# A2 LEVEL CHEMISTRY

# 4.3.1 CHROMATOGRAPHY

# 4.3.2 SPECTROSCOPY

# TEST

Answer all questions

Max 39 marks

| | |
|---|---|
| Name | …….. |
| Mark | ……../39 ……....% Grade …… |

**1.** Chromatography is an important analytical technique used to separate mixtures into their individual components.

(a) Define the following terms used in chromatography.

*$R_f$ value* .....

.....

*retention time* .....

.....

[2]

(b) Volatile organic compounds that enter soil via waste disposal sites affect the quality of the soil.

A preliminary step in analysing soil quality involves separation of these volatile components using gas/liquid chromatography.

(i) What name is given to the process by which components in a mixture are separated during gas/liquid chromatography?

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[1]

(ii) What are the roles of the gas and liquid in gas/liquid chromatography?

role of gas .....

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role of liquid .....

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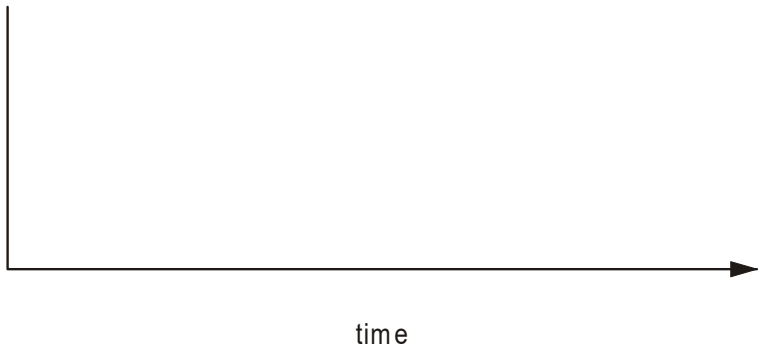
[2]

(iii) Draw a diagram of a gas/liquid chromatogram for a mixture containing two components.




[1]

(iv) Explain how the gas/liquid chromatogram could be used to determine the **percentage** composition of each component in the mixture.

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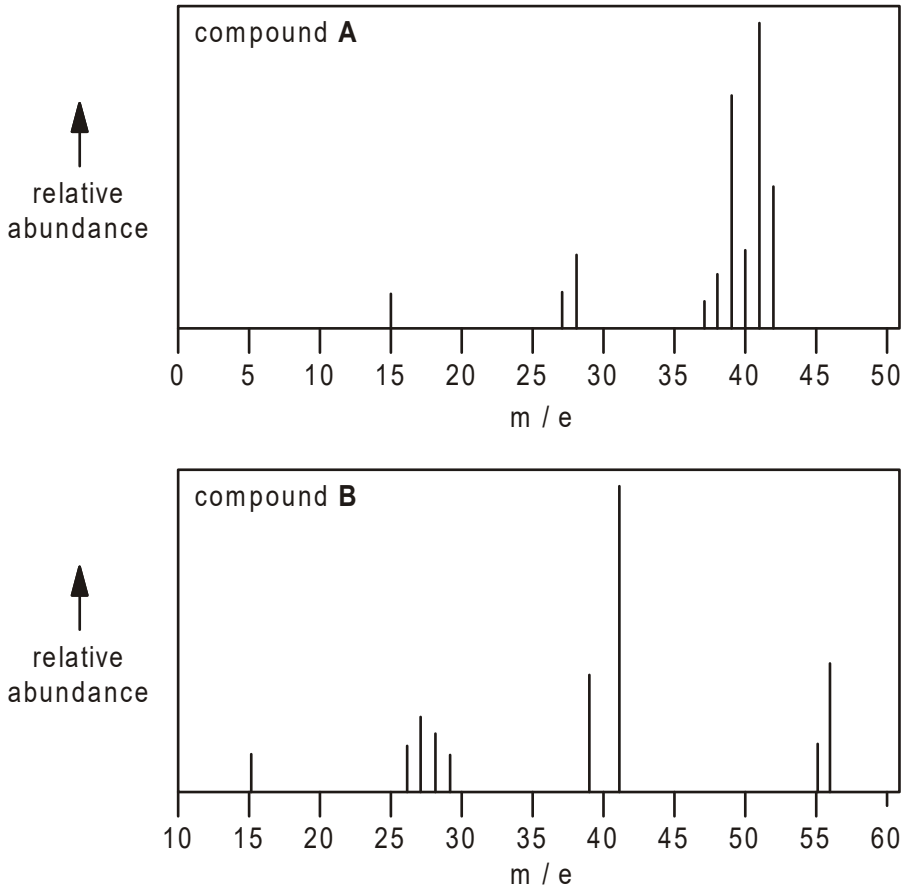
[3]

[Total 9 marks]

**2.** This question is about the use of spectrometry in helping to gain information about the structure of organic molecules.

