OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2815/04**

CHEMISTRY

Methods of Analysis and Detection

THURSDAY 19 JUNE 2008 Morning

Time: 50 minutes

Candidates answer on the question paper
Additional materials (enclosed): *Data Sheet for Chemistry*

Additional materials (required):
Scientific calculator

CUP/T38003

Candidate Forename		Candidate Surname	
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **45**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**7**	
2	**14**	
3	**11**	
4	**13**	
TOTAL	**45**	

This document consists of **11** printed pages, **1** blank page and a *Data Sheet for Chemistry*.

  [Turn over

Answer **all** the questions.

1 Mass spectrometry is an important analytical technique. It can be used to help to distinguish between isomers such as 1-chloropropane, $CH_3CH_2CH_2Cl$, and 2-chloropropane, $CH_3CHClCH_3$.

(a) (i) What are the formulae of the molecular ions of 1-chloropropane which give rise to the following peaks?

M peak .....

M + 2 peak ..... [2]

(ii) In the mass spectrum of 1-chloropropane what are the relative heights of the M and M + 2 peaks?

..... [1]

(b) Fragment ions can be used to distinguish between 1-chloropropane and 2-chloropropane.

Give the formula of a fragment ion that would be formed from 1-chloropropane but **not** from 2-chloropropane.

..... [1]

(c) Compounds of similar relative molecular mass can be distinguished by using high resolution mass spectrometry.

(i) Compounds **X** and **Y** are gases with a relative molecular mass of approximately 44. High resolution mass spectrometry revealed the molecular ion peaks at *m*/*e* 43.9898 and 44.0624 respectively.

Use the table of relative isotopic masses below to identify each of the gases. Show your working.

X and **Y** each contain only two of the elements carbon, hydrogen and oxygen.

isotope	relative isotopic mass
hydrogen, ^{1}H	1.0078
carbon, ^{12}C	12.0000
oxygen, ^{16}O	15.9949

Compound **X**, molecular ion peak at *m*/*e* 43.9898.

Compound **Y**, molecular ion peak at *m*/*e* 44.0624.

[2]

(ii) Explain why high resolution mass spectrometry of the molecular ion **cannot** be used to distinguish between 1-chloropropane and 2-chloropropane.

.....

..... [1]

[Total: 7]

2 **(a)** Thin-layer chromatography, tlc, can be used to separate the amino acids in a mixture.

(i) Identify the mobile and the stationary phases in tlc.

mobile phase ..... [1]

stationary phase ..... [1]

(ii) Explain how tlc separates the amino acids.

.....

..... [2]

(iii) The amino acids in the mixture are colourless.

How are the amino acids made visible in the final chromatogram?

..... [1]

(b) The mixture of amino acids was analysed using two-way chromatography.

Describe how two-way chromatography is carried out and explain why it is more effective than one-way chromatography.

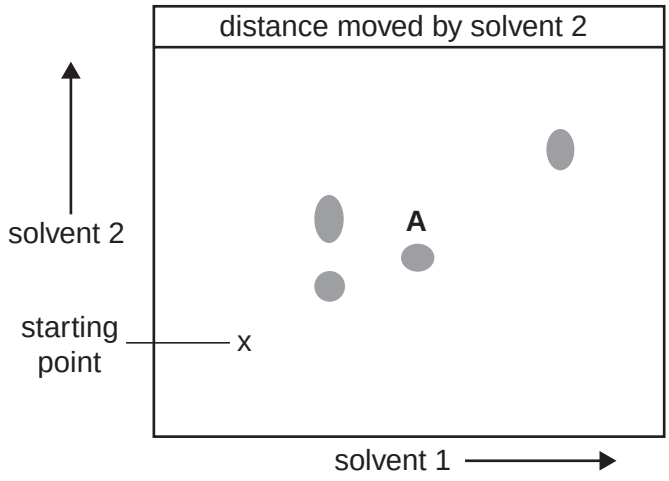
.....

.....

.....

..... [3]

(c) The two-way chromatogram of the mixture of amino acids is shown below.



(i) How many different amino acid spots would have been separated by **solvent 1**?

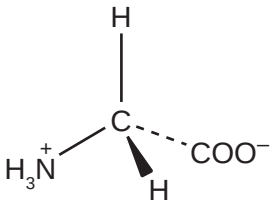
..... [1]

(ii) Estimate the R_f value of amino acid **A** in **solvent 2**.

