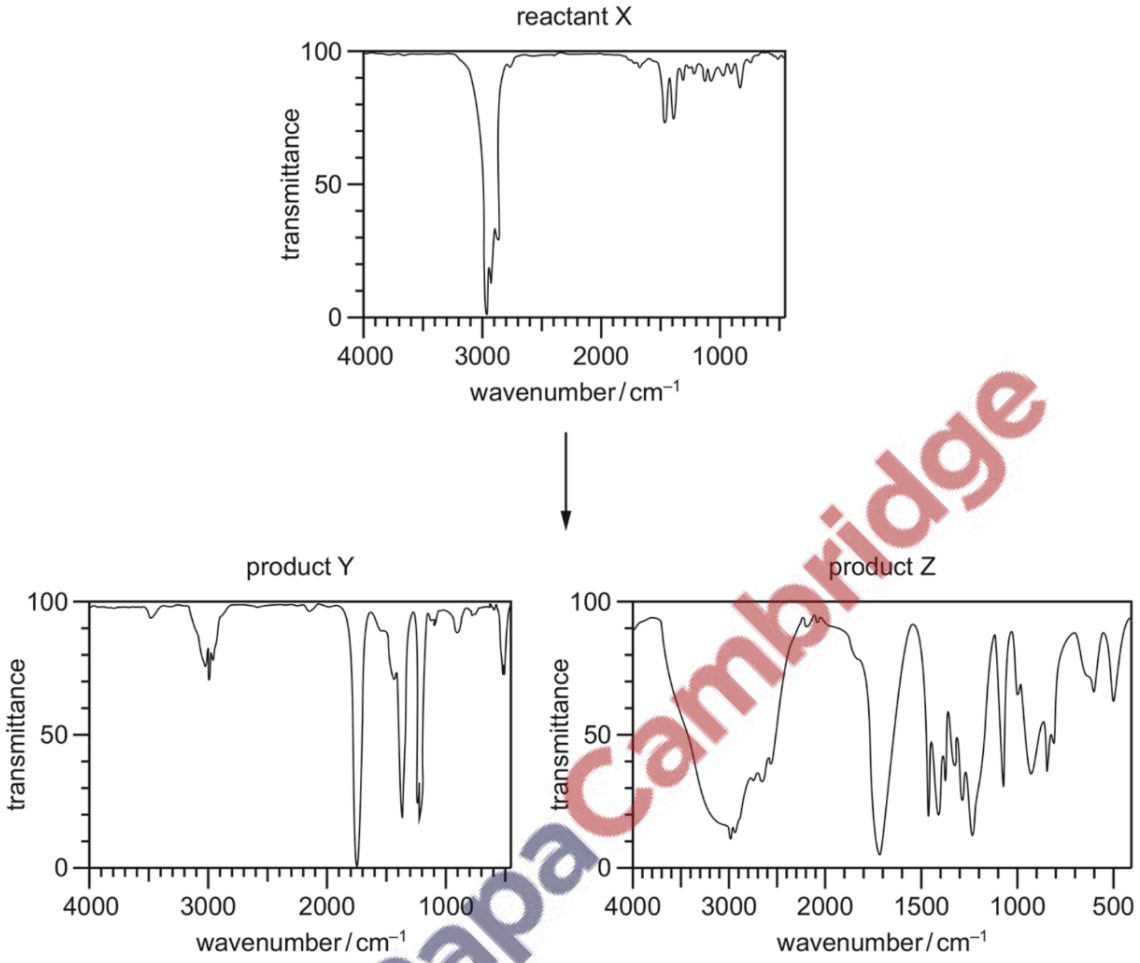
1.

