

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

2815/04

Methods of Analysis and Detection

Monday

26 JUNE 2006

Morning

50 minutes

Candidates answer on the question paper.

Additional materials:

Data Sheet for Chemistry

Scientific calculator

Candidate Name	Centre Number	Candidate Number										
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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

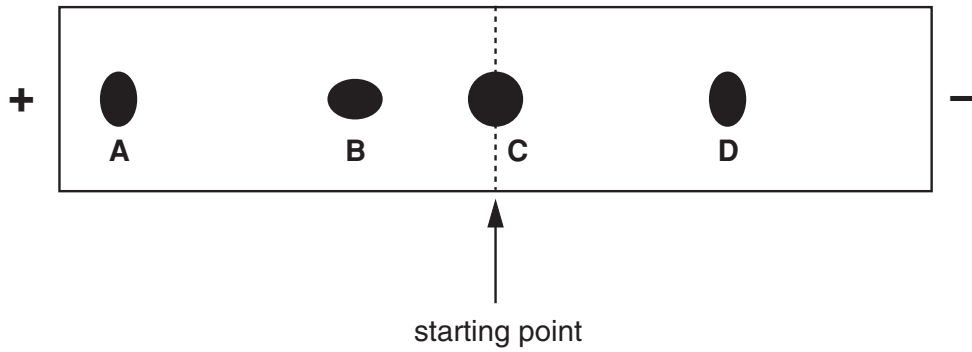
- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised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

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	7	
2	12	
3	12	
4	14	
TOTAL	45	

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

Answer **all** the questions.

- 1 A mixture of four amino acids, **A**, **B**, **C** and **D**, was analysed by paper electrophoresis. The paper was soaked in a buffer solution at pH 7. The results of this analysis are shown in the diagram below.



(a) Explain why

(i) amino acid **C** does not move during electrophoresis,

.....
 [1]

(ii) amino acid **D** moves as it does,

.....
 [1]

(iii) amino acid **A** moves further than amino acid **B** during electrophoresis.

.....
 [1]

(b) How could the electrophoresis process be modified to cause the amino acid **C** to migrate towards the negative electrode? Explain your answer by referring to the general structure of an amino acid.

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..... [4]

[Total: 7]

2 Atoms and molecules can be made to emit or absorb electromagnetic radiation. These properties can be used in the analytical technique known as spectroscopy.

(a) The atomic emission spectra of hydrogen and helium appear as a series of lines on a dark background.

(i) What changes are taking place in the hydrogen atoms that give rise to these lines?

.....

 [2]

(ii) At the high frequency end of the emission spectrum of hydrogen, the lines appear closer together until they converge. The frequency at which this occurs is called the *convergence limit*.

Explain why this convergence of spectral lines is observed.

.....

 [2]

(iii) The highest frequency convergence limit of helium occurs at 5.90×10^{15} Hz. Calculate the first ionisation energy of helium, in kJ mol^{-1} . Express your answer to an appropriate number of significant figures.

the Planck constant = $6.63 \times 10^{-34} \text{ J s}$
 the Avogadro constant = $6.02 \times 10^{23} \text{ mol}^{-1}$

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

- (b) Absorption of electromagnetic (EM) radiation by molecules may produce changes to molecular energies.
- (i) Complete the table below to show which spectroscopic technique is associated with each molecular energy.

molecular energy affected by EM radiation	spectroscopic technique
electronic	
nuclear spin (in an external magnetic field)	
vibrational	

[3]

- (ii) In each of these spectroscopic techniques, the sample will be exposed to a whole range of frequencies of electromagnetic radiation.

Explain why the molecules of a sample only absorb particular frequencies of the radiation.

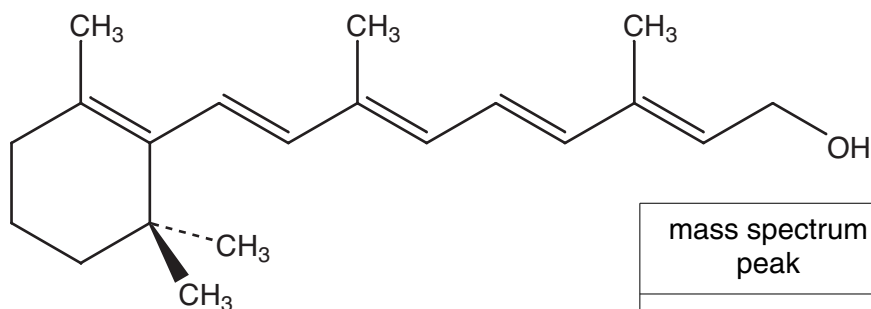
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..... [2]

[Total: 12]

- 3 Retinol (vitamin A) is an important dietary requirement for maintaining healthy vision. The structure of retinol is given below together with data from its mass spectrum.



mass spectrum peak	m/e	relative abundance
M	286	100
M+1	287	21.8

- (a) Use the data to confirm the total number of carbon atoms in the retinol molecule.

[2]

- (b) Retinol contains structural features that act as chromophores.

- (i) Explain what is meant by the term *chromophore*.