..... [1]

(d) Amino acids can also be separated by electrophoresis. The separation depends on the mass of, and the charge on, the amino acid ion as well as the pH of the mixture.

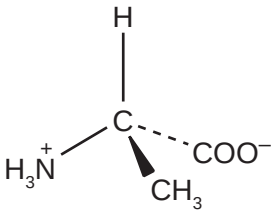
At a pH of 5.8 glycine forms a zwitterion.



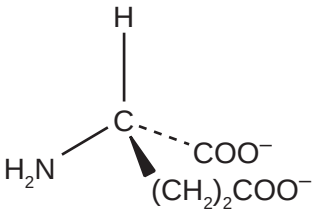
Draw the ion formed by glycine at pH 2.

[1]

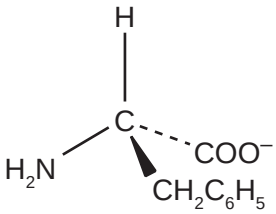
(e) At a pH of 6.0 the four amino acids in a mixture exist in the forms **B**–**E** shown below.



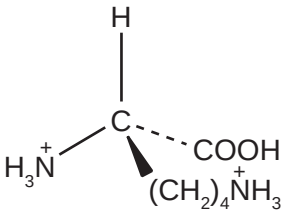
B



C

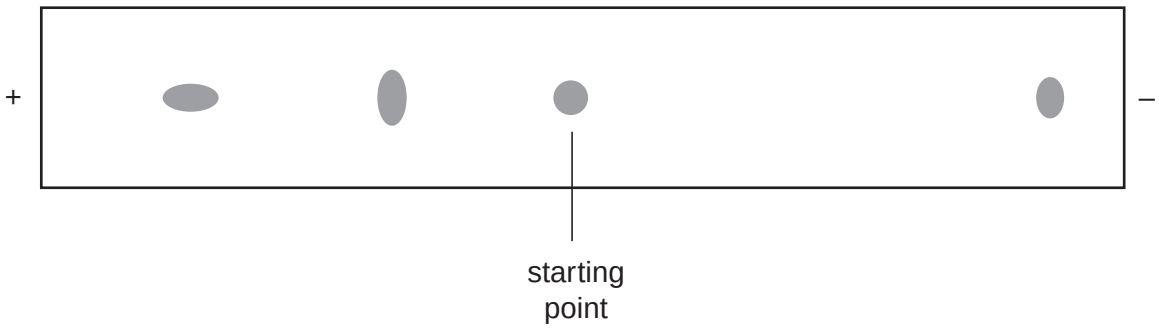


D



E

The diagram below shows the result of the electrophoresis of the mixture of the four amino acids at pH 6.0.



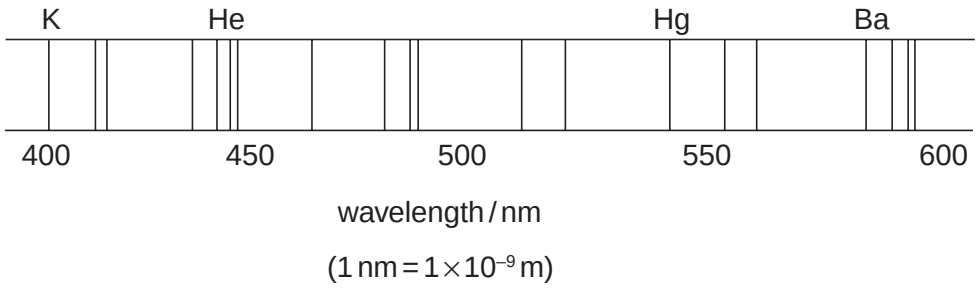
Label the spots **B**, **C**, **D** and **E** appropriately. [3]

[Total: 14]

3 This question is about the use of spectroscopy in analysing radiation from space.

Analysis of light from a star in the constellation Andromeda produced the line emission spectrum shown below.

The lines provide evidence for the existence of various elements, some of which are shown on the spectrum below.



($1\,nm = 1 \times 10^{-9}\,m$)

(a) Explain the process which brings about the formation of a single emission line in the spectrum above.

.....

..... [1]

(b) For each element present in the star, several series of lines are seen.

(i) Explain how a **single series** of lines is produced.

.....

..... [1]

(ii) Explain why **several series** of lines are produced by each element.

.....