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



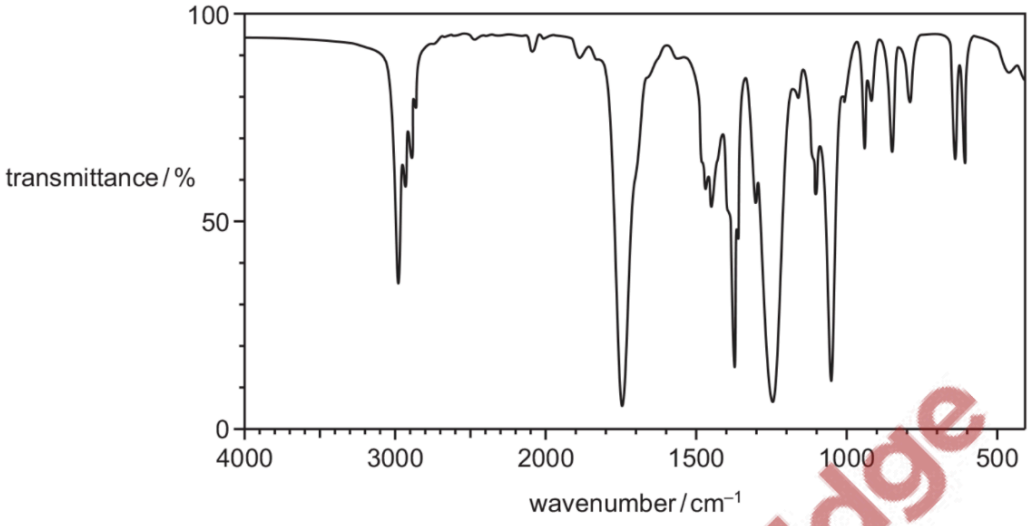
Which row could be correct?

	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

Ans: B

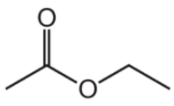
2.

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

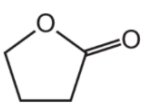


What could be the skeletal formula of compound X?

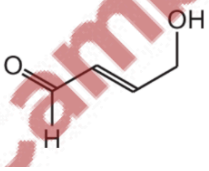
A



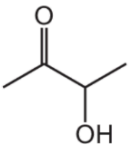
B



C



D

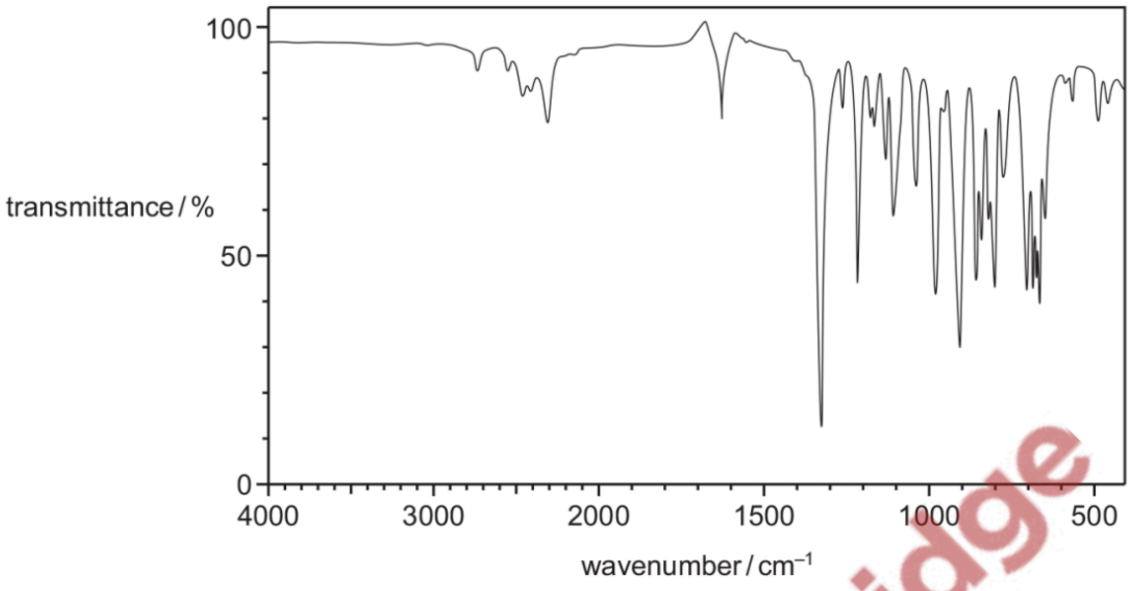


Ans: A

- C–H (alkane): 2850–2950
- C=O (ester): 1710–1750
- C–O (ester): 1040–1300
- Thus C & D can be ruled out.
- Empirical for A: C2H4O
- Empirical for B: C2H3O

3.

