

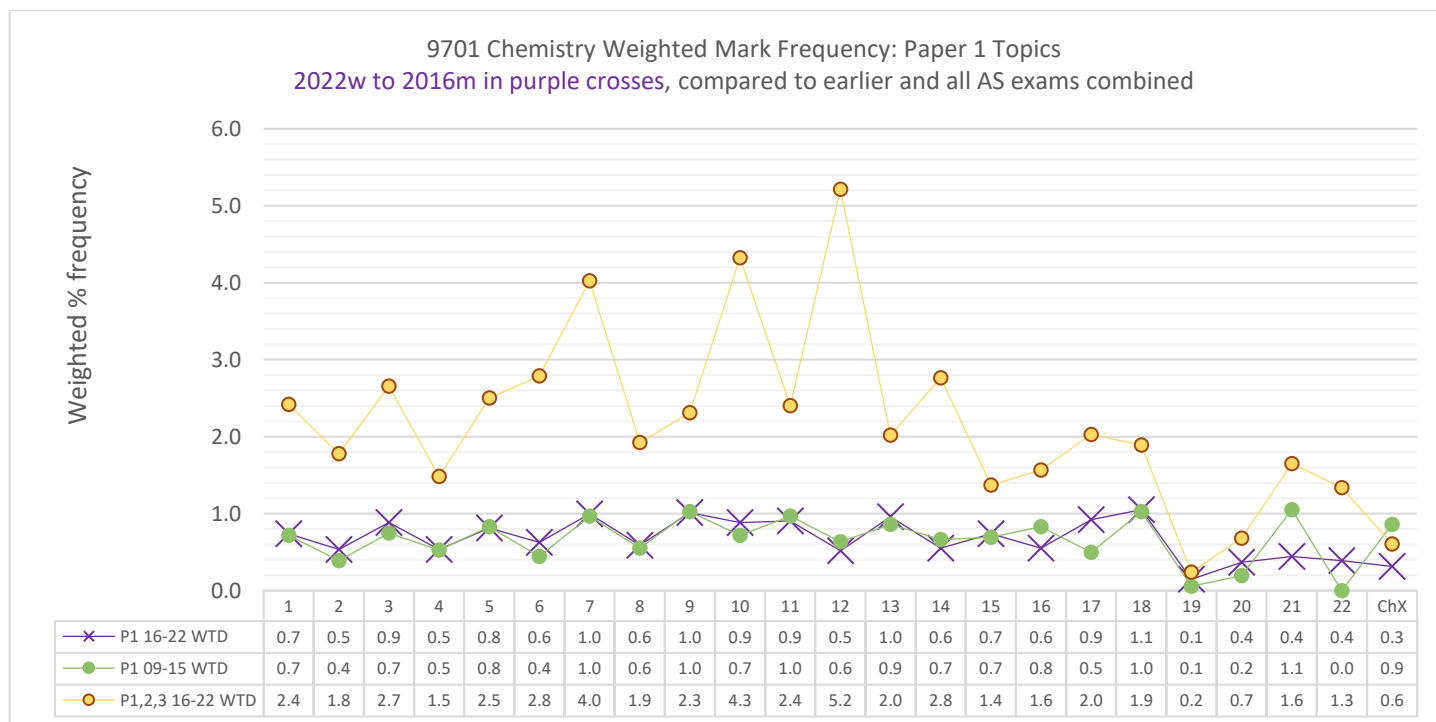
# ALyl Chem 22 EQ P1 22w to 09s Paper 1 Analytical techniques 21marks

As you start and work through this worksheet you can tick off your progress to show yourself how much you have done, and what you need to do next. The first task is just to read the first question and should take you less than one minutes to complete.

## Paper 1 Topic 22

**Checklist** Tick each task off as you go along

RANK:	P1 Noob	P1 Novice	P1 Bronze	P1 Silver	P1 Gold	P1 <sup>1</sup> Winner	P1 Hero	P1 Legend
	1 Q started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
<b>Topic (marks)</b>	21	1	2	5	8	11	16	21
<b>Time @75s/mark (minutes)</b>	26	1	3	7	11	13	20	26



What the most thoughtful students will get out of their extensive studying will be a capacity to do meaningful brain-based work even under stressful conditions, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades will also happen, but the most important goal from skillful action in study is being better at any important task, even if circumstances do not feel ideal.

As you are moving through your studies you can learn more about yourself by trying out new ways to manage yourself, and analysing how effective those new techniques were. In this reflective process not only will you get better at working positively and productively to deliver ambitious and successful outcomes, but you will be working towards one aspect of life's highest pursuit, summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

- To complete these questions, as important as your answer, is checking your answer against the mark scheme.
- For each page or group of 10 questions, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each topic.
- Multiple choice questions, done carefully where you explain and show yourself your thinking using written notes as you move through each question, can be more useful than just Paper 2 for students aiming for a C or B grade. Paper 2 should be the larger focus for students aiming for A and A\* grades, however.
- If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are NOT using the marking scheme correctly; your correct answer might not be fully complete for all the marks you are awarding. The marks easiest to miss rely on providing the largest amount of detail.

<sup>1</sup> **DO NOT** work on these higher levels of completion in your A2 year unless you have also achieved at least a "Silver" (25%) in the same topic in **Paper 2**, which is **MOST** of your **AS grade**, and Paper 3 which is a smaller part of your year but still important.

