OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

CHEMISTRY   **2815/04**

Methods of Analysis and Detection

| Tuesday | **24 JUNE 2003** | Morning | 50 minutes |

Candidates answer on the question paper.
Additional materials:
    Data Sheet for Chemistry
    Scientific calculator

Candidate Name		Centre Number	Candidate Number

TIME   50 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

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

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	9	
2	12	
3	13	
4	11	
TOTAL	45	

This question paper consists of 10 printed pages and 2 blank pages.

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2

Answer **all** the questions.

1 **(a)** In the mass spectrum of an organic compound, there is usually a small peak with an m/e value one unit greater than that of the molecular ion, M.

What is responsible for this peak?

.... [1]

(b) In the mass spectrum of bromoethane, there is an additional peak at (M + 2).

(i) What is responsible for the (M + 2) peak?

.... [1]

(ii) What will be the approximate ratio for the heights of the M and (M + 2) peaks in bromoethane?

.... [1]

(c) The molecules carbon monoxide, CO, and ethane, C_2H_4, both have M_r values of 28. However, the two molecular ions can be distinguished using a high resolution mass spectrometer. Suggest why this is the case.

....

....

.... [2]

(d) The mass spectrum shown below was obtained from a compound of formula C_xH_yO.

	m/e	relative abundance
M	46	14.6
M + 1	47	0.32
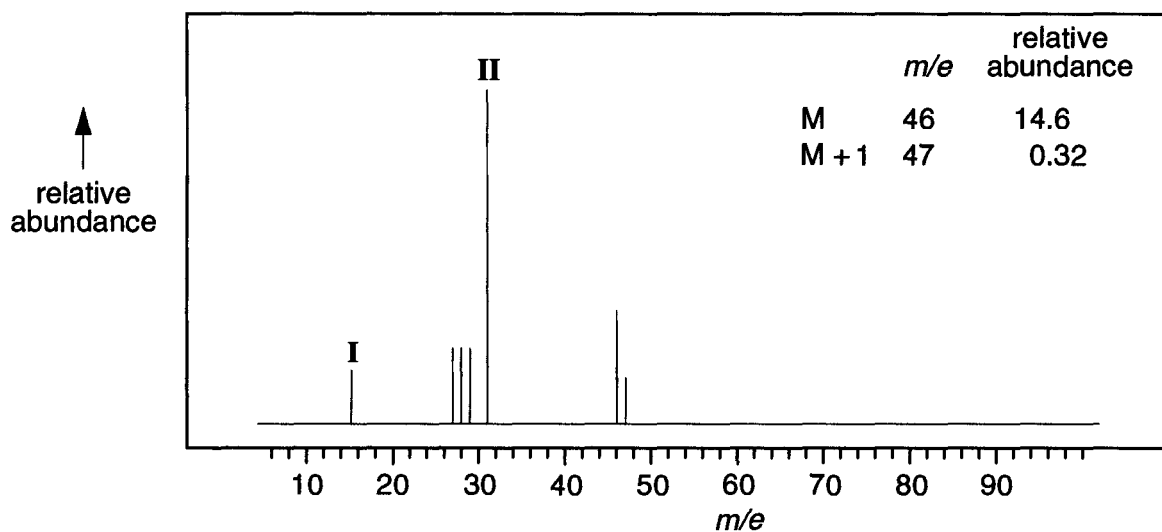
(i) Suggest the identity of the ions responsible for the labelled peaks in the spectrum.

I ....

II .... [2]

(ii) Use any other data from the spectrum to determine the values of x and y, and hence the formula of the compound.

[2]

[Total: 9]

[Turn over

2 Under certain conditions, atoms of many elements emit energy in the ultraviolet and visible regions of the spectrum. The spectrum below was obtained from the energy emitted by a star.

