



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**CHEMISTRY** **9701/43**  
Paper 4 Structured Questions **October/November 2010**  
**1 hour 45 minutes**

Candidates answer on the Question Paper.  
Additional Materials: Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number and candidate number on all the work you hand in.  
Write in dark blue or black pen.  
You may use a pencil for any diagrams, graphs, or rough working.  
Do not use staples, paper clips, highlighters, glue or correction fluid.  
**DO NOT WRITE ON ANY BARCODES.**

**Section A**  
Answer **all** questions.

**Section B**  
Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.  
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.  
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
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8	
9	
10	
11	
<b>Total</b>	

This document consists of **19** printed pages and **1** blank page.

## Section A

Answer **all** the questions in the space provided.

- 1 (a) (i) Write equations to illustrate the reactions of the following oxides with water.

phosphorus(V) oxide .....

sulfur(IV) oxide .....

- (ii) When  $\text{NO}_2$  reacts with water, nitrogen undergoes a disproportionation reaction in which one nitrogen atom decreases its oxidation number by 1 and another nitrogen atom increases its oxidation number by 1. A mixture of two acids results. Suggest an equation for the reaction between  $\text{NO}_2$  and water.

.....

- (iii) In a similar disproportionation reaction,  $\text{ClO}_2$  reacts with aqueous  $\text{NaOH}$  to produce a solution containing two chlorine-containing sodium salts. Suggest an equation for the reaction between  $\text{ClO}_2$  and aqueous  $\text{NaOH}$ .

.....

[4]

- (b) The major source of sulfur for the manufacture of sulfuric acid by the Contact process is the de-sulfurisation of 'sour' natural gas. Many natural gas wells produce a mixture of volatile hydrocarbons (mainly  $\text{CH}_4$  and  $\text{C}_2\text{H}_6$ ) together with up to 25% hydrogen sulfide,  $\text{H}_2\text{S}$ .

- (i) Complete and balance the following equation showing the complete combustion of a gaseous mixture consisting of 2 mol of  $\text{CH}_4$ , 1 mol of  $\text{C}_2\text{H}_6$  and 1 mol of  $\text{H}_2\text{S}$ .

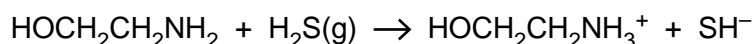


- (ii) Explain why it is important to remove the  $\text{H}_2\text{S}$  before burning the natural gas industrially.

.....

.....

The  $\text{H}_2\text{S}$  is removed by passing the 'sour' natural gas through a solvent containing ethanolamine. The following reaction takes place.



- (iii) If a sample of natural gas contains 5% by volume of  $\text{H}_2\text{S}$ , calculate the mass of ethanolamine required to remove all the  $\text{H}_2\text{S}$  from a  $1000\text{dm}^3$  sample of gas, measured under room conditions.

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The H<sub>2</sub>S can be recovered by warming the solution to 120 °C, when the above reaction is reversed. The ethanolamine can then be recycled.

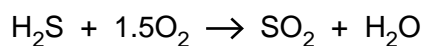
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- (iv) What *type* of reaction is occurring here?

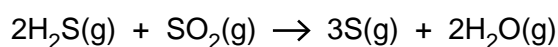
.....

The recovered H<sub>2</sub>S is converted to sulfur by the following two reactions.

- I Part of the H<sub>2</sub>S is burned in air.



- II The gas stream resulting from reaction I is then blended with the remaining H<sub>2</sub>S and fed into an iron oxide catalyst bed, where sulfur and water are produced according to the following equation.



- (v) Use the following data to calculate  $\Delta H^\ominus$  for the reaction between H<sub>2</sub>S and SO<sub>2</sub>.

compound	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
H <sub>2</sub> S(g)	-21
SO <sub>2</sub> (g)	-297
H <sub>2</sub> O(g)	-242
S(g)	+11

$$\Delta H^\ominus = \dots\dots\dots \text{kJ mol}^{-1}$$

[8]

[Total: 12]

- 2 (a) Explain why complexes of transition elements are often coloured.

For  
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Use

.....

.....

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.....

.....

