1 An organic compound, **X**, was analyzed in a laboratory.

(a) Compound **X** was found to have the following percentage composition by mass:

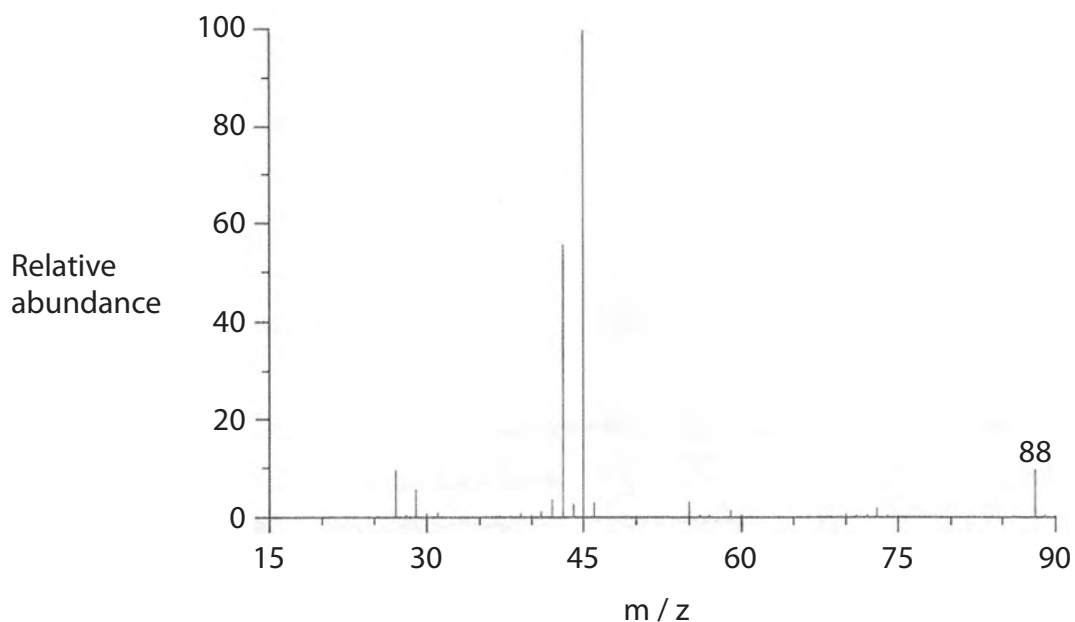carbon, C   = 54.5%

hydrogen, H   = 9.1%

oxygen, O   = 36.4%

(i) Use these data to calculate the empirical formula of compound **X**, showing your working.

(2)

(ii) The mass spectrum of **X** is shown below.

Use your answer to (a)(i), and the mass spectrum of **X**, to show that the molecular formula of compound **X** is $C_4H_8O_2$.

(2)

(b) The infrared spectrum of **X** has a broad peak at approximately 3500 cm^{-1} and a sharp peak at approximately 1700 cm^{-1}. Identify the **bond** responsible for the peak at

(2)

3500 cm^{-1}

1700 cm^{-1}

(c) (i) Some chemical information about compound **X** is given below.

- **X** is a neutral organic compound.

- **X** has no effect on Tollens' reagent.

- **X** turns hot acidified potassium dichromate(VI) solution from orange to green.

What does each of these three pieces of information suggest about the nature of **X**?

(4)

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(ii) Use your answers to parts (b) and (c)(i) to name the two functional groups present in **X**.

(1)

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*(d) The high resolution proton nmr spectrum of **X** is shown below.

Chemical shift, δ / ppm

The relative number of protons causing the peaks shown are: J = 1, K = 1, L = 3 and M = 3.

Use the information above to determine the structural formula of **X**.

In your answer, you should refer to the number of peaks, their relative sizes and their splitting patterns.

(7)

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(Total for Question = 18 marks)