# Analysis

## 22 Analytical techniques

### 22.1 Infra-red spectroscopy

#### Learning outcomes

Candidates should be able to:

- 1 analyse an infra-red spectrum of a simple molecule to identify functional groups (see the Data section for the functional groups required)

### 22.2 Mass spectrometry

#### Learning outcomes

Candidates should be able to:

- 1 analyse mass spectra in terms of  $m/e$  values and isotopic abundances (knowledge of the working of the mass spectrometer is not required)
- 2 calculate the relative atomic mass of an element given the relative abundances of its isotopes, or its mass spectrum
- 3 deduce the molecular mass of an organic molecule from the molecular ion peak in a mass spectrum
- 4 suggest the identity of molecules formed by simple fragmentation in a given mass spectrum
- 5 deduce the number of carbon atoms,  $n$ , in a compound using the  $M + 1$  peak and the formula

$$n = \frac{100 \times \text{abundance of } M + 1 \text{ ion}}{1.1 \times \text{abundance of } M \text{ ion}}$$

- 6 deduce the presence of bromine and chlorine atoms in a compound using the  $M + 2$  peak

Q# 1321/ AS Chemistry/2022/w/TZ 1/Paper 1/Q# 40//www.SmashingScience.org :o)

- 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

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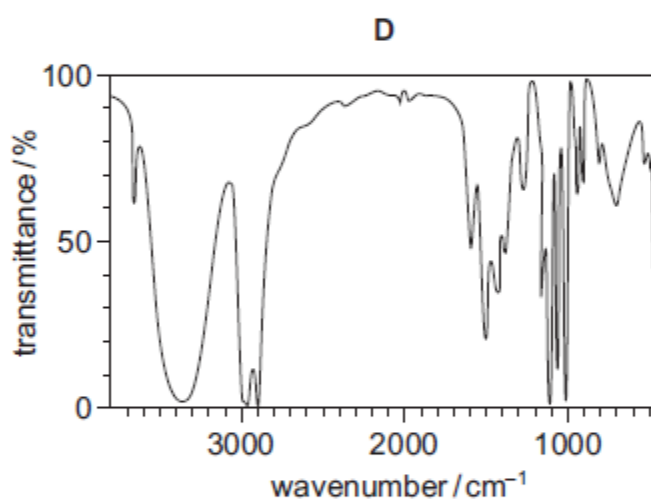
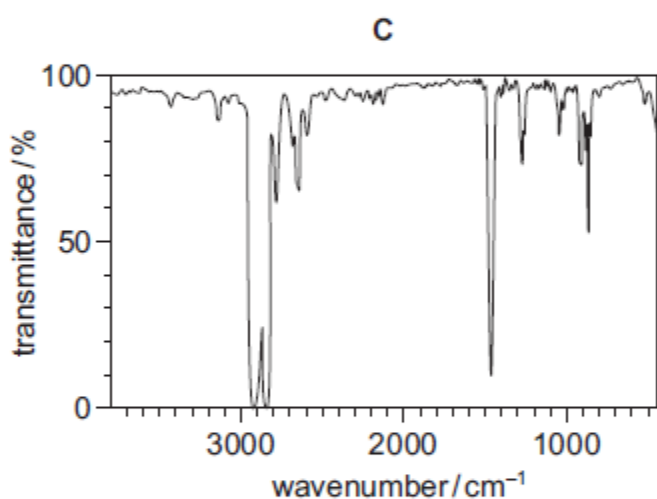
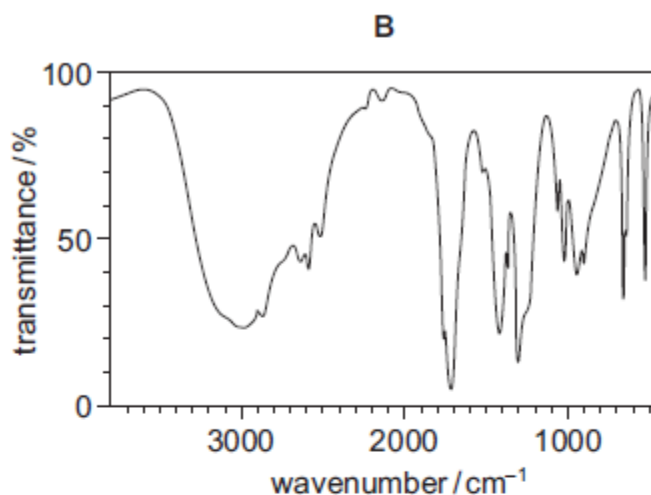
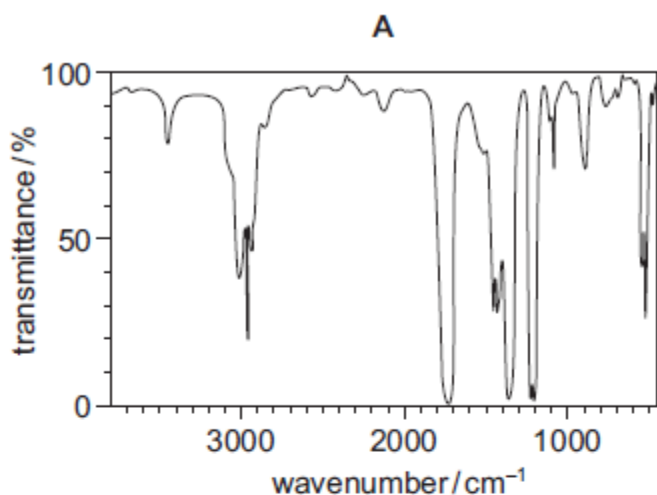
- 40 A scientist chooses either infrared spectroscopy or mass spectrometry to find a particular piece of information.

