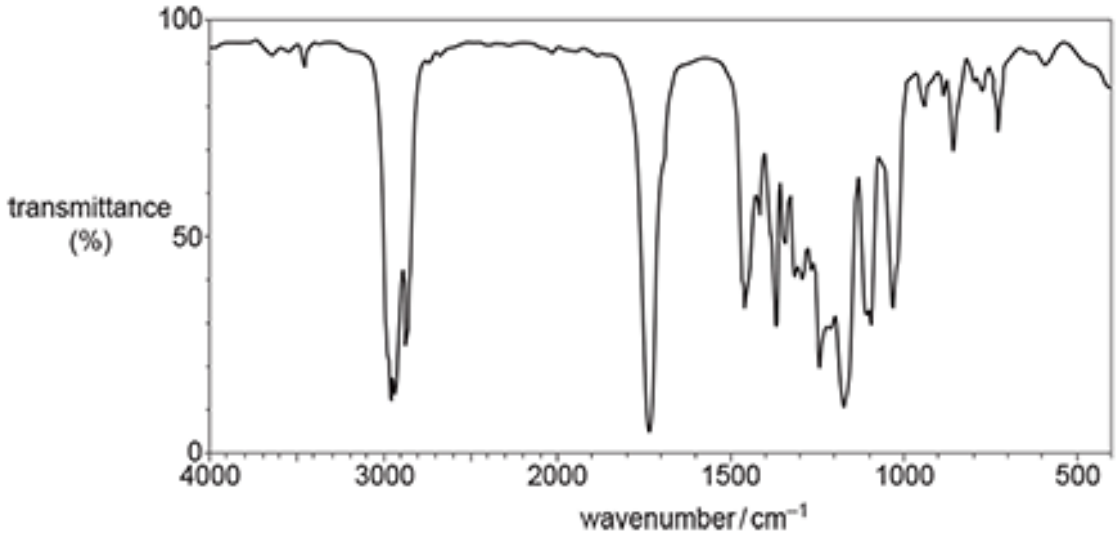
The results are shown below.

Addition of 2,4-DNP
No visible change

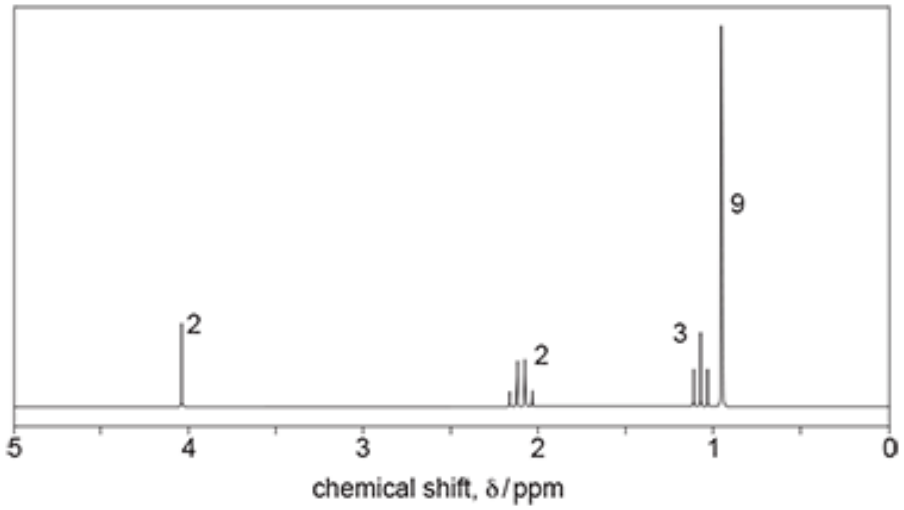
Elemental analysis by mass
C, 66.63%; H, 11.18%; O, 22.19%

Mass spectrum
Molecular ion peak at *m / z* = 144.0

IR spectrum



Proton NMR spectrum
The numbers by each peak are the relative peak areas.