H He H He Mg Fe Na He
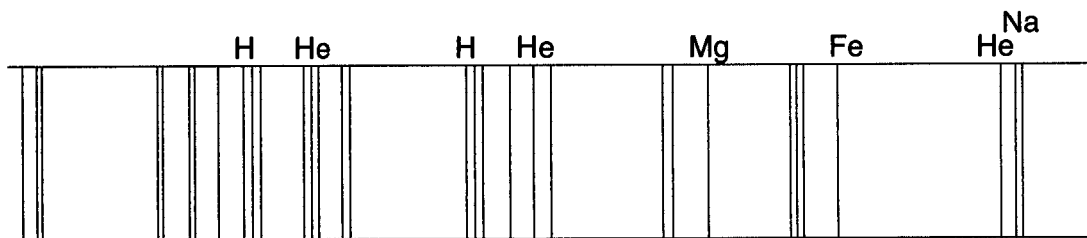
(a) Explain the process which brings about the formation of **one** of the emission lines in the spectrum.

....

....

....[2]

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

Explain how a **single series of lines** is produced.

....

....

....[2]

(c) In the spectrum, the line labelled Mg occurs in the visible region of the spectrum at a wavelength of 564 nm. It shows the presence of the element magnesium in the star.

[c, the velocity of light, $= 3.00 \times 10^8\,m\,s^{-1}$; h, the Planck constant, $= 6.63 \times 10^{-34}\,J\,s$]

(i) Convert the wavelength of this line to a frequency.

[1]

(ii) Calculate the energy of the quantum of electromagnetic radiation which produced this line.

[1]

5

(d) Molecules absorb energy in the ultraviolet/visible region of the spectrum, and this can result in some organic compounds appearing coloured.

State the features of an organic compound necessary for it to absorb energy in the ultraviolet/visible region of the spectrum.

....

....

....[2]

(e) The diagram shows a simplified ultraviolet/visible spectrum of an indicator in acid and alkaline solutions.
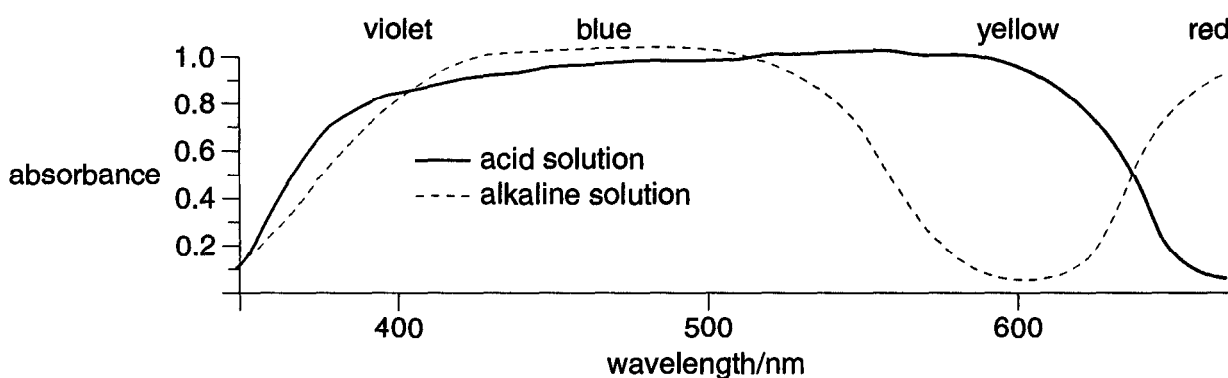
Predict the colour of the indicator in each solution.

acid solution .... alkaline solution .... [2]

(f) A different indicator has two forms, **X** and **Y**.
X absorbs at longer wavelength than **Y**. Suggest why **X** absorbs at longer wavelength.

....

....

....[2]

[Total: 12]

[Turn over

6

3 **(a)** Thin-layer chromatography can rely either on partition or on adsorption depending on the conditions.
Explain each of these processes in terms of thin-layer chromatography.

partition ....