In which row has the **best** choice been made?

	target information	analytic method used
A	identities of functional groups in an organic compound	infrared spectroscopy
B	identities of functional groups in an organic compound	mass spectrometry
C	values of successive ionisation energies of Na	infrared spectroscopy
D	values of successive ionisation energies of Na	mass spectrometry



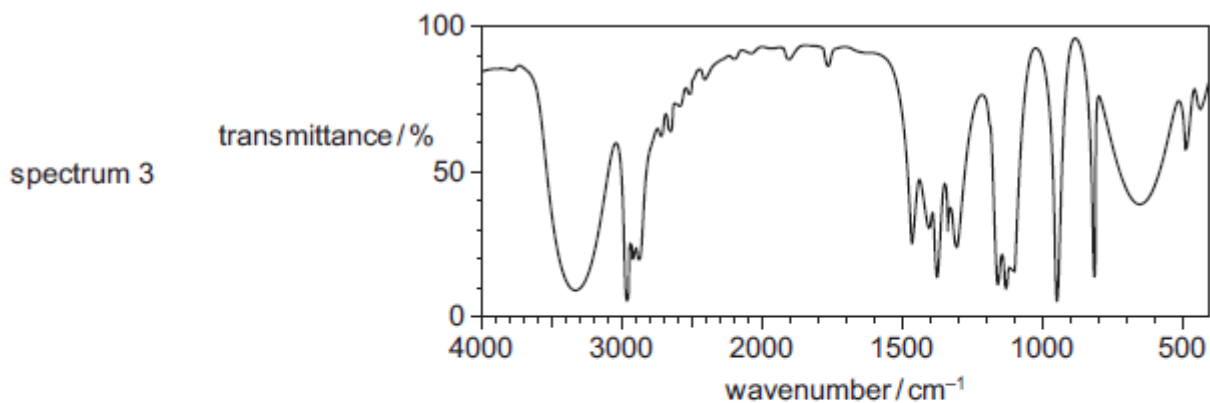
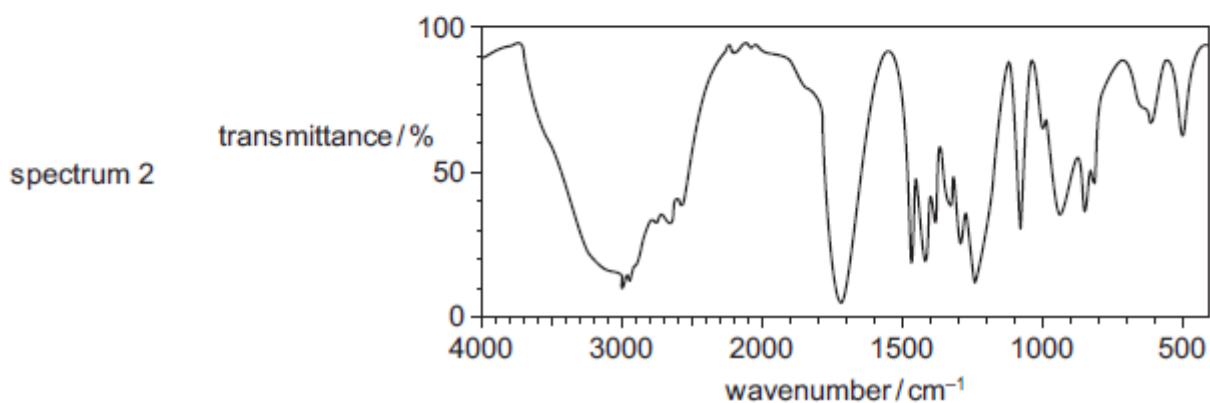
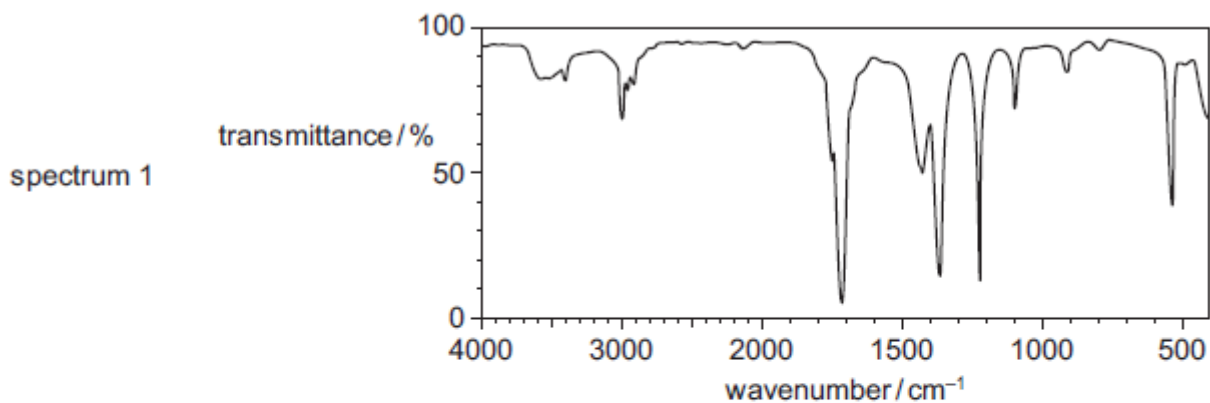
40 Which diagram shows the infrared spectrum of a compound that contains both a C=O and an O–H group?



bond	functional group containing the bond	characteristic infrared absorption range (in wavenumbers) / cm <sup>-1</sup>
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



30 The infra-red spectra of three organic compounds are shown.

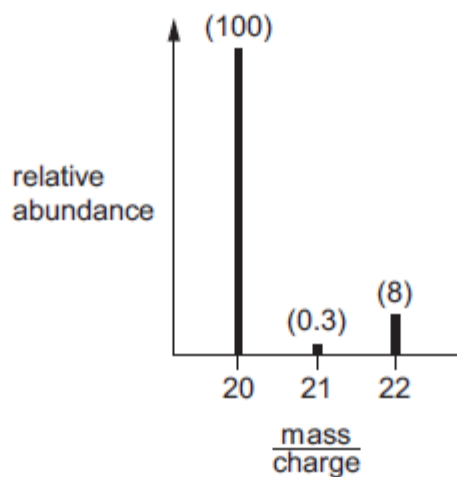


What could the three compounds be?

	spectrum 1	spectrum 2	spectrum 3
<b>A</b>	propanoic acid	propanone	propan-2-ol
<b>B</b>	propanone	propanoic acid	propan-2-ol
<b>C</b>	propanone	propan-2-ol	propanoic acid
<b>D</b>	propan-2-ol	propanoic acid	propanone

Q# 1325/ AS Chemistry/2021/w/TZ 1/Paper 1/Q# 1//www.SmashingScience.org :o)

- 1 The mass spectrum of a sample of neon is shown. The relative abundance of each peak is written in brackets above it.