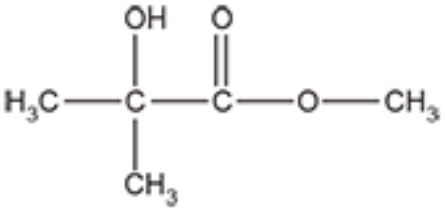
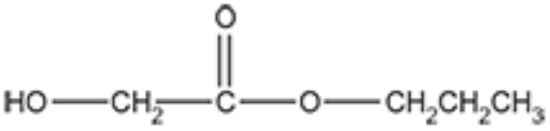
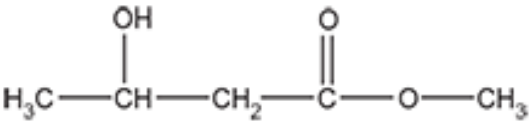
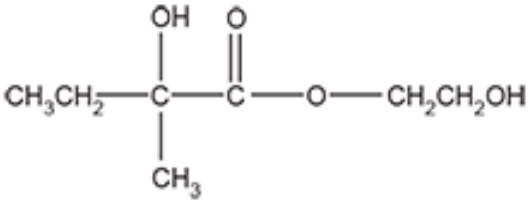


Use the information to identify the organic compound.

Show **all** your reasoning.

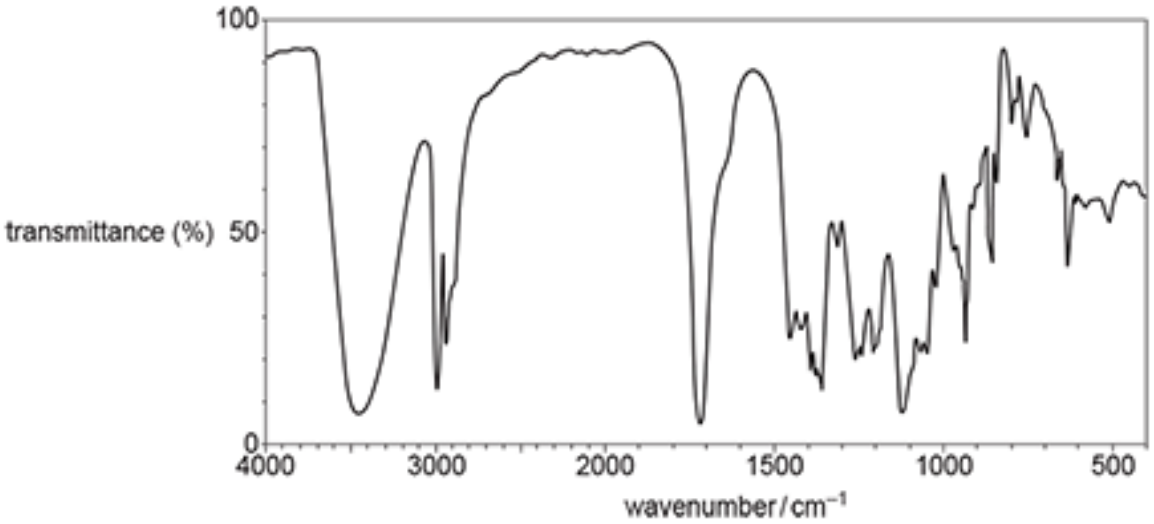
[6]

10. Which ester is most likely to produce a mass spectrum with a fragment ion at $m / z = 43$?

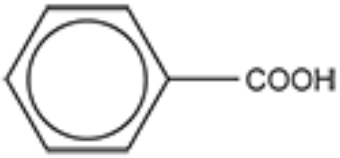
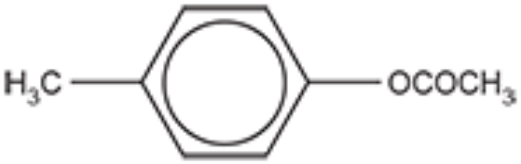
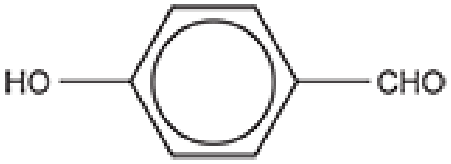
A	
B	
C	
D	