..... [3]

- (b) When water is added to white anhydrous  $\text{CuSO}_4$ , the solid dissolves to give a blue solution. The solution changes to a yellow-green colour when concentrated  $\text{NH}_4\text{Cl}(\text{aq})$  is added to it. Concentrating the solution produces green crystals of an ammonium salt with the empirical formula  $\text{CuN}_2\text{H}_8\text{Cl}_4$ . Explain these observations, showing your reasoning.

.....

.....

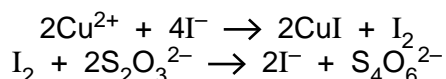
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.....

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..... [3]

- (c) Copper can be recovered from low-grade ores by 'leaching' the ore with dilute  $\text{H}_2\text{SO}_4$ , which converts the copper compounds in the ore into  $\text{CuSO}_4(\text{aq})$ . The concentration of copper in the leach solution can be estimated by adding an excess of aqueous potassium iodide, and titrating the iodine produced with standard  $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$ .



When an excess of  $\text{KI}(\text{aq})$  was added to a  $50.0\text{cm}^3$  sample of leach solution, and the resulting mixture titrated,  $19.5\text{cm}^3$  of  $0.0200\text{mol dm}^{-3}$   $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$  were required to discharge the iodine colour.

Calculate the  $[\text{Cu}^{2+}(\text{aq})]$ , and hence the percentage by mass of copper, in the leach solution.

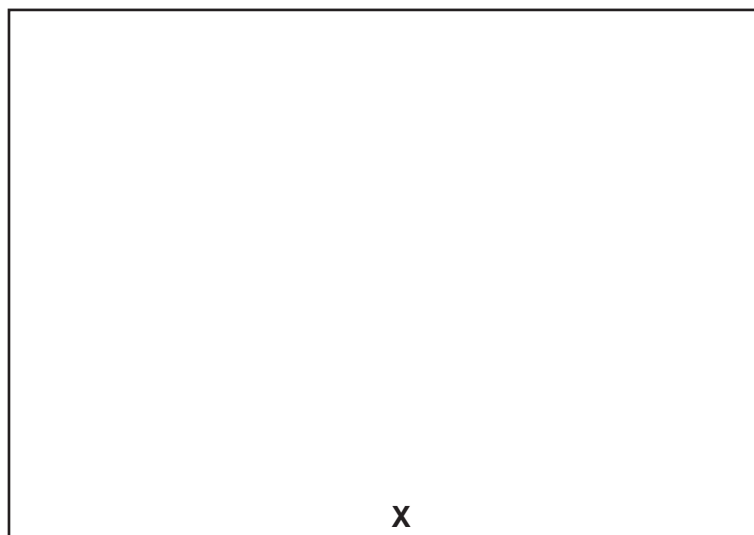
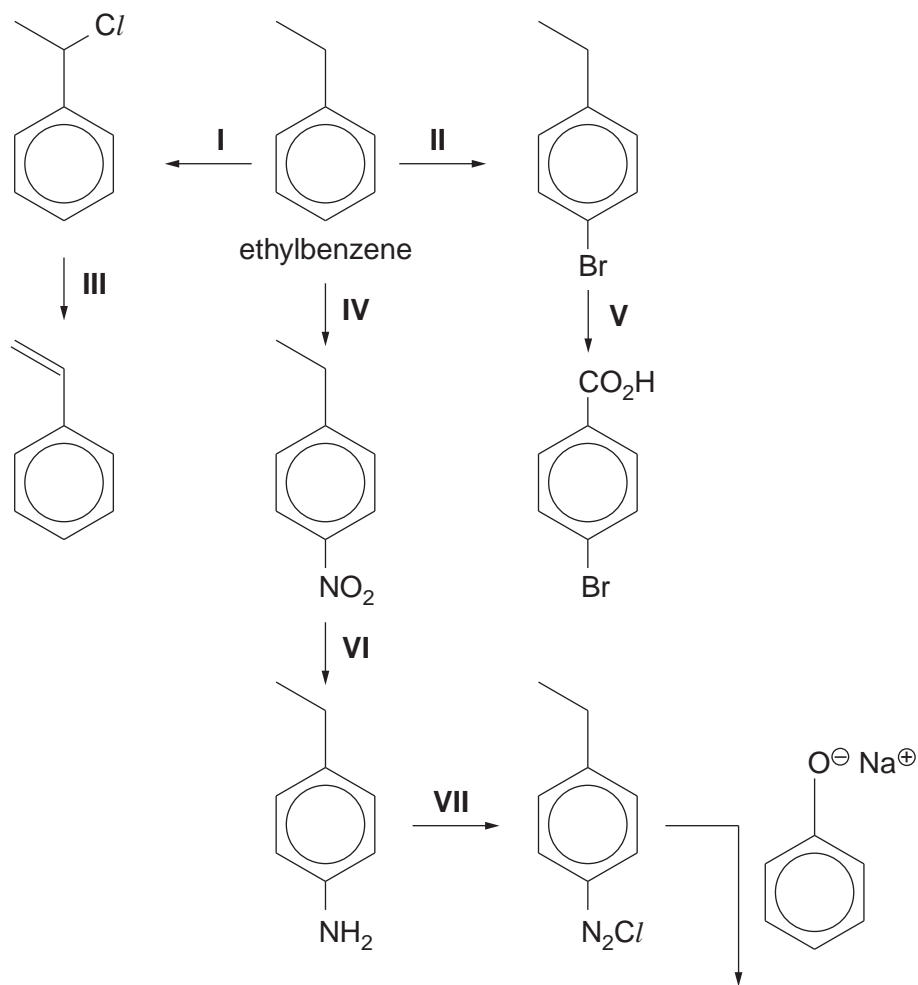
percentage of copper = ..... % [3]

