OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

Methods of Analysis and Detection

2815/04

Wednesday **25 JANUARY 2006** Afternoon 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, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for graphs and diagrams only.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT** WRITE IN THE AREA **OUTSIDE** THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.

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	11	
2	14	
3	10	
4	10	
TOTAL	45	

This question paper consists of 11 printed pages and 1 blank page.

SPA (MML/CG 11214 6/05) T05791/4

Registered Charity Number: 1066969

Answer **all** the questions.

1 Human blood serum contains a number of ions, including Na^+ and K^+. The concentration of these ions can be determined using atomic emission spectroscopy. An increase in the concentration of K^+ ions in blood serum can be an indicator of disease or internal injury.

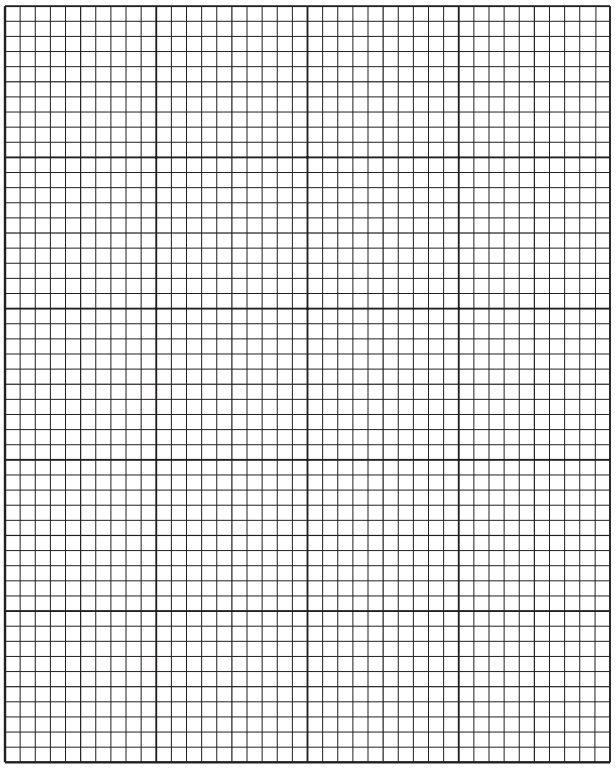
(a) An analyst obtained the following results from solutions containing K^+ ions.

K^+ ion concentration / mmol dm^{-3}	relative emission reading
0.0	0
1.0	6
2.0	11
3.0	17
4.0	24
6.0	35
8.0	49

1 mmol = 1×10^{-3} mol

(i) Plot a calibration graph for the analysis using these data.

relative emission reading



K^+ ion concentration / mmol dm^{-3}

[3]

(ii) A 10 cm^3 sample of blood serum from a patient was diluted to 100 cm^3. The resulting solution was analysed and found to have a relative emission reading of 21. Calculate the concentration of K^+ ions in the patient's blood in mmol dm^{-3}.

answer = ... mmol dm^{-3} [2]

(iii) The analyst needed to measure the K^+ concentration in the blood serum of a **different** patient.

Suggest a practical step that the analyst would have taken before measuring the new patient's sample.

.....

..... [1]

(iv) The same analyst then needed to measure the **Na^+** concentration in the blood serum of a patient.

How would the apparatus and method have been modified for this analysis?

.....

.....

..... [2]

(b) The emission spectrum of potassium includes a line at 770 nm.

the velocity of light = 3.00×10^8 m s^{-1}
the Planck constant = 6.63×10^{-34} J s
the Avogadro constant = 6.02×10^{23} mol^{-1}

Calculate the energy of this light in kJ mol^{-1}.