Your answer ☐ **[1]**

11. The infrared spectrum of an organic compound is shown below.

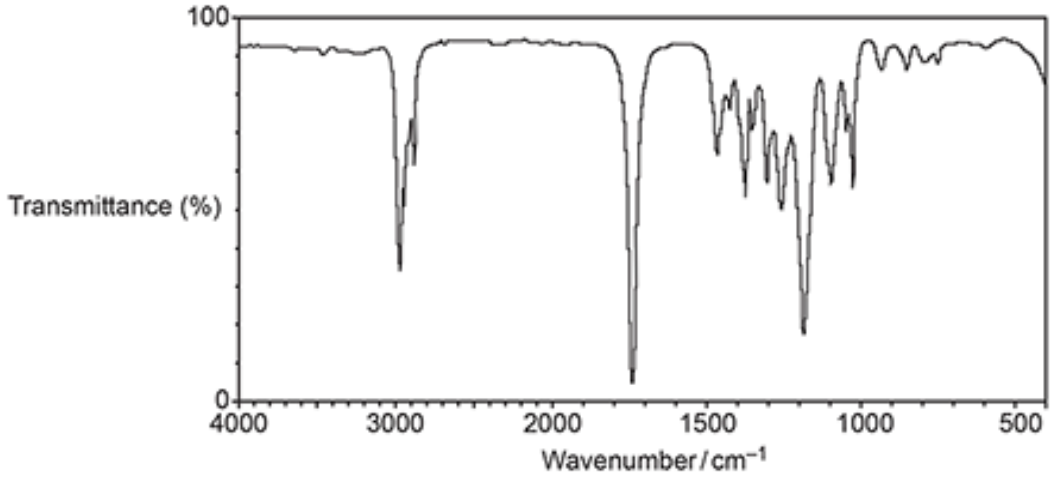


Which compound could have produced this spectrum?

A	
B	
C	
D	

Your answer ☐ **[1]**

12. The infrared spectrum of an organic compound is shown below.



Which compound could have produced this spectrum?

A $H_2C=CHCH_2CH_2OH$
B $CH_3COOCH_2CH_3$
C $H_2NCH_2COOCH_3$
D $(CH_3)_2CHCONH_2$

Your answer ☐ **[1]**

13. This question is about unsaturated hydrocarbons.

Compounds **B** and **C** are **branched** hydrocarbons that are structural isomers of C_6H_{12}.

Compounds **B** and **C** both have stereoisomers.

• Compound **B** has *cis* and *trans* isomers but does **not** have optical isomers.

• Compound **C** has optical isomers but does **not** have *cis* and *trans* isomers.

i. What is meant by the term **structural isomers**?

[1]

ii. What is meant by the term **stereoisomers**?

[1]

iii. Draw structures for the *cis* and *trans* isomers of the branched hydrocarbon **B**.

***cis* isomer**	***trans* isomer**

[2]

iv. Draw 3D structures for the optical isomers of compound **C**.

Optical isomers	

[2]

v. Compounds **D** and **E** are two more structural isomers of C_6H_{12}.

Compounds **D** and **E** do **not** show stereoisomerism.

Table 16.1 shows NMR and infrared (IR) spectral data for **D** and **E**.

	Number of peaks in ^{1}H NMR spectrum	**Number of peaks in ^{13}C NMR spectrum**	**IR peak at 1620–1680 cm^{-1}**
D	1	1	No
E	1	2	Yes

Table 16.1

Draw the structures of **D** and **E** and explain how the spectral data in **Table 16.1** provides evidence for the structures.