..... [1]

(c) In the spectrum, the line at 590 nm shows the presence of sodium in the star.

$c = 3.00 \times 10^{8}\,m\,s^{-1}$; $h = 6.63 \times 10^{-34}\,J\,s$; $L = 6.02 \times 10^{23}\,mol^{-1}$.

(i) Calculate the frequency of the line at 590 nm. State the units.

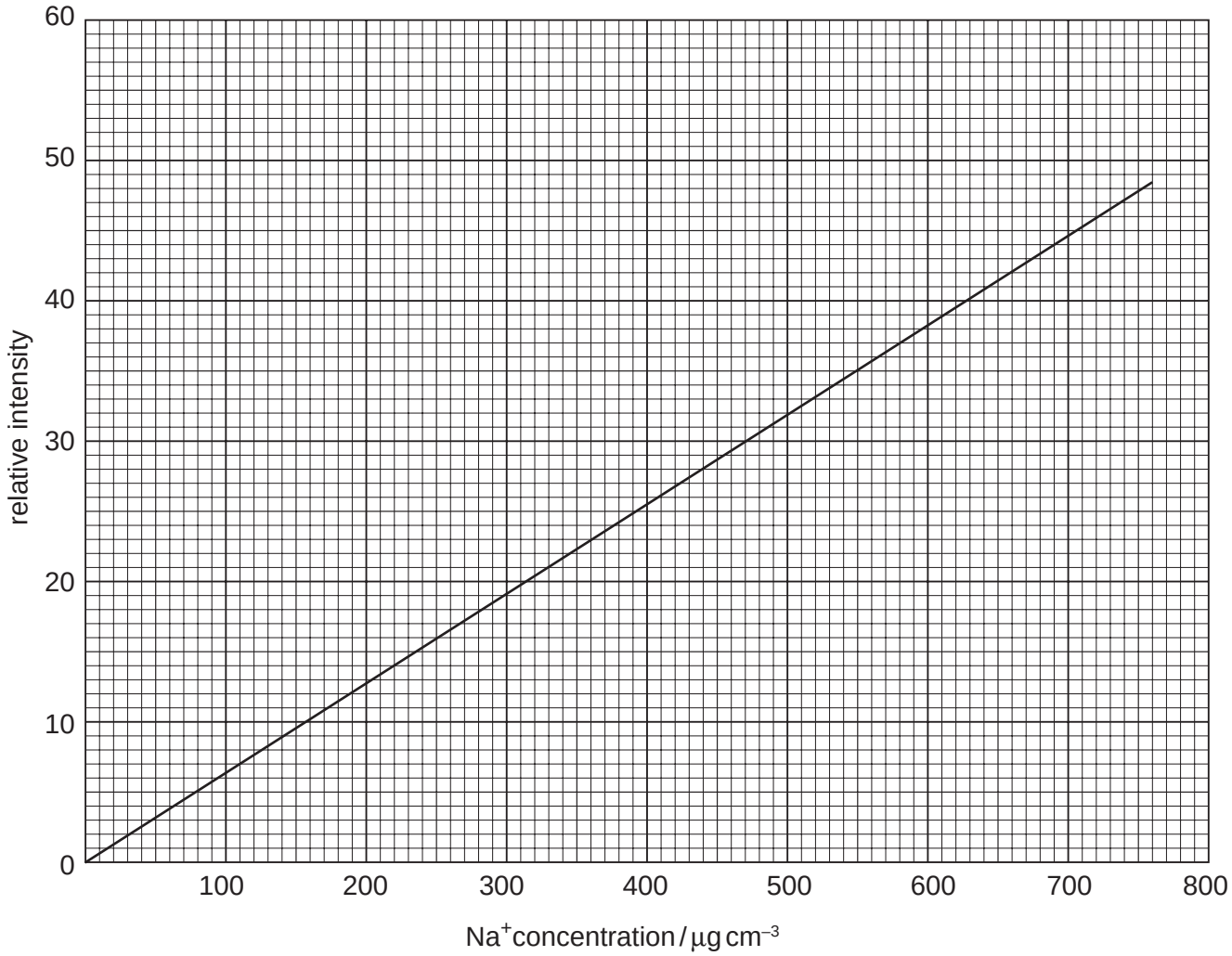
frequency = ... units ..... [2]

(ii) Calculate the energy, in $J\,mol^{-1}$, that produced the line at 590 nm. Quote your answer to **three** significant figures.

energy = ... $J\,mol^{-1}$ [3]

(d) Too many sodium ions, Na^+, in the diet may raise blood pressure and a diet high in Na^+ may increase the risk of heart disease, stroke, and kidney damage.