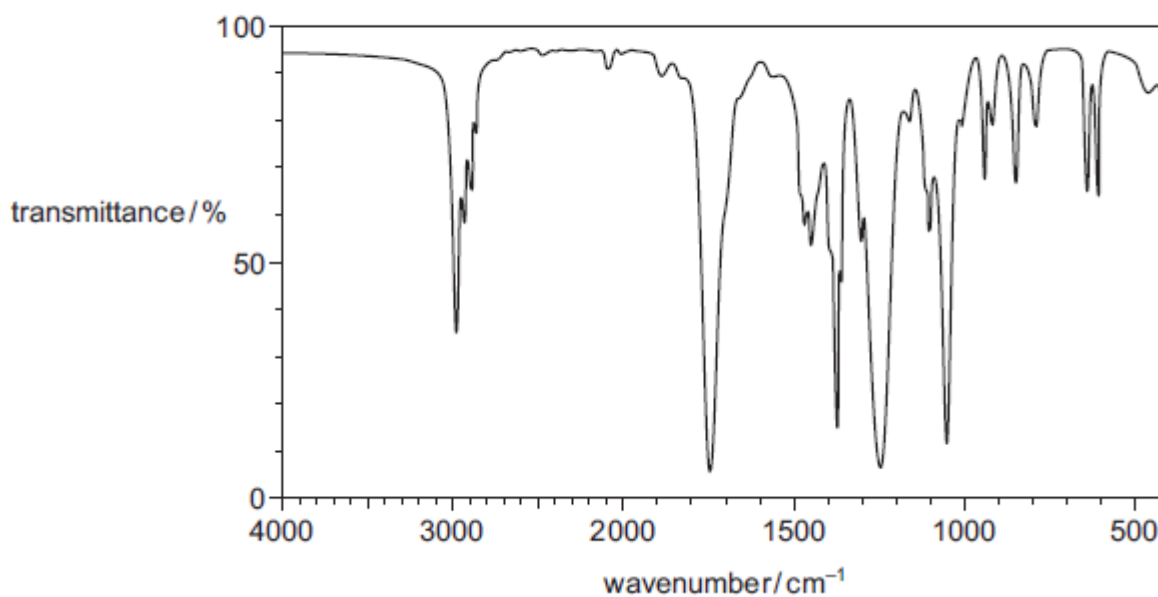


What is the relative atomic mass,  $A_r$ , of this sample of neon?

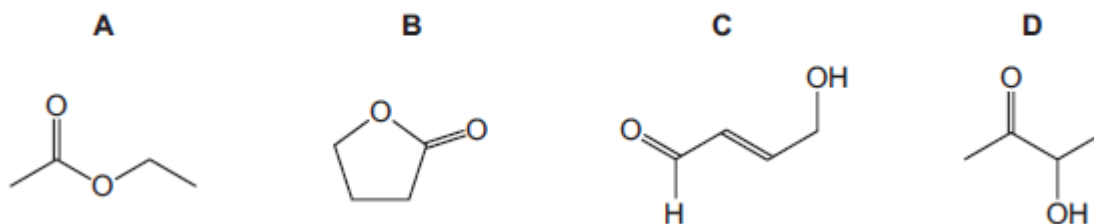
- A 20.15      B 20.20      C 21.00      D 21.82

Q# 1326/ AS Chemistry/2021/s/TZ 1/Paper 1/Q# 26//www.SmashingScience.org :o)

- 26 Compound X has the empirical formula  $C_2H_4O$ . Its infra-red spectrum is shown.



What could be the skeletal formula of compound X?



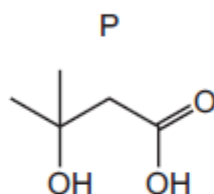
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

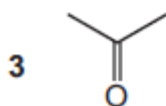
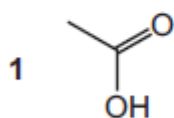
**38** An excess of P reacts with Q, in the presence of concentrated sulfuric acid, to form R.

Effervescence is seen when a piece of sodium is added to pure R.

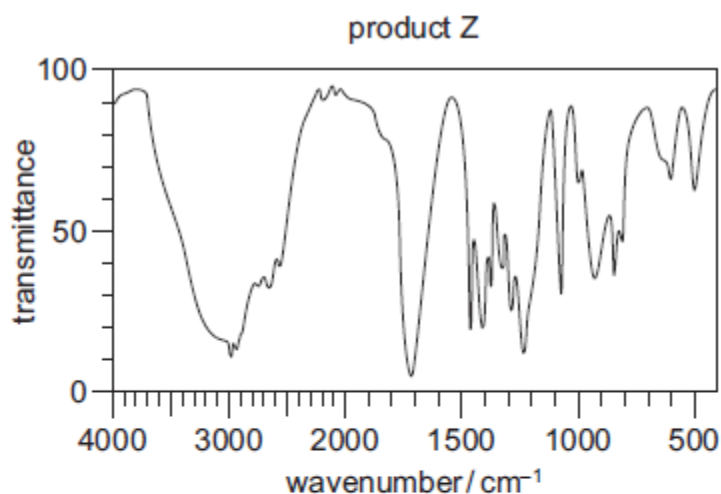
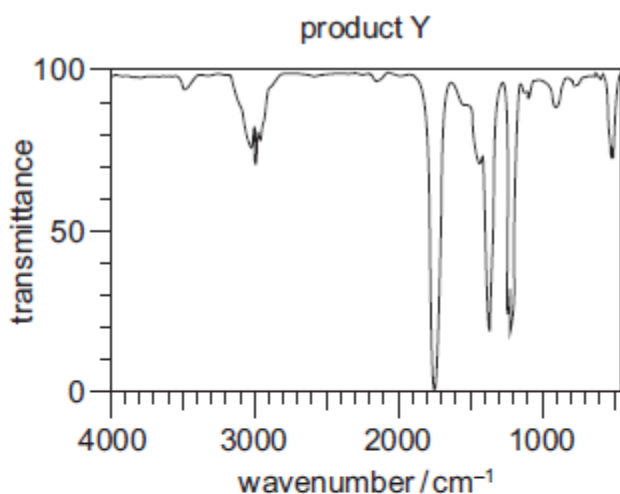
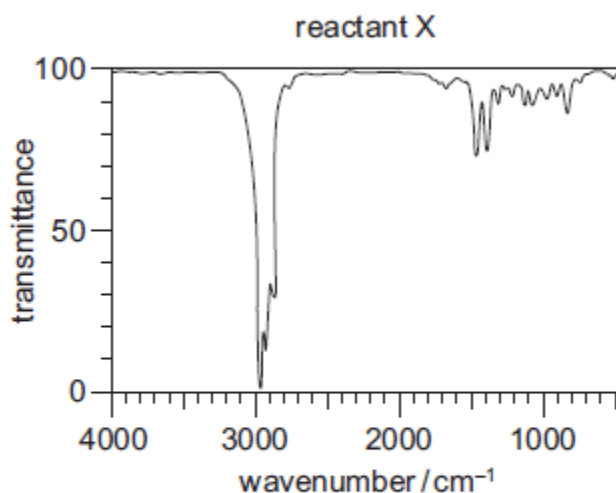
The structure of P is shown.