The major peaks in the mass spectra of two hydrocarbons **A** and **B** are shown below. Compounds **A** and **B** have the same empirical formula.




(i) Deduce the molecular formula of each compound.

Compound **A** .....

Compound **B** .....

[2]

(ii) Draw the structural formula of compound **A**.

[1]

(iii) Suggest the species responsible for the peak at *m/e* 41 in the spectrum of compound **B**.

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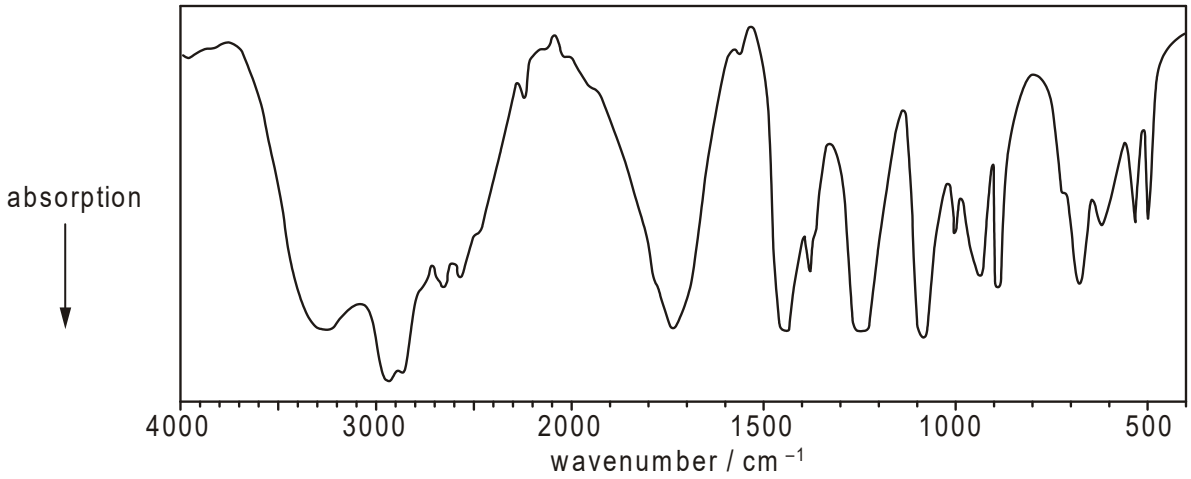
[2]

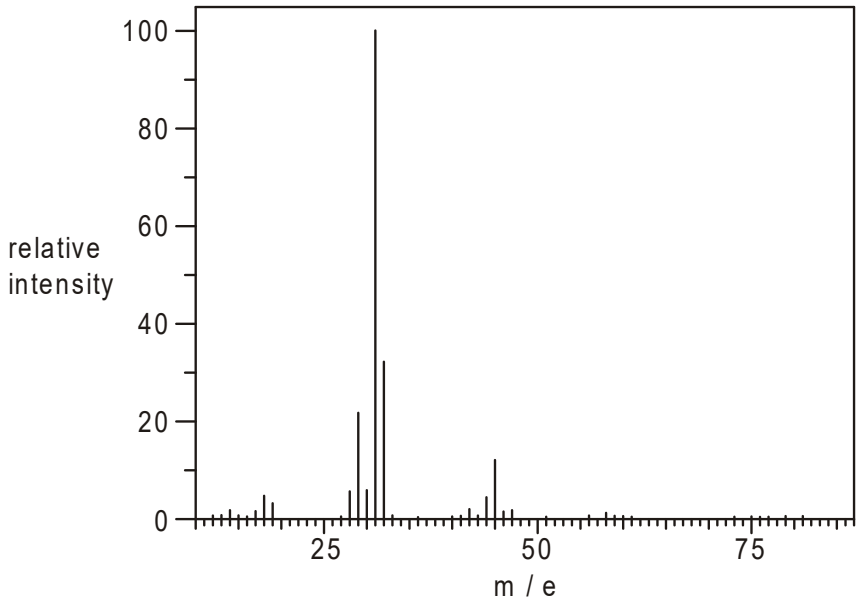
[Total 5 marks]

**3.** Compound **G** can be extracted from sugar-cane and is commonly used in 'rejuvenating' skin creams because it helps to remove some of the dead cells from the skin surface.