By measuring the intensity of a single emission line it is possible to use a calibration graph to determine the Na^+ content in a sample of food.



($1\,\mu g = 10^{-6}\,g$)

A 1.00 g sample of food was dissolved in hydrochloric acid. The solution was neutralised and then made up to 100 cm^3.

1 cm^3 of this solution gave a relative intensity of 35.

Use the calibration graph to calculate the percentage, by mass, of Na^+ in the food sample.

[3]

[Total: 11]

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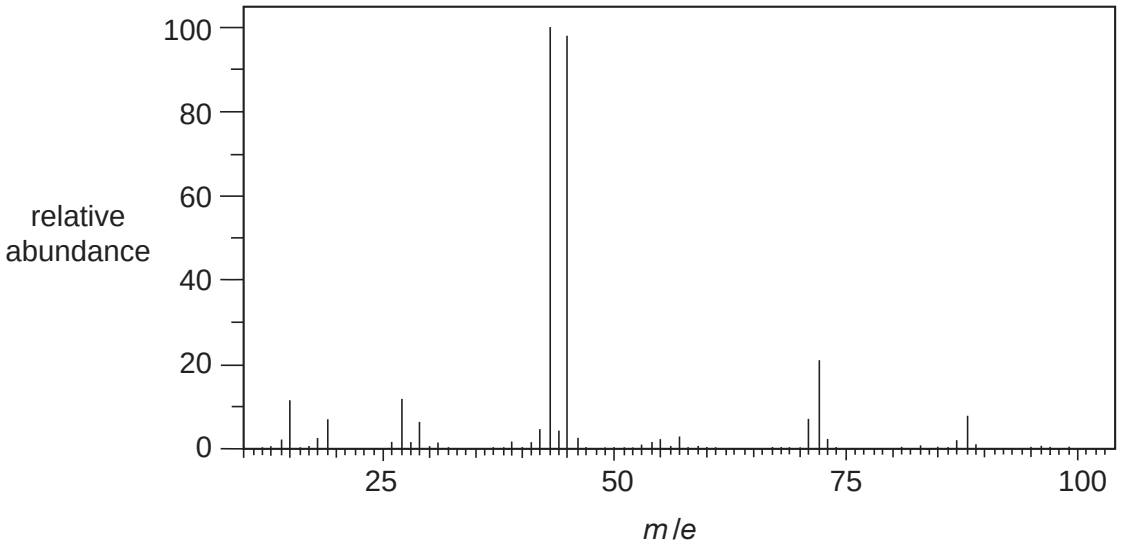
4 Compound **F** is a pale yellow liquid formed in the fermentation of glucose by certain bacteria. It is used as an aroma carrier in the preparation of flavours and essences.

(a) Compound **F** has the following percentage composition by mass: C = 54.5; H = 9.1; O = 36.4.

