Chromatography

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Analytical techniques
Sub-Topic	Chromatography
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **63 minutes**

Score: **/52**

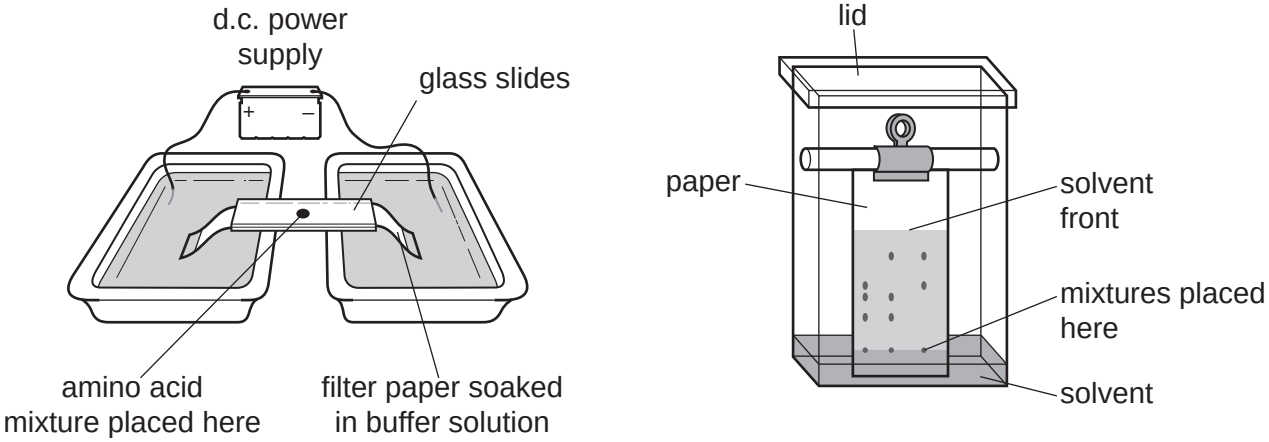
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Modern methods of chemical analysis often rely on the interpretation of data gathered from instrumental techniques.

(a) Electrophoresis and paper chromatography can both be used to separate amino acids from a mixture obtained from polypeptides.



In each case, give **one** property of the amino acids that causes their separation.

electrophoresis .....

.....

paper chromatography .....

.....

[2]

(b) Amino acids are colourless.

How are the positions of the different amino acids made visible so that measurements can be made?

.....

..... [1]

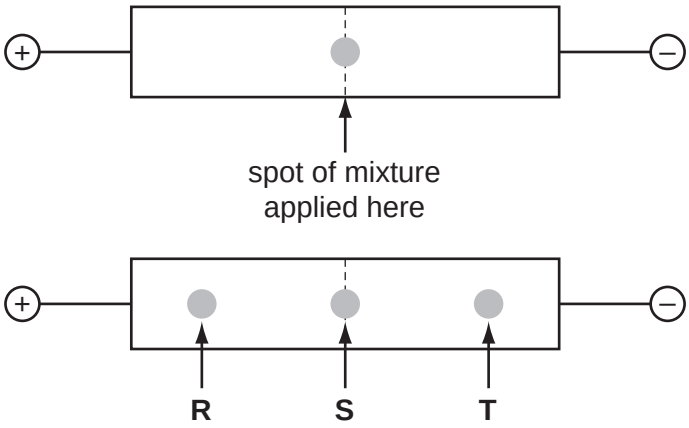
(c) Which **measurements** need to be made in order to identify individual amino acids in paper chromatography?

.....

..... [1]

(d) The diagram shows the results of electrophoresis on a mixture of the amino acids glycine, lysine and glutamic acid at pH 7.0. The structures of the amino acids at pH 7.0 are shown.

glycine: $H_3N^+CH_2CO_2^-$
lysine: $H_3N^+CH(CH_2CH_2CH_2CH_2NH_3^+)CO_2^-$
glutamic acid: $H_3N^+CH(CH_2CH_2CO_2^-)CO_2^-$



Identify the amino acids responsible for the spots labelled **R**, **S** and **T**.