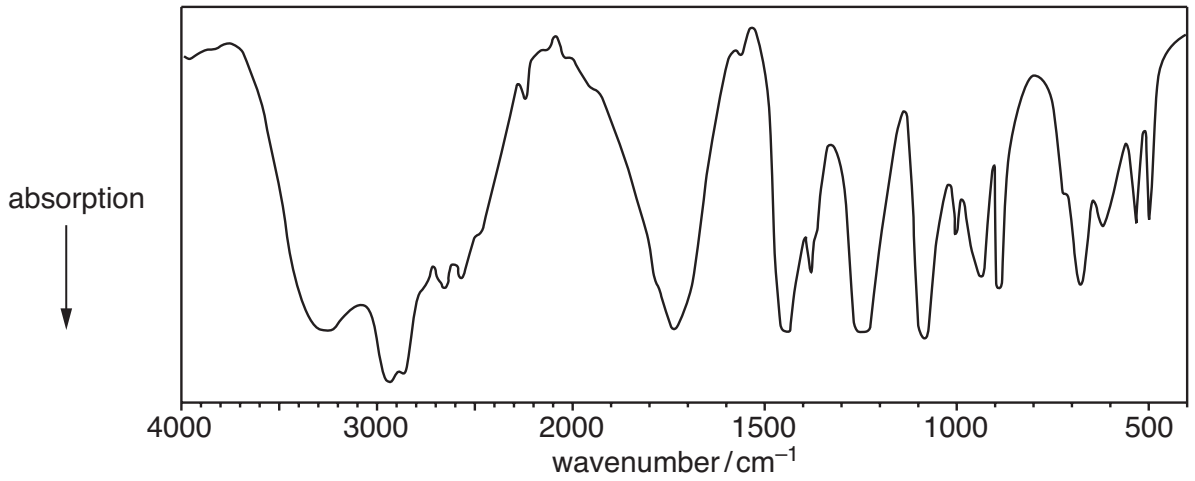
answer = ... kJ mol^{-1} [3]

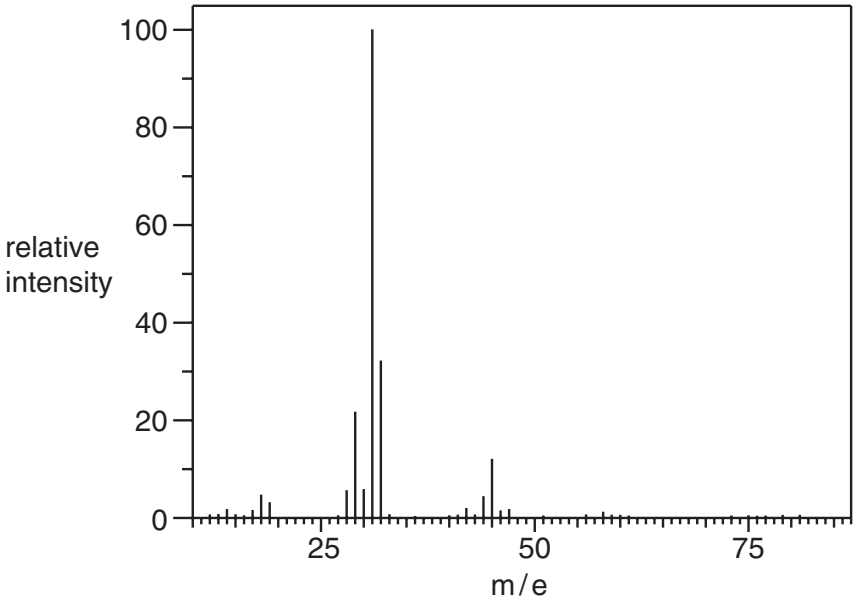
[Total: 11]

2 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 .....

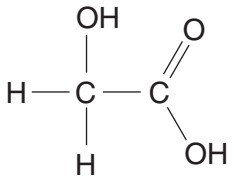
..... [2]

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

.....