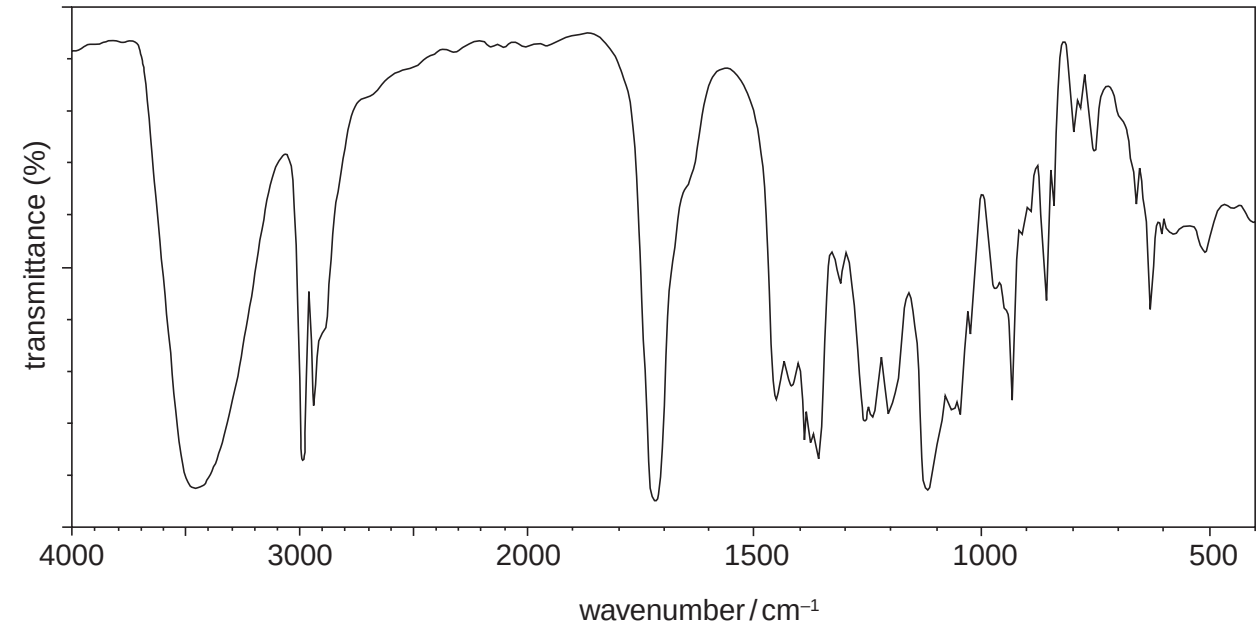
Use the percentage composition **and** the mass spectrum shown below, to deduce the empirical formula and to show that the molecular formula of compound **F** is $C_4H_8O_2$. Show all of your working.

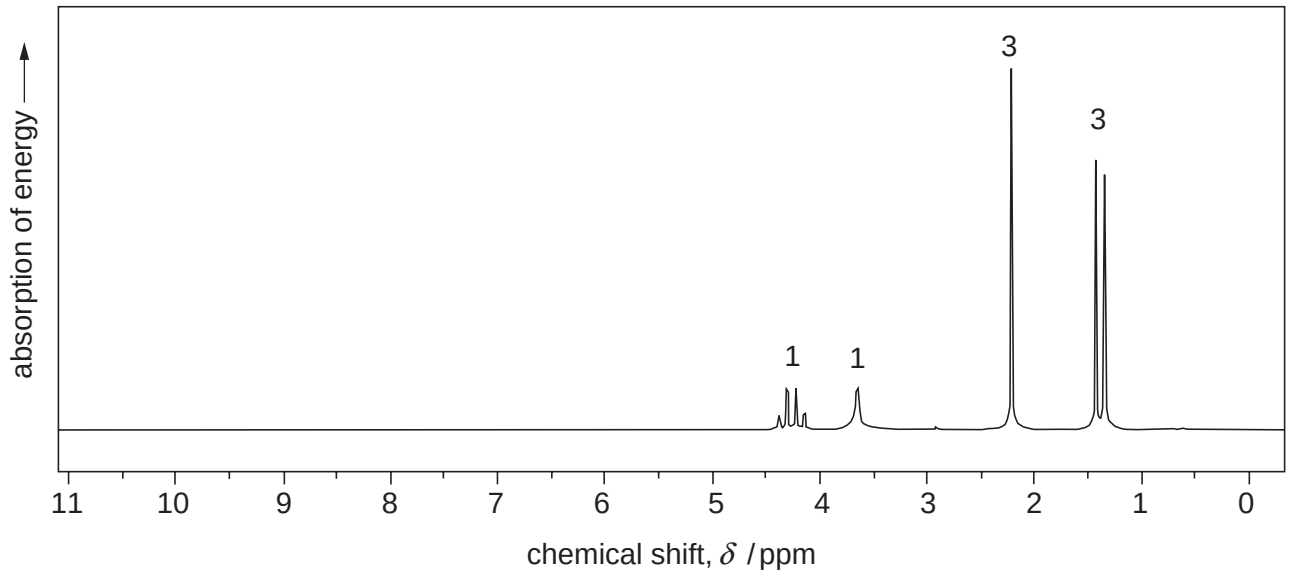


[3]

(b) In this question, one mark is available for the quality of use and organisation of scientific terms.

The infra-red and n.m.r. spectra of compound **F** are shown below.





Use as much data as possible from the infra-red and n.m.r. spectra to identify structural features present in compound **F**. Hence suggest a structural formula for compound **F**.

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The structural formula of compound **F** is

[9]

Quality of Written Communication [1]

[Total: 13]

END OF QUESTION PAPER

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