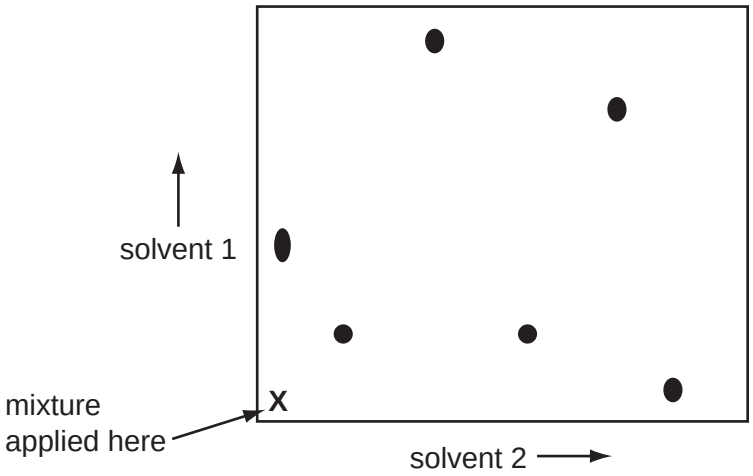
R .....

S .....

T .....

[3]

(e) This diagram shows the results of two-way paper chromatography of a mixture of amino acids.



To answer these questions you need to indicate clearly on the diagram above as directed in the questions.

(i) Put a **U** next to the amino acid that travelled furthest in solvent 2.

(ii) Put a ring around the **two** amino acids that were **not** separated in solvent 1.

(iii) Put a **W** next to the amino acid that was very soluble in **both** solvents.

[3]

[Total: 10]

2 **(a)** A mixture of amino acids can be separated by electrophoresis. During an electrophoresis experiment,

- different amino acids move in different directions,
- different amino acids move at different speeds,
- some amino acids do not move at all.

Explain these observations.

.....

.....

.....

..... [3]

(b) **(i)** A mixture of amino acids can also be separated by thin-layer chromatography. Identify the mobile and the stationary phases in this type of chromatography.

mobile phase .....

stationary phase .....

(ii) What is the process by which thin-layer chromatography can separate a mixture?

.....
[3]

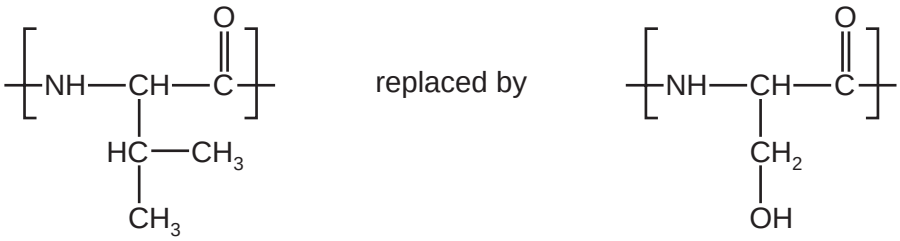
(c) State **three** structural features of DNA.

.....

.....

..... [3]

(d) Some diseases are caused by a mutation in the DNA base sequence which results in one amino acid being replaced by another during protein synthesis.
Suggest what changes in the interactions that form the tertiary structure would result from a mutation that replaced a valine residue with a serine residue.



val ser

.....

.....

..... [2]

[Total: 11]

3 (a) Explain what is meant by the term *partition coefficient* .

.....

..... [2]

(b) When 20 cm^3 of ethoxyethane were shaken with 75 cm^3 of an aqueous solution containing 5.00 g of an organic compound, **J**, in 75 cm^3 of water, it was found that 2.14 g of **J** were extracted into the ethoxyethane.

Calculate the partition coefficient, $K_{partition}$, of **J** between ethoxyethane and water.

$K_{partition}$ = ... [2]

(c) In a new experiment

- 10 cm^3 of ethoxyethane were shaken with 75 cm^3 of an aqueous solution containing 5.00 g of **J** and the layers were separated.
- The aqueous layer was shaken with a second 10 cm^3 portion of ethoxyethane and the layers were separated.
- The two organic layers were combined.