D	**E**

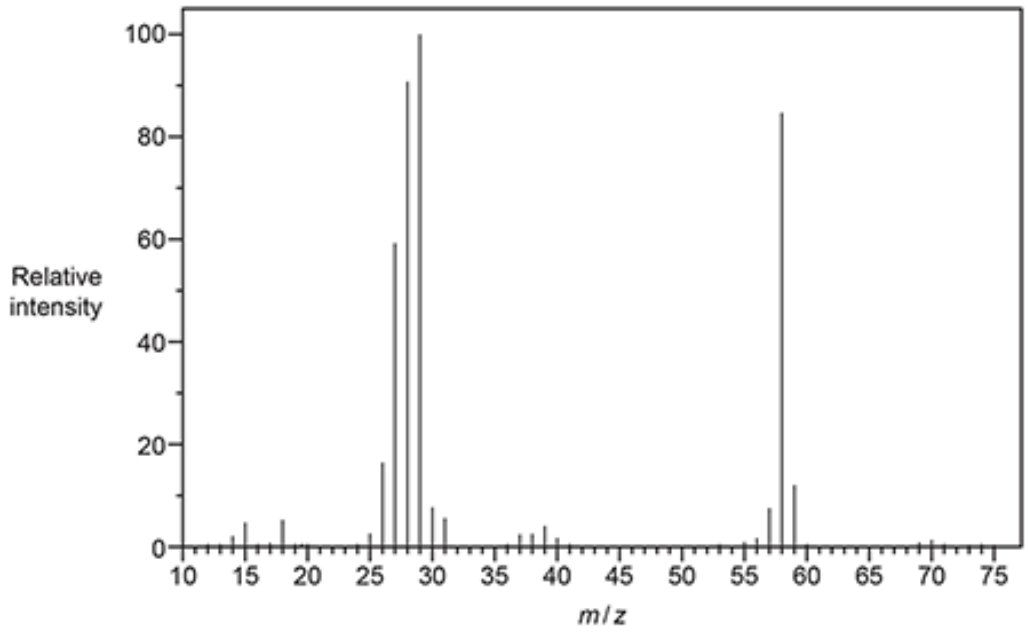
[4]

14. A student is provided with two unknown carbonyl compounds, **F** and **G**.

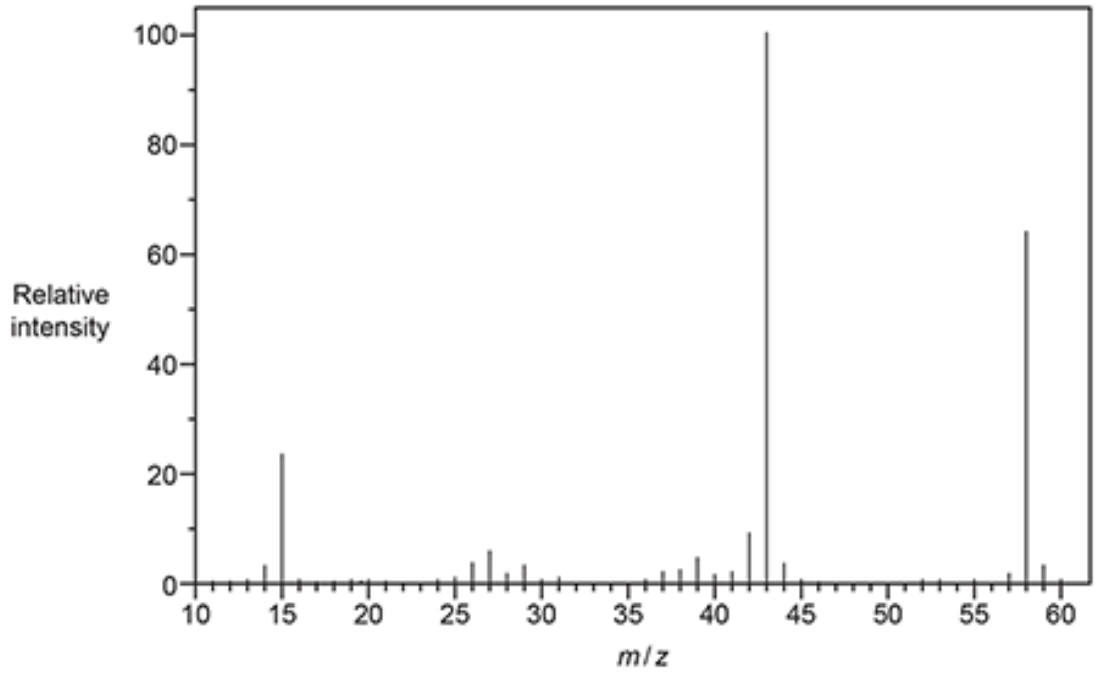
The compounds are analysed and found to have identical percentage compositions by mass:
C: 62.07%; H: 10.34%; O: 27.59%