....

....

adsorption ....

....

....

[2]

(b) Write an expression for the term R_f value.

[1]

(c) The diagram shows a two-way chromatogram produced from a mixture of amino acids.
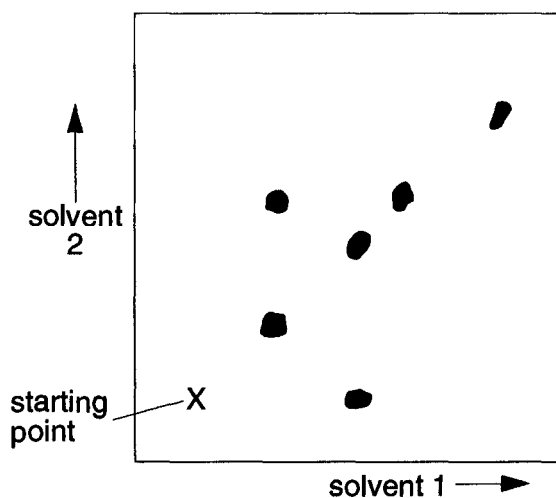
(i) How many amino acids were present in the original sample?

....[1]

(ii) What reagent could be used to make the amino acids visible?

....[1]

(iii) Circle the amino acid that travelled fastest in **both** solvents. [1]

(iv) Label with an **S** the amino acid that did not move in solvent 2. [1]

(d) Mixtures of amino acids may also be separated by electrophoresis. The diagram shows the result of electrophoresis on such a mixture.

starting point
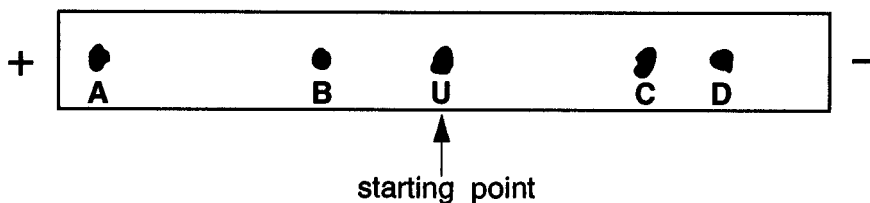
(i) Label with **P** an amino acid with a positive charge. [1]

(ii) Which amino acid, **A, B, C** or **D**, has the lowest M_r? [1]

(iii) The amino acid labelled **U** has no overall charge at the pH of the buffer used. The experiment was repeated with a buffer of higher pH.

Explain what would happen to the amino acid labelled **U**.

....

....

....[2]

(e) A modification of simple electrophoresis is used in DNA profiling, which may be used in criminal investigations.

(i) How are the DNA fragments detected?

....[1]

(ii) Apart from crime detection, suggest **one** other use of DNA profiling.

....

....
[1]

[Total: 13]

[Turn over

8

4 In this question, one mark is available for the quality of written communication.

(a) Spectroscopic analysis relies on various atomic and molecular processes occurring at different energies. State the regions of the electromagnetic spectrum in which

(i) electronic transitions occur ....[1]

(ii) n.m.r. spectra are produced ....[1]

(b) The following spectra were obtained for compound **R**, C_xH_yO.

absorbance

↓

wavelength/cm^{-1}

energy absorbed

↑

peak at δ = 4.8
not present in D_2O

3

4

1

chemical shift, δ

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9

> The mass spectrum of compound **R** shows a molecular ion peak at m/e = 108
> and a peak at m/e = 91.

Use this spectral information to identify the functional group(s) present in compound **R** and to deduce a possible structure for **R**. You should identify all relevant data by which you arrive at your answer.

....

....

....

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....

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....

....

....

....

....

....

....

....

....

(c) Give **one** other peak that you would expect to see in the mass spectrum of compound **R**.

Explain your answer. ....

....

....[8]

Quality of Written Communication [1]

[Total: 11]