Use the value of $K_{partition}$ you calculated in **(b)** to calculate the total mass of **J** extracted by this procedure.

total mass of **J** = ... [2]

(d) Paper chromatography and gas / liquid chromatography both rely on the partition of compounds between mobile and stationary phases.

(i) Identify the mobile phase in paper chromatography.

.....

(ii) Suggest what type of liquid is used for the stationary phase in gas / liquid chromatography.

.....

(iii) Both these techniques can be used to separate mixtures.

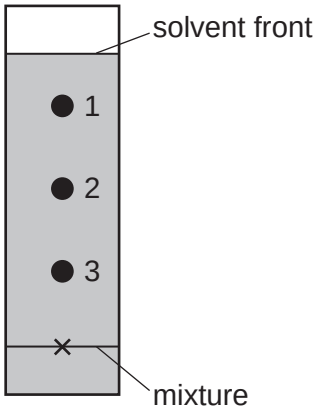
State what you would measure in order to distinguish between the components in the mixture in

1. paper chromatograp , ...

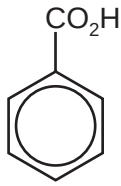
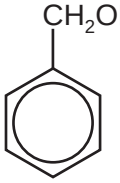
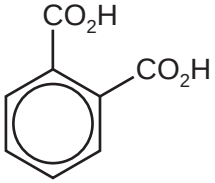
2. g / liquid chromatography. .....

[4]

(e) A mixture of three compounds was analysed by paper chromatography using a non-polar solvent. The resulting chromatogram is shown.



Identify which compound is responsible for each spot.

compound	spot
	
	
	

[1]

[Total: 11]

4 Modern methods of analysis have had far-reaching effects on a number of branches of science including medicine, forensic science, environmental monitoring and archaeology.

(a) Outline, in simple terms, the technique of DNA fingerprinting.

.....

.....

.....

.....

.....

.....

[4]

(b) Complete the table by indicating whether the items can be used for DNA fingerprinting. Use a tick (✓) for items which can be used for DNA fingerprinting and a cross (**x**) for items which cannot.

item for testing	suitable for DNA fingerprinting
human hair	
piece of a flint tool	
piece of Iron Age pot	
piece of Roman leather	

[3]

(c) Various forms of chromatography can be used to separate and analyse mixtures. HPLC (high performance liquid chromatography) can be used to separate each of the following mixtures. State another method of chromatography which would separate each mixture.

insecticides in a sample of water .....

dyes present in a foodstuff .....

drug residue in an athlete's urine .....

[3]

[Total: 10]

5 Chromatography is an important analytical technique in chemistry. There is a number of techniques under the general heading of chromatography.

(a) Paper and gas chromatography rely on partition to separate the components in a mixture, whereas thin-layer chromatography uses adsorption.

Explain what is meant by **(i)** *partition* and **(ii)** *adsorption*, in the context of chromatography.

(i) partition .....

.....

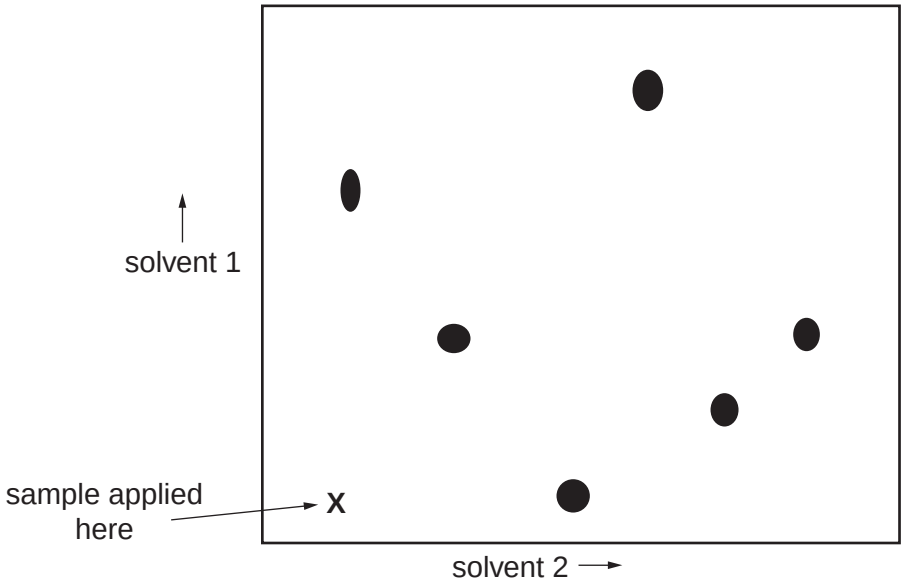
.....