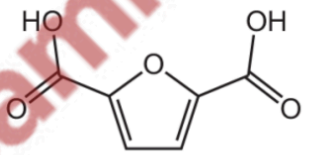
The infra-red spectrum of molecule Z is shown.



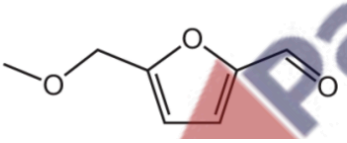
What could be the identity of Z?

A

B



C



D

Ans: D

4.

The table shows the molecular formulae of three molecules P, Q and R. None of the molecules are cyclic.

molecule	molecular formula
P	CH_4O
Q	CH_2O_2
R	CH_2O

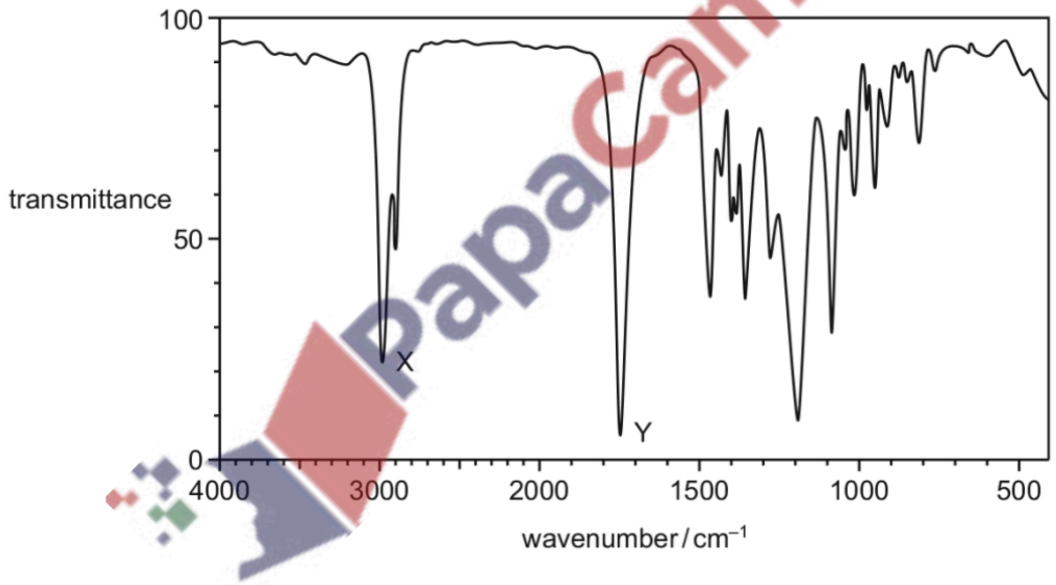
Which molecules show a strong absorption between 1610 cm^{-1} and 1750 cm^{-1} in their infra-red spectra?

A Q only **B** R only **C** Q and R only **D** P, Q and R

Ans: C

5.

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

Ans: B

O−H peak is broad!

6.

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?

