Mass Spectra & Infrared

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Application of Core Principles of Chemistry
Sub Topic	Mass Spectra & Infrared
Booklet	Question Paper

Time Allowed: **29 minutes**

Score: **/24**

Percentage: **/100**

Grade Boundaries:

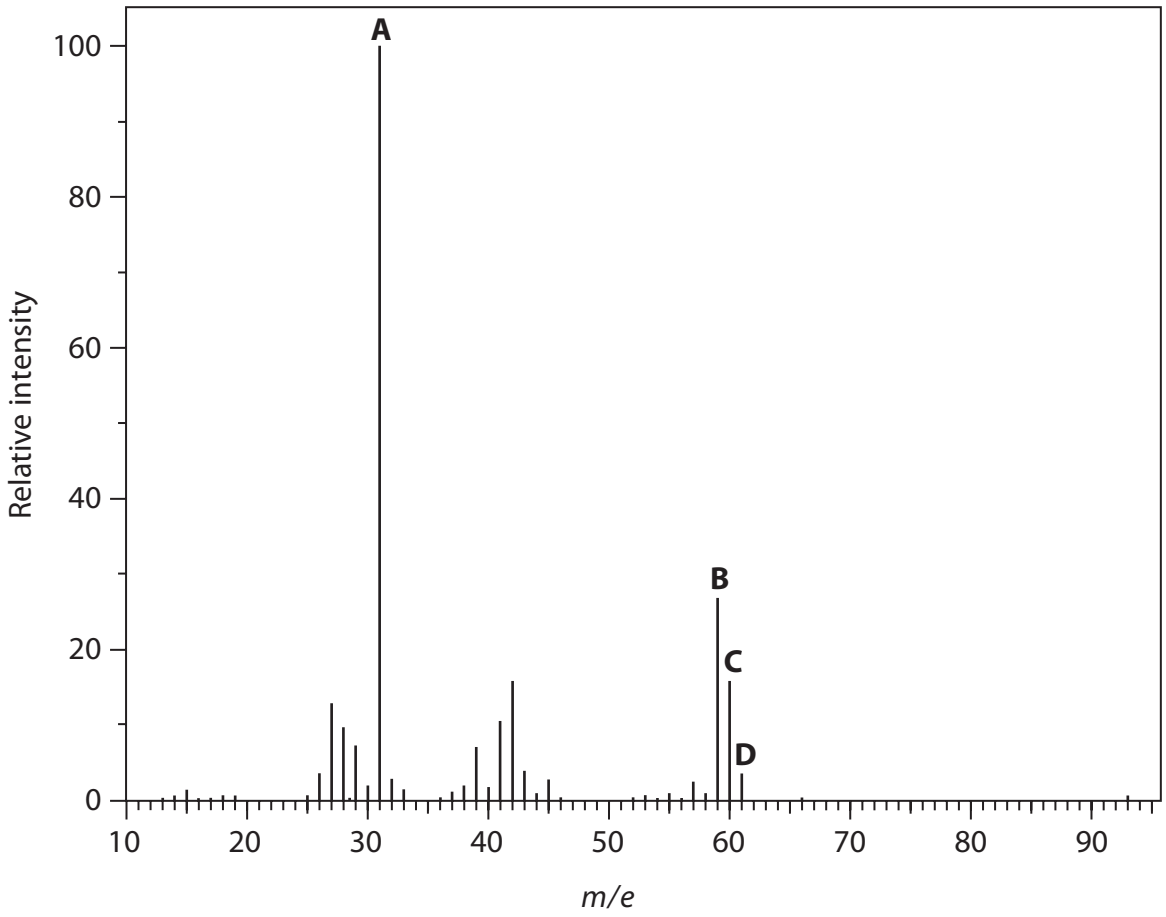
A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Which of these molecules does **not** absorb infrared radiation?

- ☒ **A** carbon monoxide
- ☒ **B** carbon dioxide
- ☒ **C** oxygen
- ☒ **D** water

(Total for Question 1 = 1 mark)

2 The mass spectrum of propan-1-ol is shown.

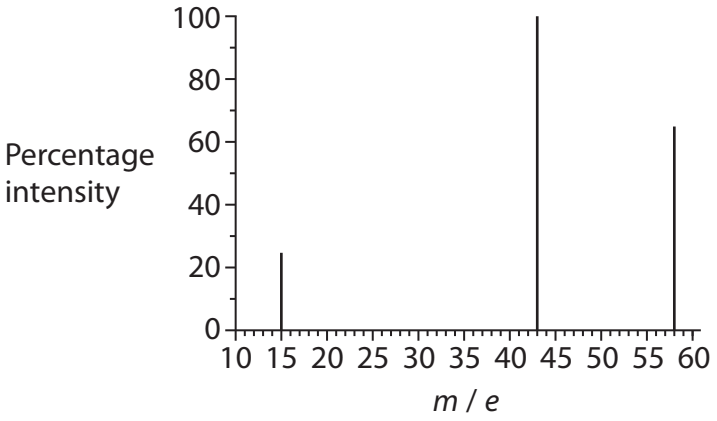


Which peak represents the molecular ion for propan-1-ol containing a carbon-13 isotope?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 2 = 1 mark)

3 A simplified mass spectrum of an organic compound is shown in the diagram.



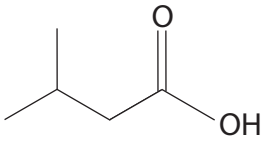
Which of the following compounds produces this spectrum?