..... [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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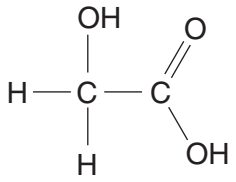
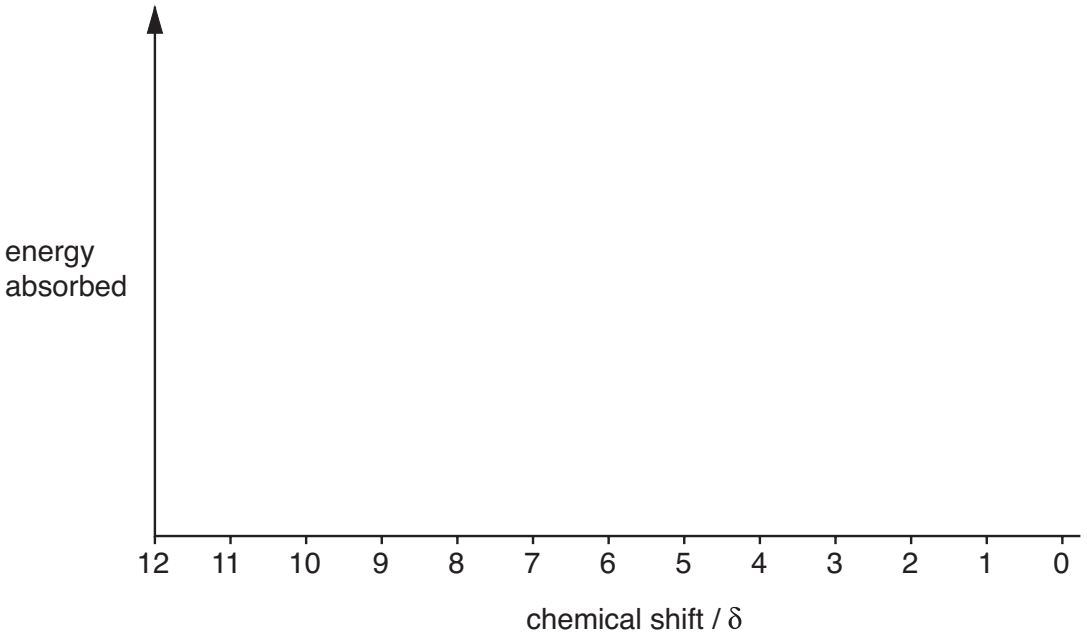
[4]

(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]

(d) Another ingredient commonly used in skin creams is propane-1,2-diol, molecular formula $C_3H_8O_2$. Like compound **G**, propane-1,2-diol also has a relative molecular mass of 76. High-resolution mass spectrometry can be used to distinguish between molecules with similar molecular masses.

The precise values for relative isotopic masses are shown in the table below.

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

Show, by calculation, how a high-resolution mass spectrum of a sample of skin cream could be used to determine if both compounds were present in the sample.

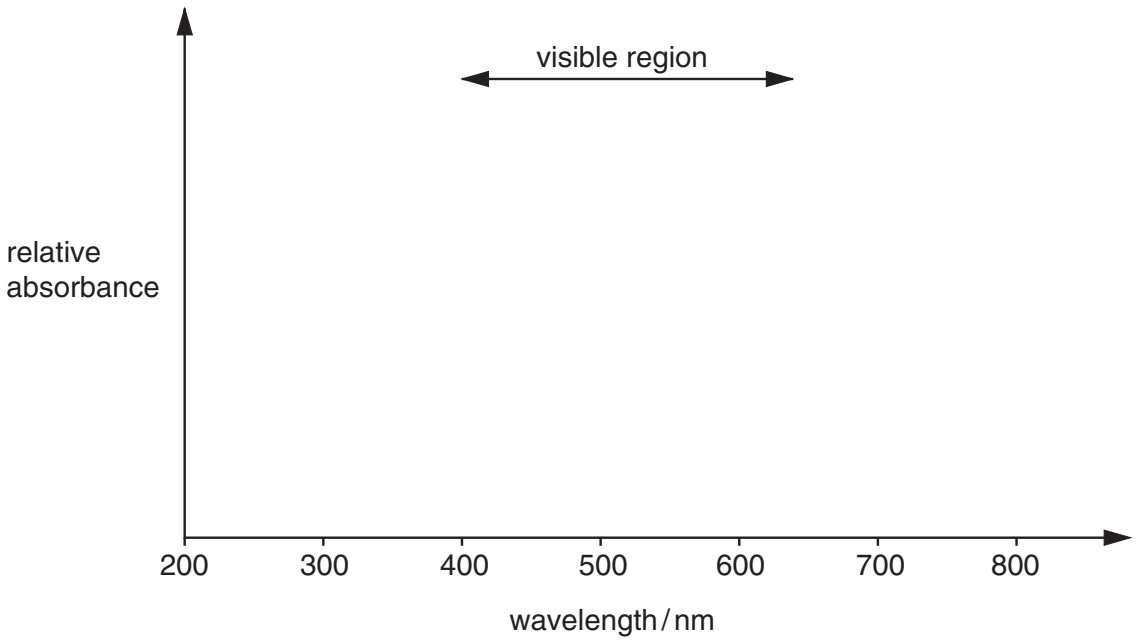
.....