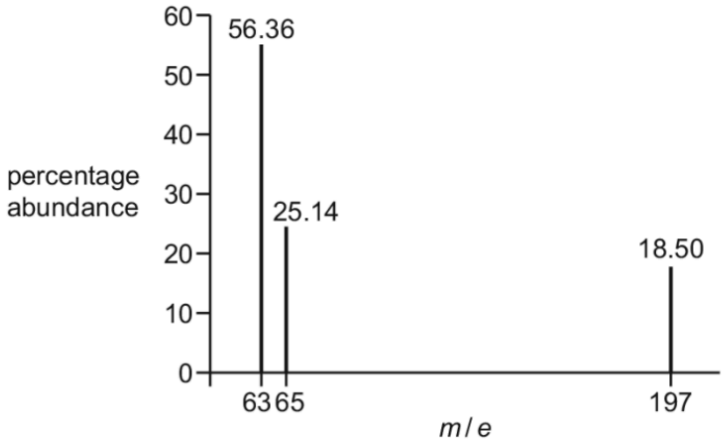
A 3 **B** 5 **C** 6 **D** 9

Ans: B

- 16 + 16 = 32
- 16 + 17 = 33
- 16 + 18 = 34
- 17 + 17 = 34
- 17 + 18 = 35
- 18 + 18 = 36
- 32, 33, 34, 35, 36. So 5! Don't count the 34 twice!!

7.

The mass spectrum of an alloy of copper and gold is shown.



Which expression can be used to calculate the relative atomic mass, A_r, of copper present in this sample?

A $\frac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14 + 18.50)}$

B $\frac{(56.36 \times 63) + (25.14 \times 65) + (18.50 \times 197)}{(56.36 + 25.14 + 18.50)}$

C $\frac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14)}$

D $\frac{(56.36 \times 63) + (25.14 \times 65)}{(63 + 65)}$

Ans: C

- 63 and 65 is for copper; 197 is for gold!!

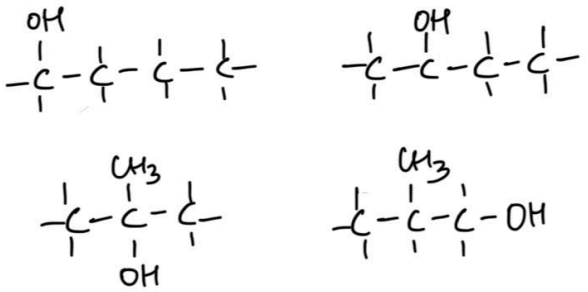
8.

How many **structural** isomers with the molecular formula $C_4H_{10}O$ give infra-red absorptions both at approximately 1200 cm^{-1} and at approximately 3400 cm^{-1}?

A 2 **B** 4 **C** 6 **D** 7

Ans: B

- Hydroxy compounds



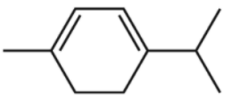
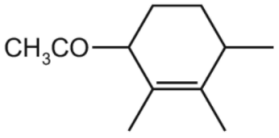
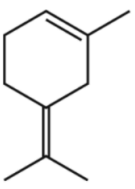
9.

Compound **S** can be extracted from natural compounds. Reacting **S** with hot, concentrated $KMnO_4$ produces the organic product, **T**. Some of the absorptions found in the infra-red spectra of **S** and **T** are described.

S has no strong absorption between 1670 and 1740 cm^{-1}.

T has a strong absorption at 1720 cm^{-1} but has **no** strong, broad absorption between 2500 and 3000 cm^{-1}.

From this information, what could be the formulae of **S** and **T**?

	S	T
A	$CH_3(CH_2)_5CH{=}CH_2$	$CH_3(CH_2)_5CO_2H$
B		$CH_3COCH_2CH_2COCH(CH_3)_2$
C		$CH_3COCH(COCH_3)CH_2CH_2CH(COCH_3)CH_3$
D		$HO_2CCH_2CH_2COCH_2COCH_3$