The molecular formula of **G** is $C_2O_3H_4$ and the compound contains **two different** functional groups containing oxygen atoms.

The infra-red and mass spectra of **G** are shown below.




(a) After inspection of the mass spectrum of **G**, an analyst wrote the comment:

'The molecular ion peak appears to be missing from the spectrum.
The base peak is due to a fragment ion with m / e = 31.'

(i) Explain what is meant by the following terms.

*molecular ion peak* .....

.....

*base peak* .....

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[2]

(ii) Suggest why the molecular ion peak is missing from the spectrum.

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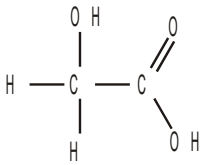
[1]

(b) The structure of compound **G** is shown below.



Show how the infra-red and mass spectra confirm this structure. In your answer, you should suggest a possible structure for the ion that gives the base peak at m / e = 31 in the mass spectrum.

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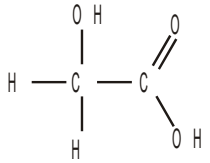
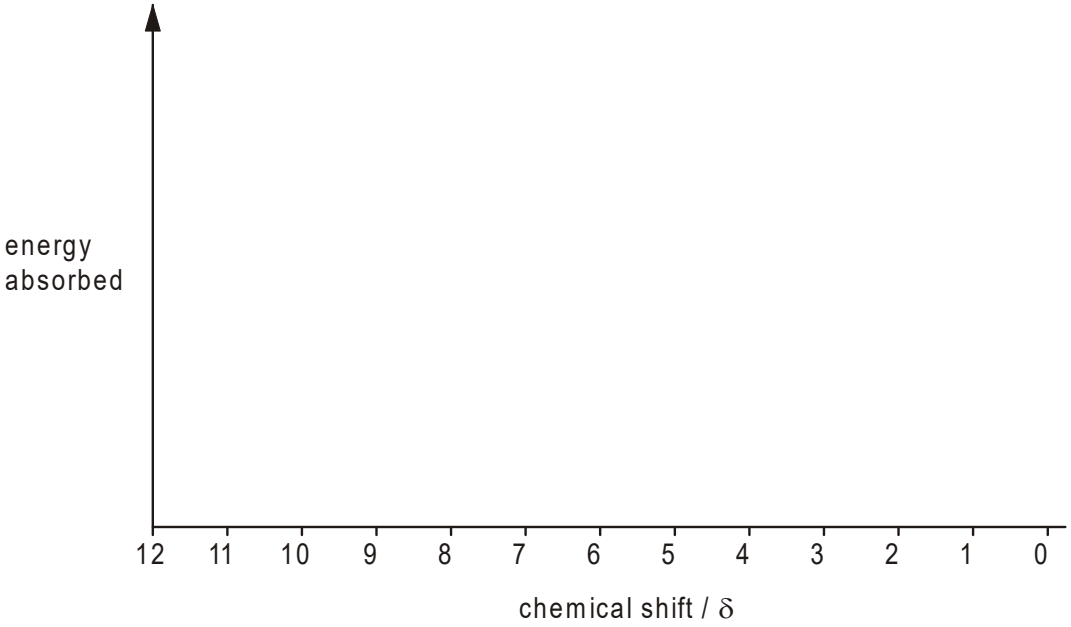
[4]

(c) The structure of compound **G** is shown below.



Sketch the $^{1}H$ n.m.r. spectrum of compound **G** and label the relative peak areas. Label any peaks that would be lost from the spectrum on shaking with $D_2O$.




[4]

[Total 11 marks]

**4.** Forest fires release a large number of organic compounds into the atmosphere. These include alcohols and carboxylic acids. An environmental chemist is trying to identify one of these compounds in a sample of air.

The unknown compound **X** is thought to be a carboxylic acid with empirical formula $C_2H_3O_2$.

(a) Mass spectrometry is used to help deduce the molecular formula of compound **X**.