[Total: 9]



4 The following chart shows some reactions of ethylbenzene and compounds produced from it.

For  
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Use



(i) Draw the structure of compound **X** in the box provided in the chart above.

- (ii) Suggest reagents and conditions for each of the reactions, writing them in the spaces below.

For  
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Use

**reaction I** .....

**reaction II** .....

**reaction III** .....

**reaction IV** .....

**reaction V** .....

**reaction VI** .....

**reaction VII** .....

[Total: 8]

- 5 Chlorine is manufactured by the electrolysis of brine,  $\text{NaCl}(\text{aq})$ . At the cathode,  $\text{H}_2(\text{g})$  and  $\text{OH}^-(\text{aq})$  are produced, but the product at the anode depends on the  $[\text{NaCl}(\text{aq})]$  in the solution. Either  $\text{O}_2(\text{g})$  or  $\text{Cl}_2(\text{g})$  is produced.

(a) The equation for the cathode reaction is  $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ .

Starting from **neutral**  $\text{NaCl}(\text{aq})$ , write equations for the production at the anode of

(i)  $\text{O}_2(\text{g})$ , .....

(ii)  $\text{Cl}_2(\text{g})$ . .....

[2]

(b) For electrolysis to occur, the voltage applied to the cell must be at least as large as the  $E_{\text{cell}}^\ominus$ , as calculated from standard electrode potentials.

Use the *Data Booklet* to calculate  $E_{\text{cell}}^\ominus$  for the production at the anode of

(i)  $\text{O}_2(\text{g})$ , .....

(ii)  $\text{Cl}_2(\text{g})$ . .....

[2]

(c) (i) By using **one** of the phrases *more positive*, *less positive* or *no change*, use the equations you wrote in (a) to deduce the effect of increasing  $[\text{Cl}^-(\text{aq})]$  on

• the  $E_{\text{anode}}$  for the production of  $\text{O}_2(\text{g})$ , .....

• the  $E_{\text{anode}}$  for the production of  $\text{Cl}_2(\text{g})$ . .....

(ii) Hence explain why the  $\text{Cl}_2(\text{g}) : \text{O}_2(\text{g})$  ratio increases as  $[\text{NaCl}(\text{aq})]$  increases.

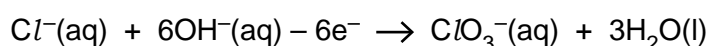
.....

..... [3]

(d) Sodium chlorate(V) is prepared commercially by electrolysis  $\text{NaCl}(\text{aq})$  in a cell which allows the cathode and anode electrolytes to mix.

The cathode reaction is the same as that described in (a).

The equation for the anode reaction is



(i) Construct an ionic equation for the overall reaction.

.....



- (ii) Calculate the mass of  $\text{NaClO}_3$  that is produced when a current of 250 A is passed through the cell for 60 minutes.