Which organic compounds could be compound Q?



30 When reactant X is treated with a suitable reagent, products Y and Z are formed. Infrared spectra of X, Y and Z are shown.



Which row could be correct?

	X	Y	Z
A	2,3-dimethylpent-2-ene	propanone	butanone
B	2-methylpent-2-ene	propanone	propanoic acid
C	pent-2-ene	ethanoic acid	propanoic acid
D	propyl propanoate	propan-1-ol	propanoic acid

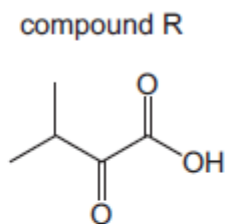
Q# 1329/ AS Chemistry/2020/w/TZ 1/Paper 1/Q# 37//www.SmashingScience.org :o)

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct



37 The structure of compound R is shown.

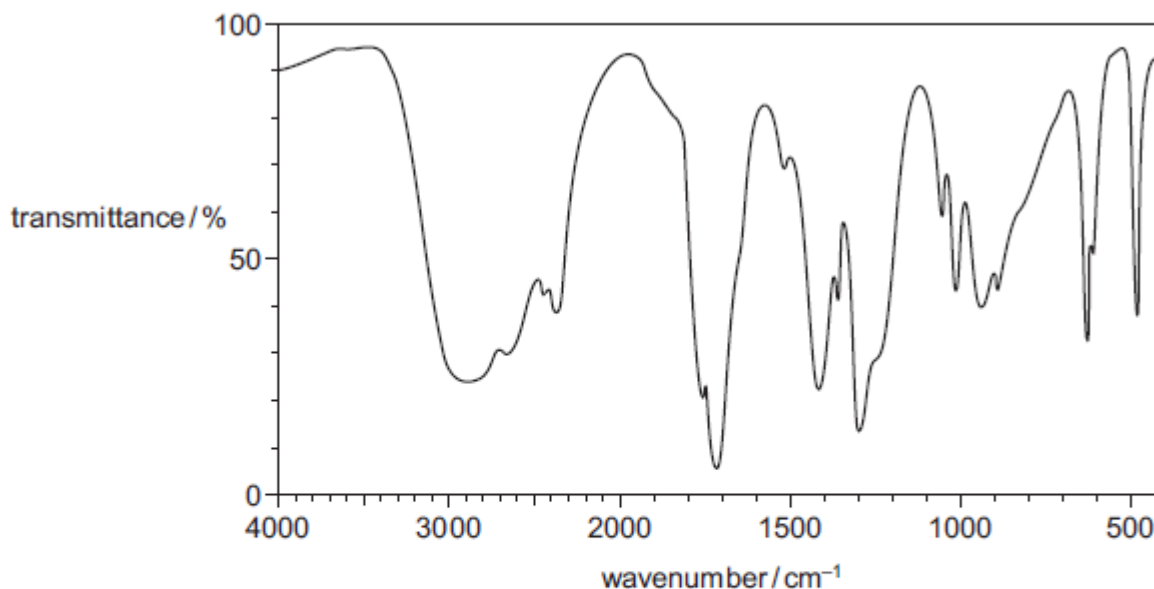


Which statements about compound R are correct?

- 1 It has an  $M_r$  of 116.
- 2 It contains two groups that show strong absorptions between  $1640$  and  $1740\text{ cm}^{-1}$  in its infrared spectrum.
- 3 Its only infrared absorption between  $2500$  and  $3000\text{ cm}^{-1}$  is sharp and strong.

Q# 1330/ AS Chemistry/2020/s/TZ 1/Paper 1/Q# 29//www.SmashingScience.org :o)

29 Compound X has the infra-red spectrum shown.



What could be the identity of compound X?