..... [3]

[Total: 14]

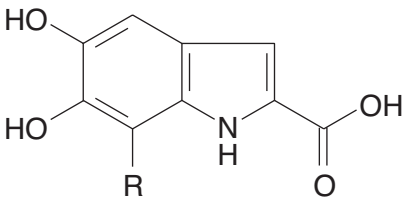
3 Melanin is a complex polymer synthesised by the body to provide protection from ultraviolet radiation. Melanin shows a strong absorption peak in the ultraviolet that tails off across the visible region of the electromagnetic spectrum.

(a) Use the axes below to sketch an absorption spectrum for melanin that matches the above description.



[2]

(b) Melanin contains chemical groups related to the structure of a molecule known as indole. An example of such a group present in melanin is shown in the diagram below.



R = rest of melanin structure

(i) Which structural features present in this part of the melanin molecule are responsible for absorption in the ultraviolet / visible range of the electromagnetic spectrum?

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..... [3]

(ii) A single melanin molecule contains many indole-based groups.

Suggest what effect this has on the ultraviolet absorption properties of melanin.

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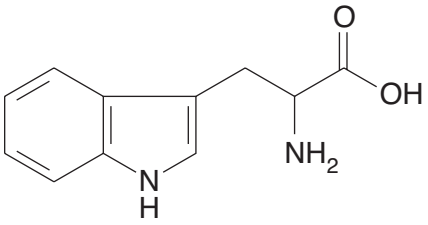
..... [1]

(c) Analysis of a protein may involve both partial hydrolysis of the protein molecule into fragments, and also complete hydrolysis into individual amino acids.

A protein contains the amino acid tryptophan, shown below. Tryptophan contains a similar indole-based structure to that found in melanin and it also absorbs in the ultraviolet region of the spectrum.



tryptophan

(i) A chemist carried out partial hydrolysis of the protein using an enzyme and analysed the resulting fragments by electrophoresis.

What assumption would be made by relying on the ultraviolet absorption of tryptophan to observe the results of the electrophoresis?

.....

..... [1]

(ii) The chemist also wanted to determine what other amino acids the protein might contain.

State the reagents and conditions required to break the protein down into its constituent amino acids prior to analysis.

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..... [3]

[Total: 10]

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

Chromatography and electrophoresis are techniques that can be used in forensic analysis of evidence found at a crime scene.

(a) **(i)** Thin-layer chromatography relies on the physical processes of either partition or adsorption depending on the conditions employed.

Explain both of these processes as they occur in thin-layer chromatography.

partition .....

.....

adsorption .....

..... [2]

(ii) The R_f value of spots on the resulting chromatogram can be used to confirm the results of analysis.

Write an expression for the term R_f *value*.

[1]

(b) Gel electrophoresis equipment can be used to produce a 'genetic fingerprint'. The genetic fingerprint can be used to help identify which suspects may have been present at the scene of a crime.

Use your knowledge of electrophoresis to describe and explain how prepared samples of DNA can be used to produce such a genetic fingerprint analysis.

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..... [6]

Quality of Written Communication [1]

[Total: 10]

END OF QUESTION PAPER