.....
 [1]

- (ii) Identify the structural features of retinol that act as chromophores.

.....

 [3]

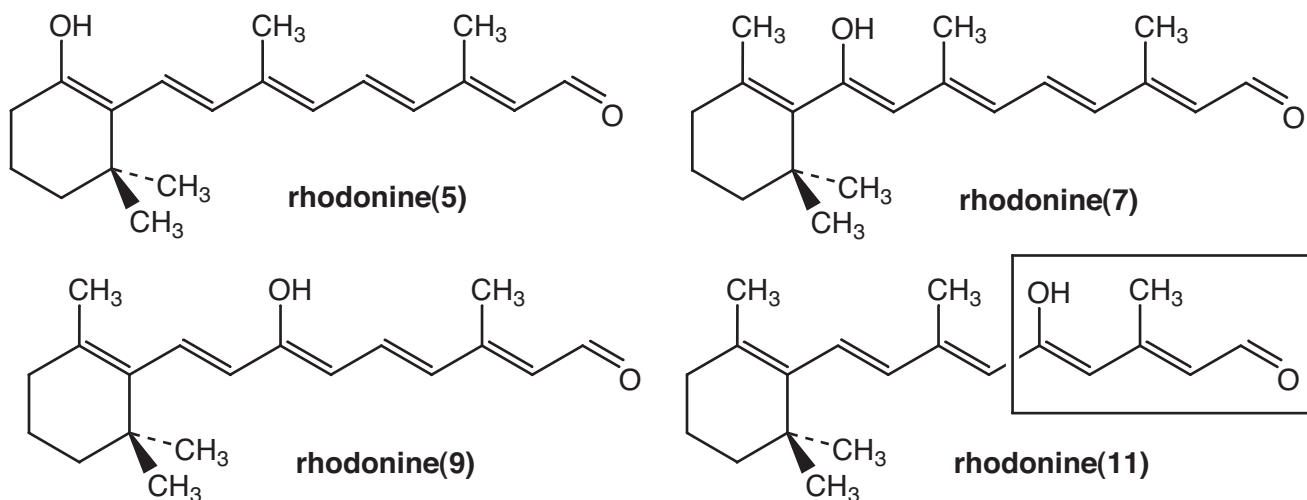
- (c) The major absorption in the ultraviolet and visible spectrum of retinol has a maximum value at 325 nm. The visible region of the electromagnetic spectrum extends from approximately 400 to 700 nm.

Suggest why retinol is **not** responsible for absorptions that give rise to the perception of colour in vision.

.....

 [2]

- (d) Recent research has suggested that the molecules associated with colour perception are rhodonines.



The section of the molecule responsible for the absorption in the uv/visible region of the spectrum lies between the two oxygen containing groups (illustrated by the **box** around part of the structure of rhodonine(11)).

At high concentrations, the rhodonines show the following absorption peaks.

compound	wavelength of absorption peak / nm
rhodonine(5)	625
rhodonine(7)	532
rhodonine(9)	437
rhodonine(11)	342

- (i) Use the chemical structures of the rhodonines to explain the trend in the wavelengths of the absorption peaks.

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 [2]

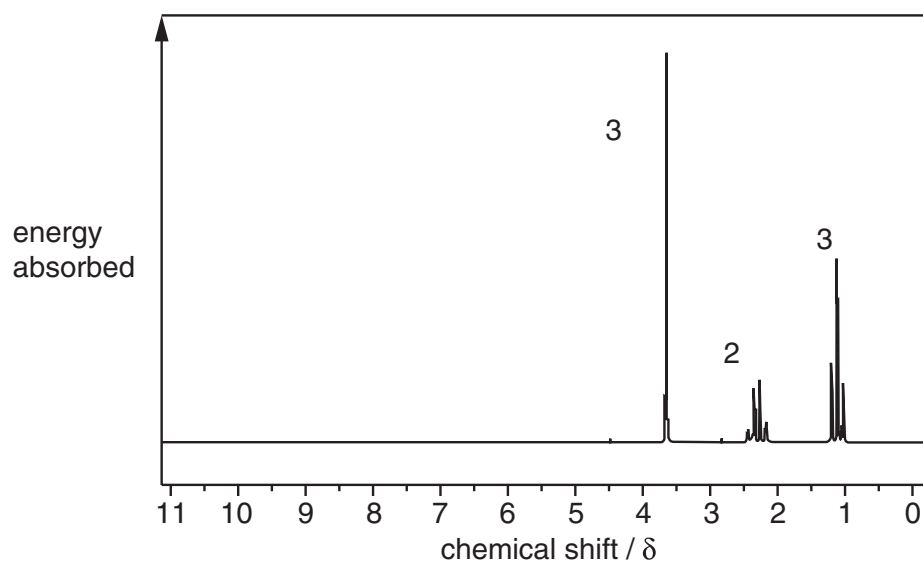
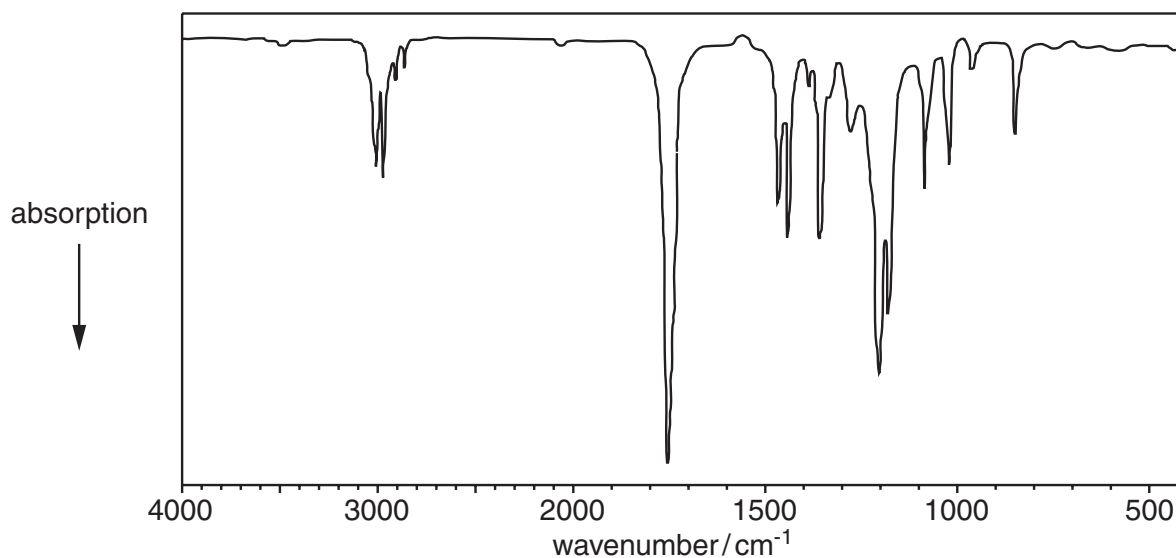
- (ii) Suggest how the rhodonines might enable a full range of colour perception across the visible region of the spectrum.