- A ethanoic acid
- B ethanol
- C ethylethanoate
- D propanone

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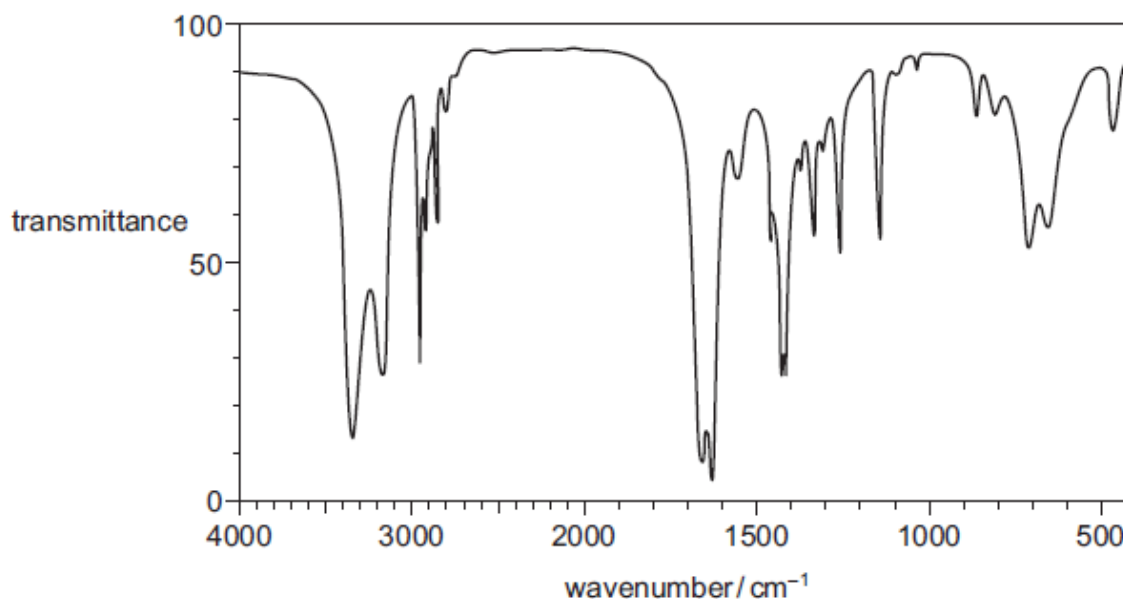
27 Which reaction would produce propanoic acid as one of its products?

- A heating  $(\text{CH}_3)_2\text{C}=\text{CHCH}_2\text{CH}_3$  with concentrated, acidified  $\text{KMnO}_4$
- B heating  $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3$  with  $\text{NaOH}(\text{aq})$
- C heating  $\text{CH}_3\text{CH}_2\text{OH}$  with acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  under reflux
- D reacting  $\text{CH}_3\text{CHO}$  with  $\text{HCN}$  then heating the organic product with  $\text{H}_2\text{SO}_4(\text{aq})$





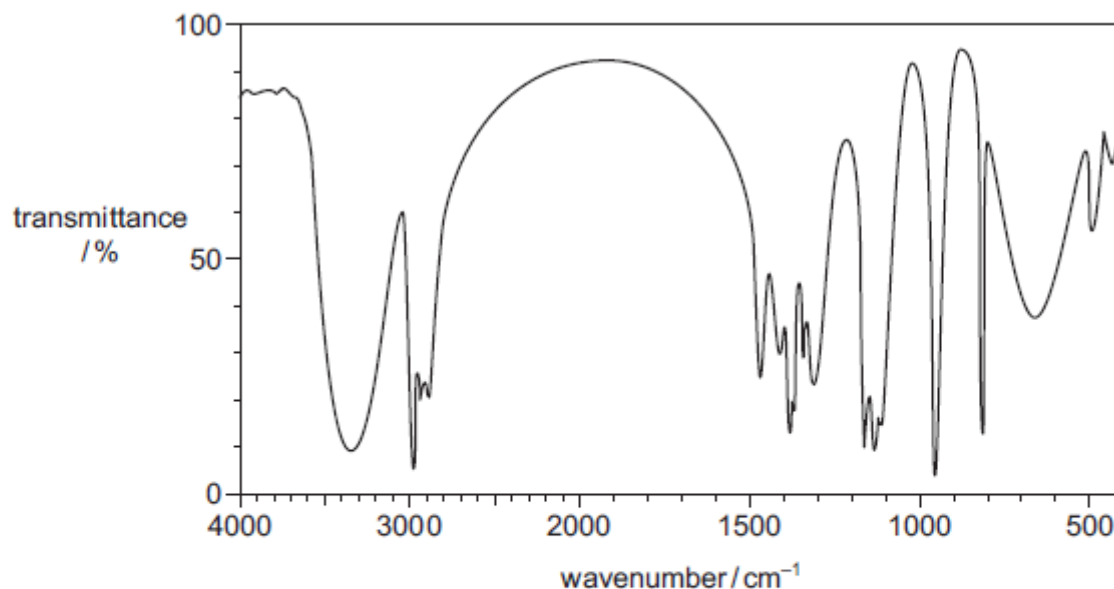
23 The infrared spectrum shown was obtained from a compound J.



Which statement about J is correct?

- A Both C=O and C≡N are present.
- B Neither C=O nor C≡N are present.
- C C=O is present but not C≡N.
- D C≡N is present but not C=O.