Ans: B

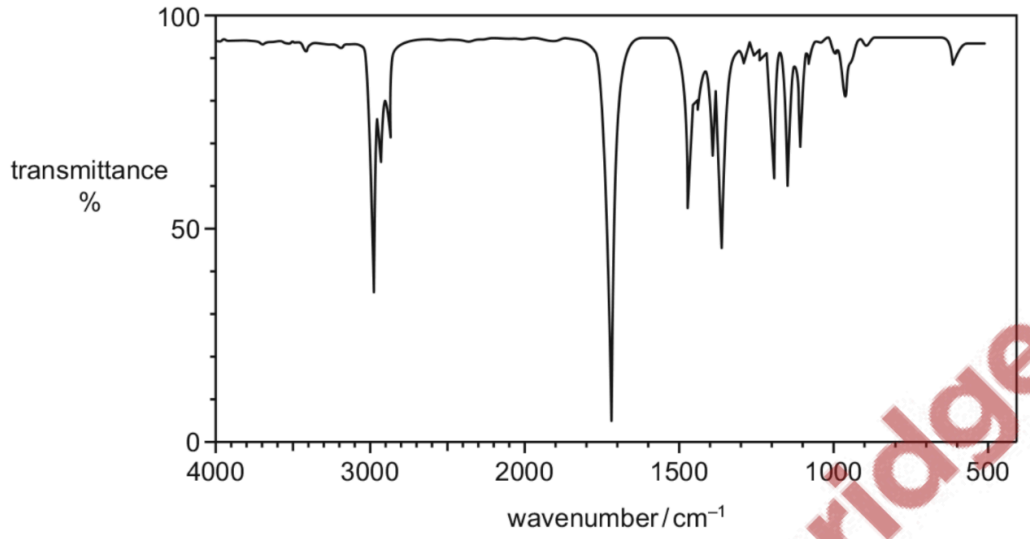
- S is not carboxylic acid, aldehyde or ketone

- T is ester, aldehyde or ketone but not carboxylic acid

10.

J is a branched-chain alcohol, $C_5H_{12}O$. **J** is heated under reflux with an excess of $Cr_2O_7^{2-}/H^+$ 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	$CH_3CH(CH_3)CH_2CH_2OH$	$CH_3CH(CH_3)CH_2CHO$
B	$CH_3CH_2CH(OH)CH_2CH_3$	$CH_3CH_2COCH_2CH_3$
C	$CH_3CH(CH_3)CH(OH)CH_3$	$CH_3CH(CH_3)COCH_3$
D	$CH_3CH(CH_3)CH_2CH_2OH$	$CH_3CH(CH_3)CH_2COOH$

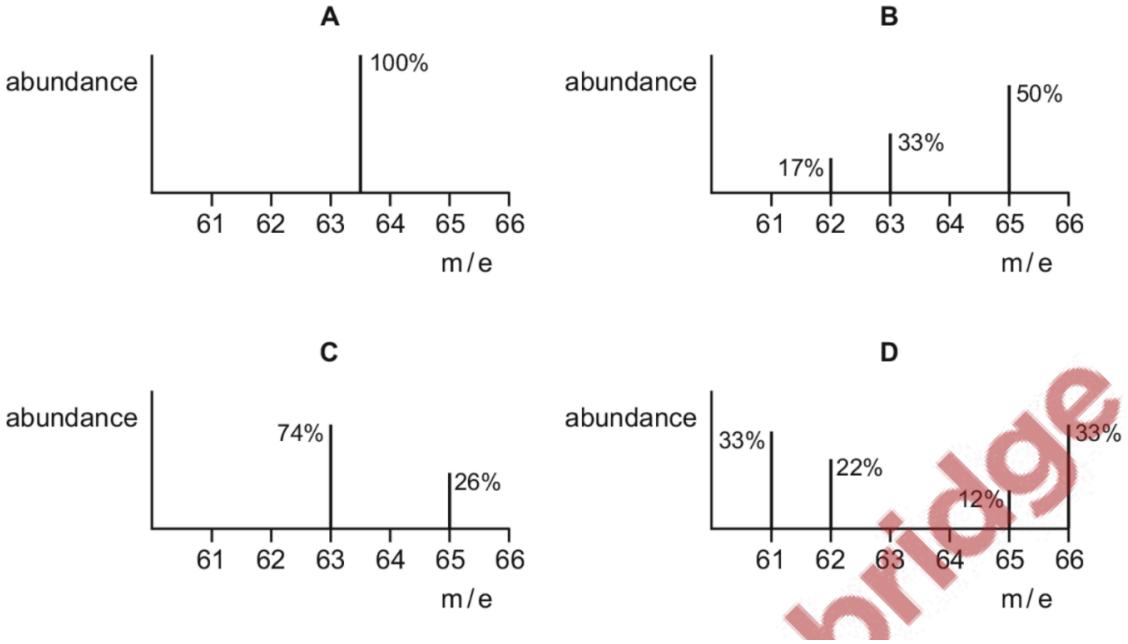
Ans: C

- A can be ruled out because aldehyde isn't formed when heated under reflux.
- B can be ruled out because J is not a branched chain alcohol.
- C and D are branched chain alcohols, and the products are correct.
- K is not carboxylic acid, because if it was, the 2500–3000 peak would be sharp AND broad, not just sharp!