.....

 [2]

[Total: 12]

- 4 The data and spectra shown below were obtained from compound **R**, which has the empirical formula C_2H_4O .



mass spectrum peak	m/e	relative abundance
M	88	32.40
M+1	89	1.43

- (a) Using the data provided by the mass spectrum, determine the molecular formula of **R**.

[1]

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

A chemist suspected, from the fruity odour produced by compound **R**, that it might be an ester. Use the evidence provided by the infrared and n.m.r. spectra of **R** to confirm this conclusion and determine the structure of the compound. Your answer should identify all the relevant data from the spectra that you use.

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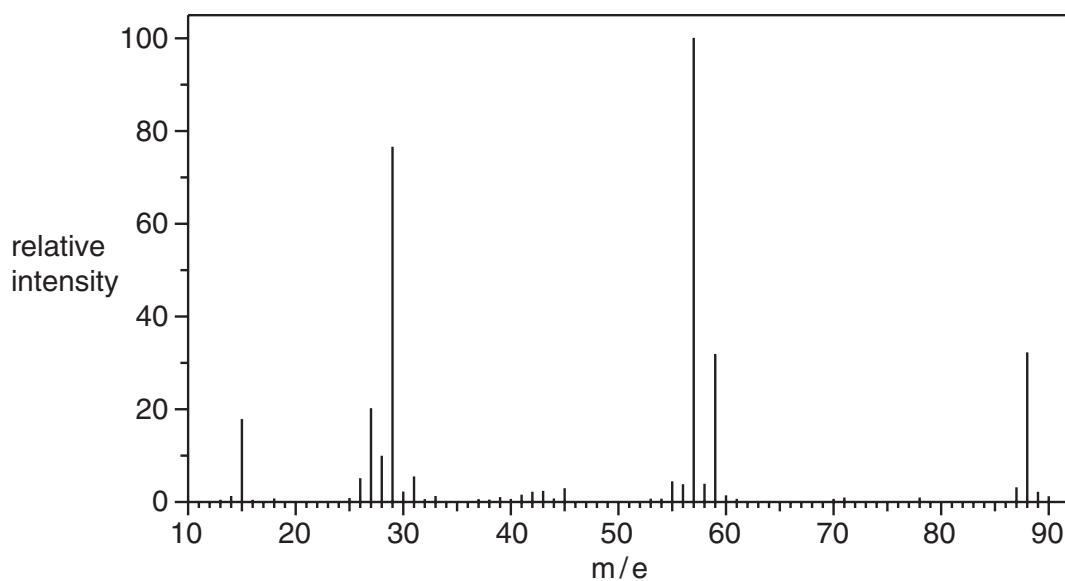
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[8]

Quality of Written Communication [1]

TURN OVER FOR PART 4(c)

(c) The mass spectrum of the ester **R** is shown below.



During mass spectrometry of ester molecules, both the bonds on each side of the C=O can break to produce fragment ions.

(i) Identify the **two** fragment ions that produce these peaks in the mass spectrum of an ester.

[2]

(ii) On the mass spectrum above label the peaks that correspond to these fragment ions.

[2]

[Total: 14]

END OF QUESTION PAPER

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