30 The infra-red spectrum of compound P is shown.

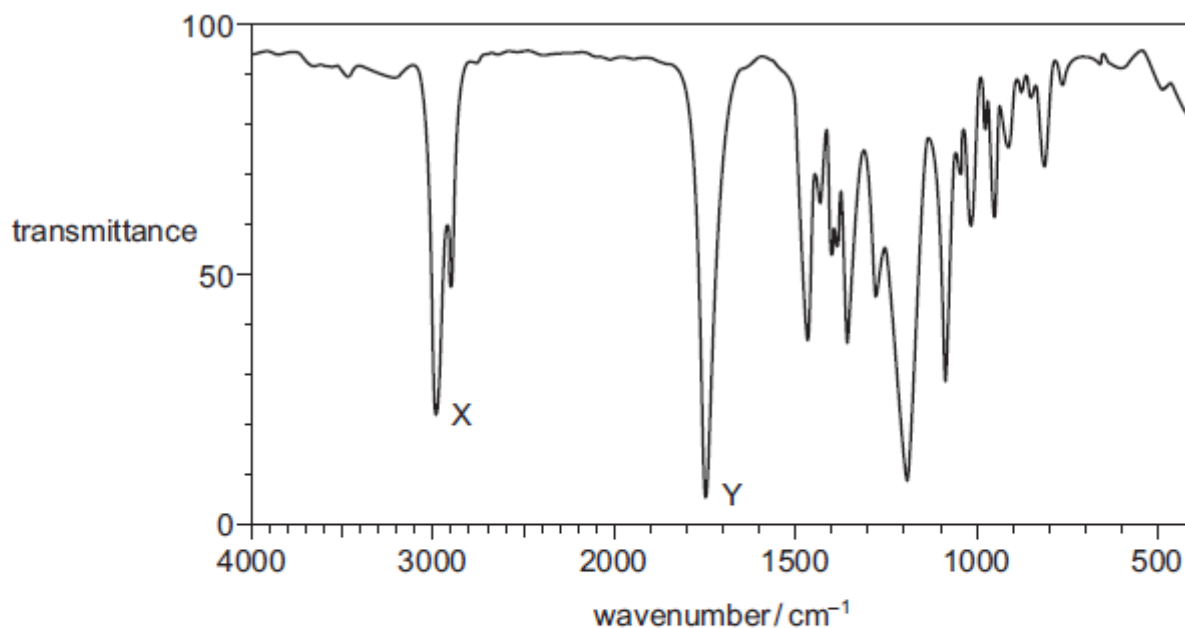


What could be compound P?

- A methyl ethanoate
- B propanal
- C propanoic acid
- D propan-2-ol



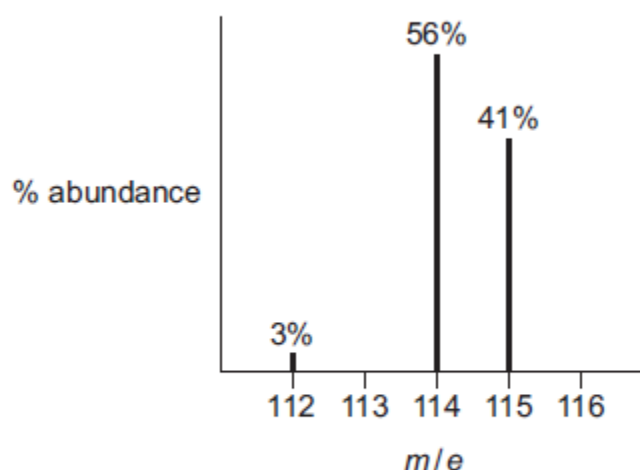
24 The infra-red spectrum of a substance with empirical formula  $C_2H_4O$  is shown.



Which bonds are responsible for peak X and peak Y?

	peak X	peak Y
A	C-H	C=C
B	C-H	C=O
C	O-H	C=C
D	O-H	C=O

2 A sample of element X is analysed using mass spectrometry. The mass spectrum obtained is shown.



What is the relative atomic mass of this sample of element X?

- A 113.7      B 114.0      C 114.2      D 114.4



30 An infra-red spectrum shows a broad peak at  $3000\text{ cm}^{-1}$  and a strong peak at  $1710\text{ cm}^{-1}$ .

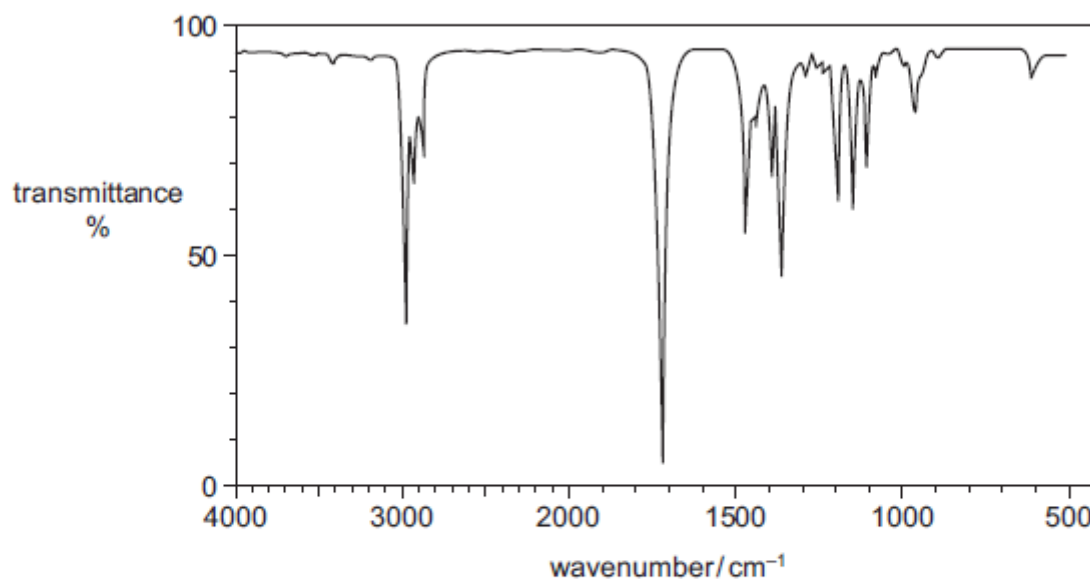
Which substance could have produced this spectrum?

- A methyl propanoate
- B propan-2-ol
- C propanoic acid
- D propanone

Q# 1337/ AS Chemistry/2018/w/TZ 1/Paper 1/Q# 30//www.SmashingScience.org :o)

30 J is a branched-chain alcohol,  $\text{C}_5\text{H}_{12}\text{O}$ . J is heated under reflux with an excess of  $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$  until no further reaction occurs. An organic compound K is formed in good yield.

The infra-red spectrum of K is shown.