The mass spectra of the two compounds are shown below.

Mass spectrum of F



Mass spectrum of G



Use the results to identify the structures of the two compounds.

Include relevant peaks present in the mass spectrum of each compound.

F	**G**

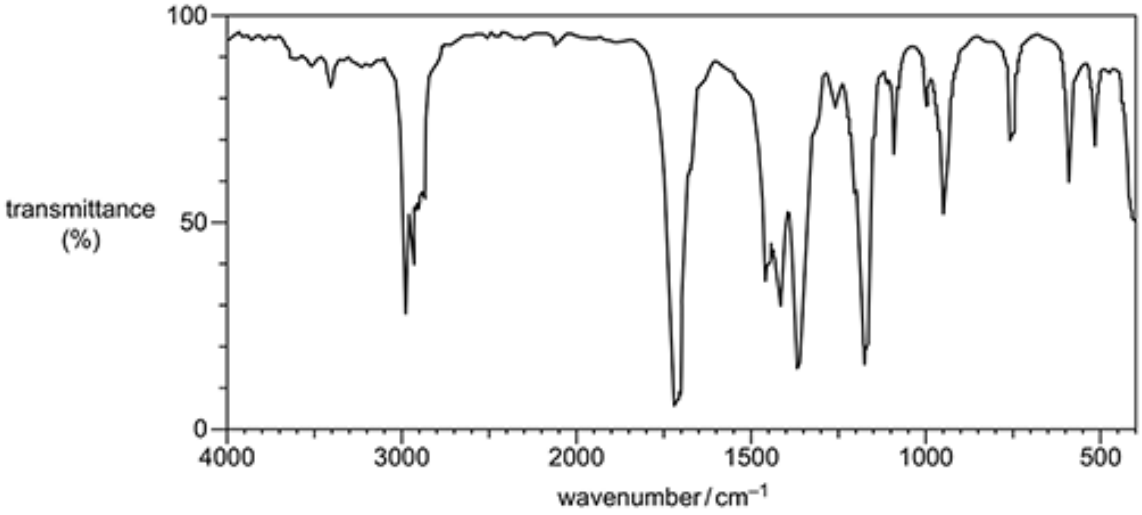
[4]

15. Which statement about absorption of radiation is correct?

A Infrared radiation can result in the breakdown of the ozone layer.
B Ultraviolet radiation can cause some polymers to photodegrade to benefit the environment.
C Ultraviolet radiation is linked to global warming.
D Ultraviolet radiation is used in modern breathalysers to measure ethanol in the breath.