(i) Describe how the mass spectrum of compound **X** is used to determine its relative molecular mass.

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[2]

(ii) The relative molecular mass of compound **X** is shown to be 118.

Explain how this relative molecular mass and the empirical formula are used to deduce that the molecular formula of compound **X** is $C_4H_6O4$. Show any working.

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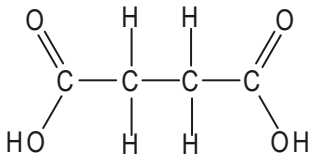
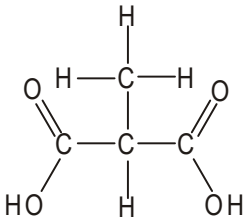
[2]

(b) The two dicarboxylic acids with molecular formula $C_4H_6O_4$ are shown below.





N.m.r. spectroscopy is used to deduce which of these is the unknown compound.

The environmental chemist obtains an n.m.r. spectrum of compound **X** and then adds some $D_2O$ and obtains a second n.m.r. spectrum.

(i) What difference would you expect between these two n.m.r. spectra?

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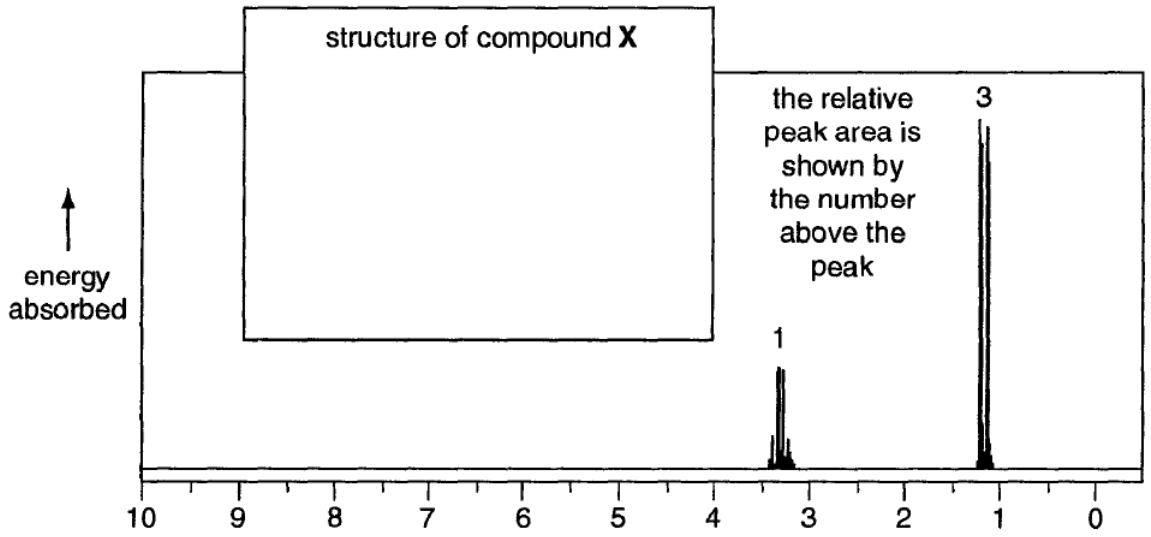
[1]

(ii) The n.m.r. spectrum of compound X in $D_2O$ is shown below.




Use this spectrum to identify which of the two carboxylic acids is compound X.

- Draw the correct structure in the box above the spectrum
- Use labels to show which protons in the structure are responsible for which peaks in the spectrum
- Explain your reasoning by referring to the relative peak areas and the spin-spin splitting patterns of the peaks

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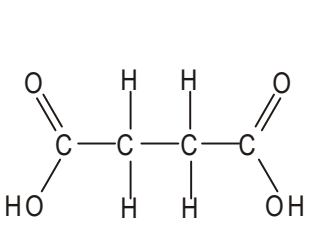
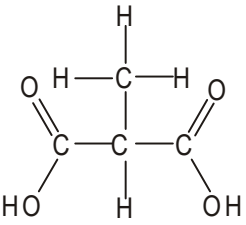
[6]

(iii) Predict the number of peaks and any spin-spin splitting expected on the n.m.r. spectrum of a solution in $D_2O$ of the other acid with formula $C_4H_6O_4$.

Explain your reasoning.

(The two possible structures of compound **X** are shown again below.)





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[3]

[Total: 14 marks]