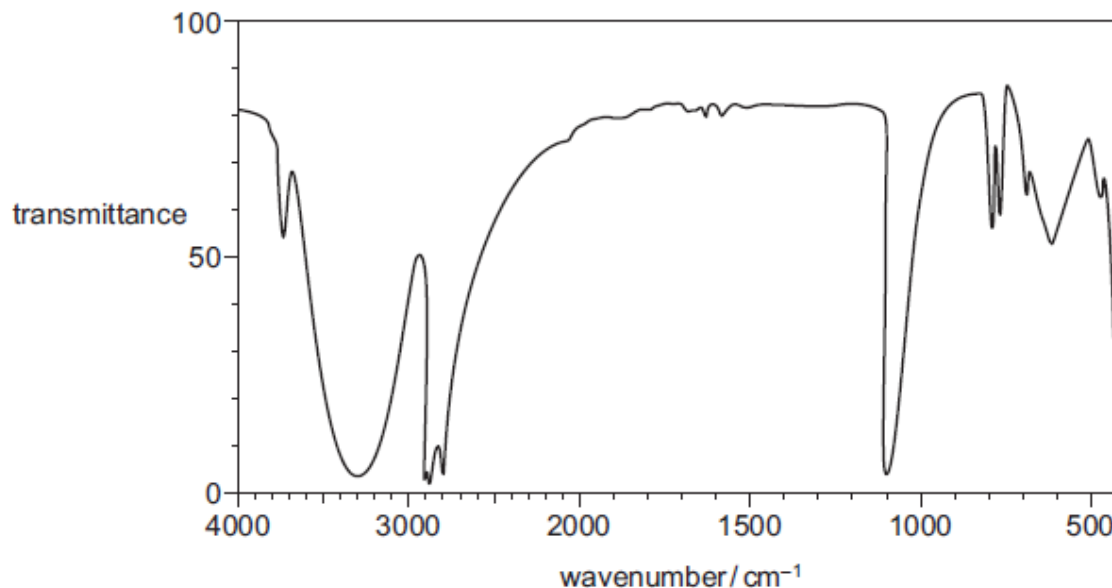


What are the structures of the branched-chain alcohol J and compound K?

	J	K
A	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CHO}$
B	$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
C	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{OH})\text{CH}_3$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{COCH}_3$
D	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$



30 Compound X contains three carbon atoms. Part of a simplified infra-red spectrum of compound X is shown.



Which compound could be X?

- A  $\text{CH}_3\text{CH}_2\text{CHO}$
- B  $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
- C  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D  $\text{CH}_3\text{CO}_2\text{CH}_3$

30 How many **structural** isomers with the molecular formula  $\text{C}_4\text{H}_{10}\text{O}$  give infra-red absorptions both at approximately  $1200\text{ cm}^{-1}$  and at approximately  $3400\text{ cm}^{-1}$ ?

- A 2                      B 4                      C 6                      D 7

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

31 Beams of charged particles are deflected by an electric field. In identical conditions the angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment, protons are deflected by an angle of  $+15^\circ$ . In another experiment under identical conditions, particle Y is deflected by an angle of  $-5^\circ$ .

What could be the composition of particle Y?

	protons	neutrons	electrons
1	1	2	2
2	3	3	5
3	4	5	1



The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

- 31 A sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions,  $X^+$ ,  $Y^+$  and  $Z^+$ .

ion	$X^+$	$Y^+$	$Z^+$
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?

- There are more electrons in  $Z^+$  than in  $X^+$ .
- The  $A_r$  of boron in the sample is 10.83 to four significant figures.
- There are more protons in  $Y^+$  than in  $X^+$ .

### Mark Scheme ALVl Chem 22 EQ P1 22w to 09s Paper 1 Analytical techniques 21marks

Q# 1321/ AS Chemistry/2022/w/TZ 1/Paper 1/Q# 40//:o)

40 | D

Q# 1322/ AS Chemistry/2022/s/TZ 1/Paper 1/Q# 40//:o)

40 | A

Q# 1323/ AS Chemistry/2022/m/TZ 2/Paper 1/Q# 40//:o)

40 | B

Q# 1324/ AS Chemistry/2021/w/TZ 1/Paper 1/Q# 30//:o)

30 | B

Q# 1325/ AS Chemistry/2021/w/TZ 1/Paper 1/Q# 1//:o)

1 | A

Q# 1326/ AS Chemistry/2021/s/TZ 1/Paper 1/Q# 26//:o)

26 | A

Q# 1327/ AS Chemistry/2021/m/TZ 2/Paper 1/Q# 38//:o)

38 | B

Q# 1328/ AS Chemistry/2021/m/TZ 2/Paper 1/Q# 30//:o)

30 | B

Q# 1329/ AS Chemistry/2020/w/TZ 1/Paper 1/Q# 37//:o)

37 | B

Q# 1330/ AS Chemistry/2020/s/TZ 1/Paper 1/Q# 29//:o)

29 | A

Q# 1331/ AS Chemistry/2020/m/TZ 2/Paper 1/Q# 27//:o)

27 | A

Q# 1332/ AS Chemistry/2020/m/TZ 2/Paper 1/Q# 23//:o)

23 | C

Q# 1333/ AS Chemistry/2019/w/TZ 1/Paper 1/Q# 30//:o)

30 | D

Q# 1334/ AS Chemistry/2019/s/TZ 1/Paper 1/Q# 24//:o)

24 | B

Q# 1335/ AS Chemistry/2019/s/TZ 1/Paper 1/Q# 2//:o)

2 | D

Q# 1336/ AS Chemistry/2019/m/TZ 2/Paper 1/Q# 30//:o)

30 | C

Q# 1337/ AS Chemistry/2018/w/TZ 1/Paper 1/Q# 30//:o)

30 | C

Q# 1338/ AS Chemistry/2018/s/TZ 1/Paper 1/Q# 30//:o)

30 | C

Q# 1339/ AS Chemistry/2018/m/TZ 2/Paper 1/Q# 30//:o)

30 | B

Q# 1340/ AS Chemistry/2017/s/TZ 1/Paper 1/Q# 31//:o)

31 | B

Q# 1341/ AS Chemistry/2016/w/TZ 1/Paper 1/Q# 31//:o)

31 | B