- ☒ **A** Propane
- ☒ **B** Propan-1-ol
- ☒ **C** Propan-2-ol
- ☒ **D** Propanone

(Total for Question 3 = 1 mark)

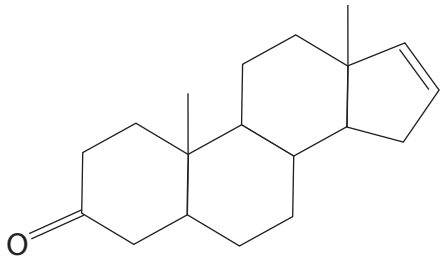
4 Some organic molecules, either on their own or as part of a mixture, contribute to some very unpleasant odours.

The molecule shown below, commonly called isovaleric acid, is responsible for the smell of sweaty feet.



Isovaleric acid can be used to produce esters that have important industrial uses in the pharmaceutical industry, as sedatives and tranquilizers, and in the food industry, as flavouring and fragrance additives.

The molecule with the systematic name (5α)-androst-16-en-3-one, labelled **X** in this question, is found in human sweat and urine.



X

However, in other situations, these molecules can induce a very different effect. For example, **X** is present in commercial products used by pig farmers to determine when sows are ready for mating.

(a) What is the systematic name for isovaleric acid?

(1)

.....

(b) What is the molecular formula of isovaleric acid?

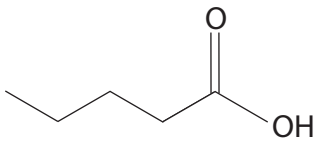
(1)

.....

(c) Isovaleric acid has three structural isomers which are also carboxylic acids. One of these acids is drawn in the first box below.

In the empty boxes below, draw the structures, using **skeletal** formulae, of the other two carboxylic acid structural isomers of isovaleric acid.

(2)

 valeric acid		

*(d) At room temperature, valeric acid is a liquid. It is sparingly soluble in water and very soluble in ethanol.

Describe simple experiments you could carry out to show the different solubilities of valeric acid in these two solvents. No measurements are required, but you should state how you would make your experiments valid.

State the expected observations from your experiments.

(3)

(e) Isoamyl alcohol is the alcohol from which isovaleric acid can be produced directly. This alcohol forms intermolecular hydrogen bonding.

Using the simplified representation R—O—H, draw a hydrogen bond between two alcohol molecules and clearly indicate the bond angle about the hydrogen involved in the hydrogen bond.

(2)

(f) There are also London forces between molecules of isoamyl alcohol.

*(i) Describe how London forces are formed.

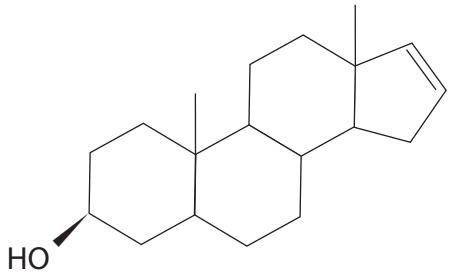
(2)

(ii) The straight-chain structural isomer of isoamyl alcohol has a boiling temperature of 138 °C.

Suggest whether the boiling temperature for isoamyl alcohol will be higher than, lower than or the same as the straight-chain isomer. Justify your choice.

(3)

(g) The molecule identified as **X** in the introduction to question 23, can be formed from the alcohol **Y** shown below.



Y

(i) The oxidation of an alcohol of this type with acidified sodium dichromate(VI) could involve either reflux or distillation.

Explain why either could be used in this case.

(1)

.....

.....

.....

(ii) An alternative reagent for the oxidation of an alcohol is acidified potassium manganate(VII), $KMnO_4$. However, this is likely to produce other products because **X** contains another functional group that could react with this reagent.

Name this other functional group in **X** and suggest the type of molecule formed in its reaction with acidified potassium manganate(VII), $KMnO_4$.

(2)

Functional group that reacts .....

Type of molecule formed .....

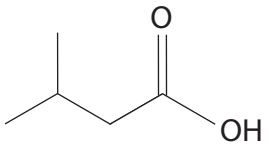
*(h) Isovaleric acid and alcohol **Y** could react together to produce a compound with a pleasant aroma, but this can be masked by even a small residue of the starting molecules.

Generally, spectroscopic methods are much more reliable than sense of smell in detecting the presence of molecules.

The infrared absorption ranges associated with some functional groups are given below.

O—H stretching in alcohols	3750 – 3200 cm^{-1}
O—H stretching in carboxylic acids	3300 – 2500 cm^{-1}
C=O stretching in aldehydes	1740 – 1720 cm^{-1}
C=O stretching in ketones	1700 – 1680 cm^{-1}
C=O stretching in carboxylic acids, alkyl	1725 – 1700 cm^{-1}
C—H stretching in alkane	2962 – 2853 cm^{-1}
C—H stretching in alkene	3095 – 3010 cm^{-1}

By quoting appropriate data, describe how both infrared spectroscopy and mass spectrometry could be used to determine the presence of **isovaleric acid**. The skeletal formula of isovaleric acid is shown below.



(4)

(Total for Question 4 = 21 marks)