Your answer ☐ **[1]**

16. Which organic compound could have produced the infrared spectrum below?



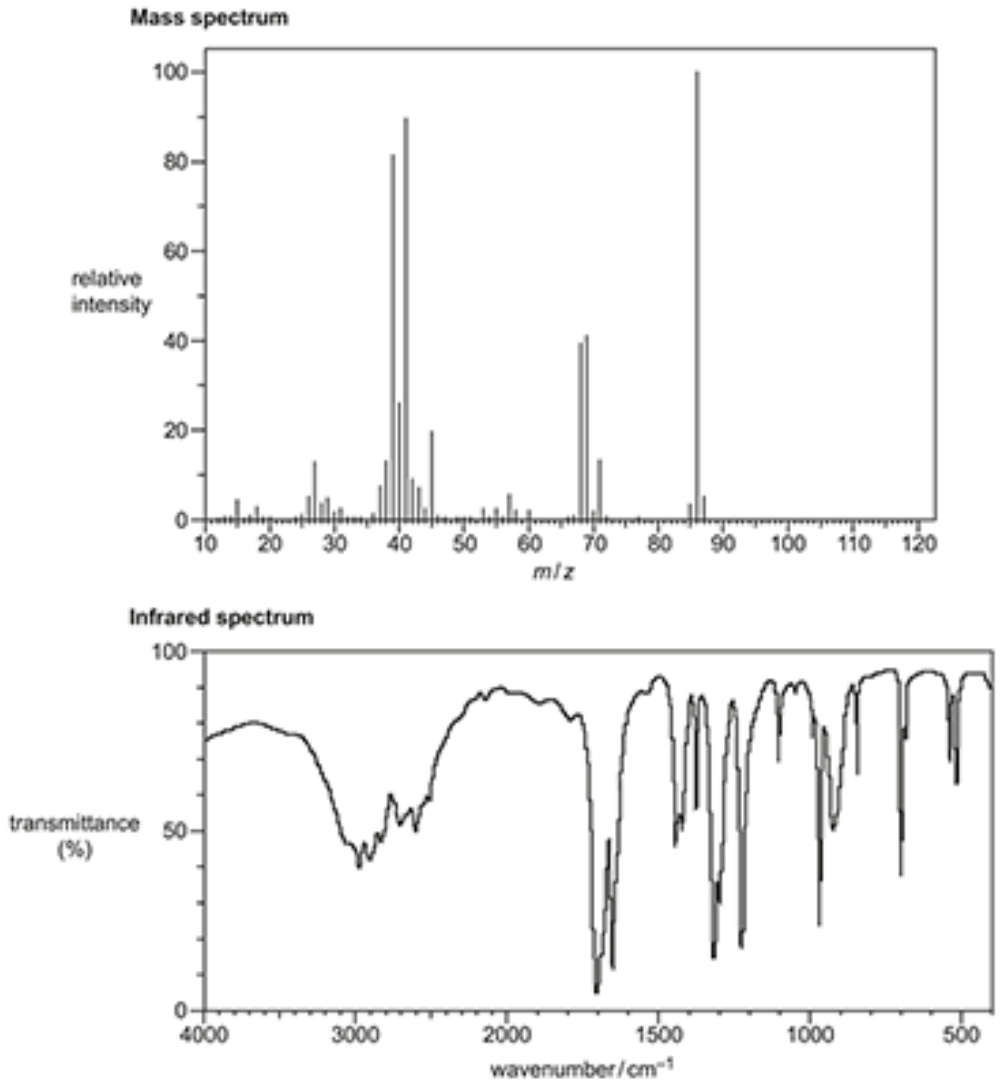
A $CH_3COCH_2CH_3$
B $CH_3CH_2CHOHCH_3$
C $CH_3COCH_2CH_2OH$
D CH_3CH_2COOH

Your answer ☐ **[1]**

17. * The organic compound **A** is unsaturated and is a *trans* stereoisomer.

Compound **A** has the following composition by mass: C, 55.8%; H, 7.0%; O, 37.2%.

The mass spectrum and the infrared spectrum of compound **A** are shown below.



Use the information to determine the structure of compound **A**.

Explain your reasoning and show your working.

[6]

END OF QUESTION PAPER