(ii) adsorption .....

.....

.....[2]

(b) In paper or thin-layer chromatography, better separation may be achieved by running the chromatogram in one solvent, then turning the paper at right angles and running it in a second solvent. The chromatogram below was produced in this way.

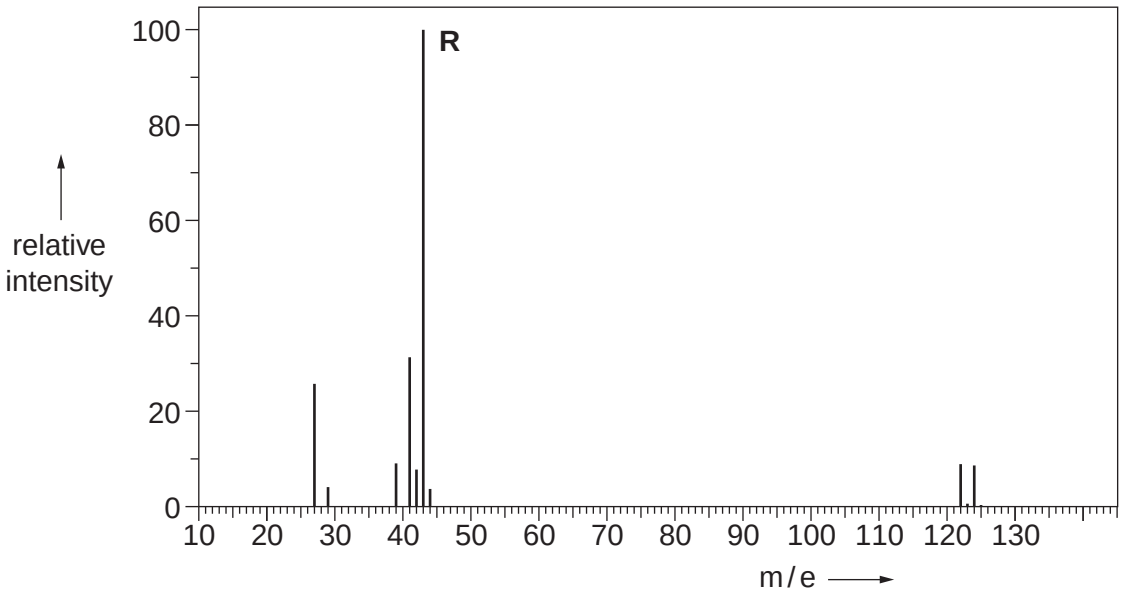


(i) Ring the spot which was insoluble in solvent 1.

(ii) Label as **A** and **B** the spots which were **not** resolved using solvent 1.

[2]

(c) The mass spectrum shown was obtained from a compound of formula C_pH_qX, where X represents a halogen atom.



(i) Deduce the identity of X, giving a reason.

X is .....

.....

(ii) If the relative heights of the M and M+1 peaks are 9 and 0.3 respectively, calculate the value of p. Use this value and the m / e value of the molecular ion to calculate the value of q, and hence the molecular formula of the compound. Show your working.

(iii) Suggest a formula for the ion responsible for the peak labelled **R**.

..... [4]

(d) In the fragmentation of alcohols which occurs in a mass spectrometer, small stable, neutral molecules are sometimes produced. Suggest the identity of **two** such molecules, each with an M_r less than 30.

(i) ..... **(ii)** ..... [2]

[Total: 10]