11.

The relative atomic mass of copper is 63.5.

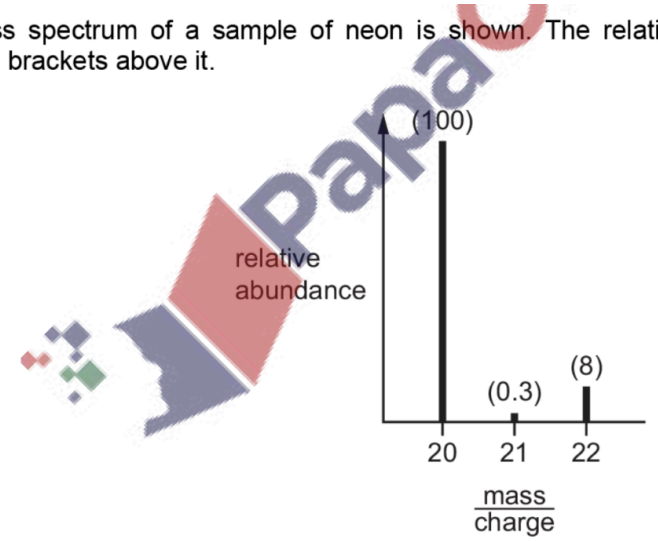
Which chart is a correct mass spectrum that would lead to this value?



Ans: C

12.

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

Ans: A

Ar = (mass x relative abundance) / (sum of relative abundances)

= (20 x 100 + 21 x 0.3 + 22 x 8) / (100 + 0.3 + 8) = 20.15

Remember to add up the relative abundances!! Don't just divide by 100!!

13.

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?

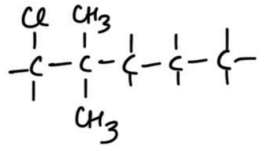
A 1-chloro-2,2-dimethylpentane

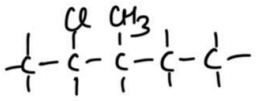
B 2-chloro-3-methylpentane

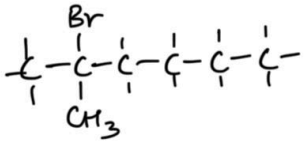
C 2-bromo-2-methylhexane

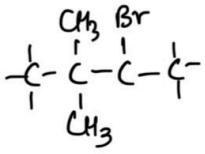
D 3-bromo-2,2-dimethylbutane

Ans: D

A 

B 

C 

D 

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

$$= \frac{100 \times x}{1.1 \times 15x} = 6$$

$\therefore$ 6 C atoms $\rightarrow$ B or D

$\rightarrow$ when M & M+2 are eq. height, Br is present

$\therefore$ option D

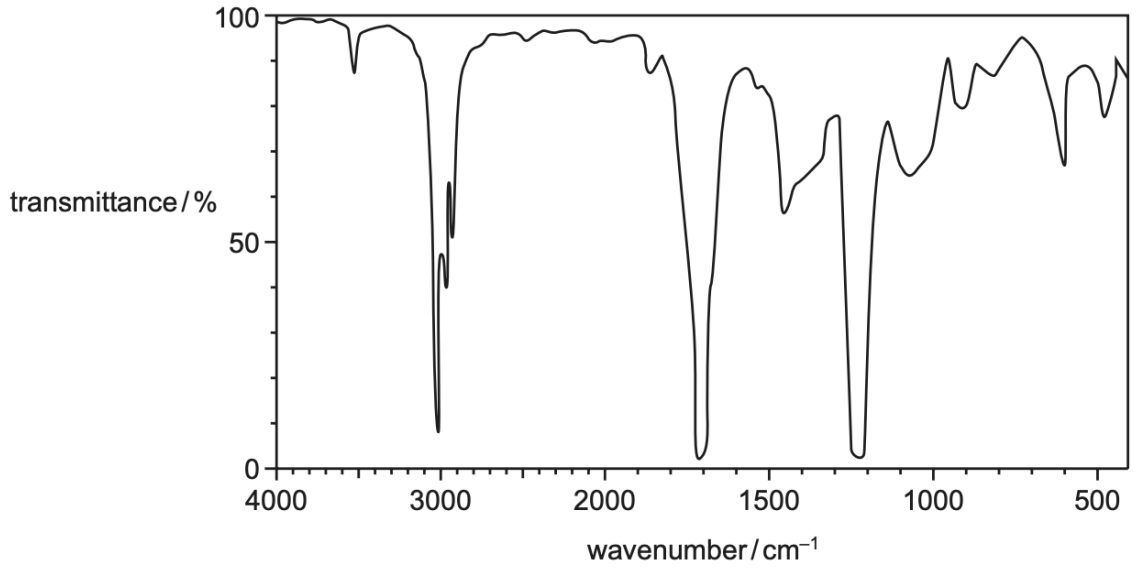
$\rightarrow$ when M & M+2 are in 3:1 ratio, Cl is present

NOTE:

- When M and M+2 have equal heights, Br is present: ratio of abundance of Br isotopes = 1:1 = 50%:50%
- When M and M+2 have height ratio = 3:1, Cl is present: ration of abundance of Cl isotopes = 3:1 = 75%:25%

14.

The infrared spectrum of a compound 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

Which functional group could the compound contain?

A alcohol

B carboxylic acid

C ester

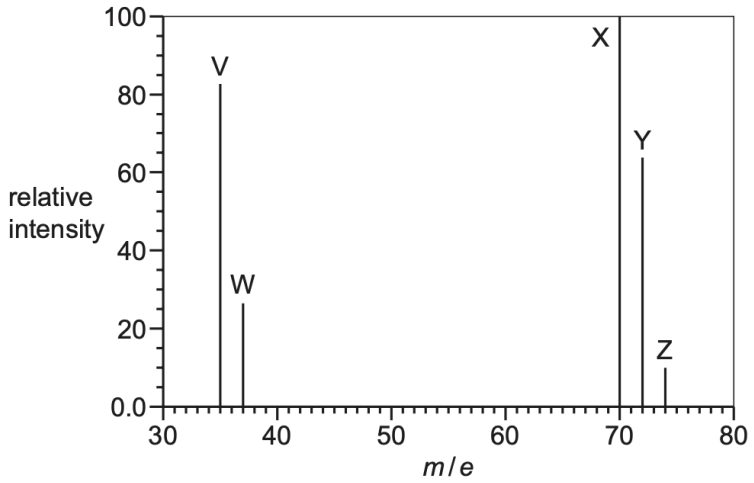
D nitrile

Ans: C

NOTE: carb acid would have a broad OH peak. The peak at 3000 is not broad, so must be an alkane peak

15.

The diagram shows the mass spectrum of a sample of chlorine. Peaks V, W, X, Y and Z are labelled.



Which statements about this spectrum are correct?

1 The relative atomic mass of chlorine can be calculated from the abundances and *m*/*e* values of 2 of the 5 peaks.

2 37.0 g of the species responsible for peak Z contains 3.011×10^{23} molecules.

3 The relative molecular mass of chlorine can be calculated from the abundances and *m*/*e* values of peaks X, Y and Z.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

Ans: A

- Peaks and abundance of V and W can be used to calculate relative atomic mass of chlorine
- Peaks and abundance of X,Y,Z can be used to calculate relative molecular mass of chlorine
- 37g of species Z = ½ the mass of Z = $(6.022 \times 10^{23}) / 2 = 3.011 \times 10^{23}$ molecules