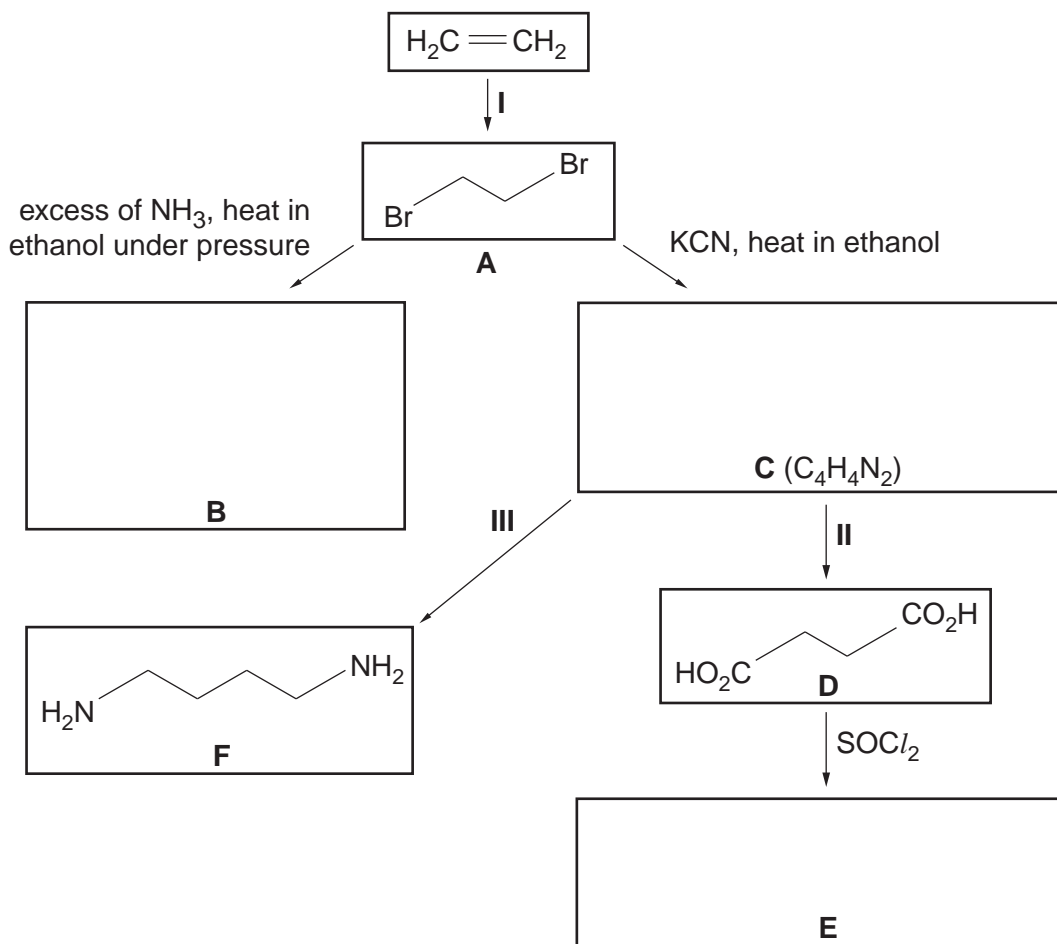
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mass of  $\text{NaClO}_3$  = ..... g [4]

[Total: 11]

- 6 The following scheme outlines the production of some compounds from ethene.

For  
Examiner's  
Use



- (a) (i) Suggest the reagent and conditions for reaction I.

.....

- (ii) Describe the mechanism of reaction I by means of a diagram. Include all whole, partial and induced charges, and represent the movements of electron pairs by curly arrows.

[3]

(b) Suggest the identities of compounds **B**, **C** and **E**, and draw their structures in the boxes opposite. [3]

(c) Suggest reagents and conditions for

reaction II,

.....

reaction III.

..... [2]

(d) During reaction II the nitrogen atoms are lost from the organic molecule. Suggest the identity of the nitrogen-containing ion produced during this reaction.

..... [1]

(e) Compounds **E** and **F** react together to give a polymer and an inorganic product.

(i) Draw **one** repeat unit of this polymer.

(ii) Identify the inorganic product.

..... [2]

(f) A  $0.100 \text{ mol dm}^{-3}$  solution of compound **D** has a pH of 2.60.

(i) Calculate the  $[\text{H}^+]$  in this solution.

.....  
.....

(ii) Hence calculate the value of  $K_a$  of compound **D**.

.....  
.....

[2]

[Total: 13]

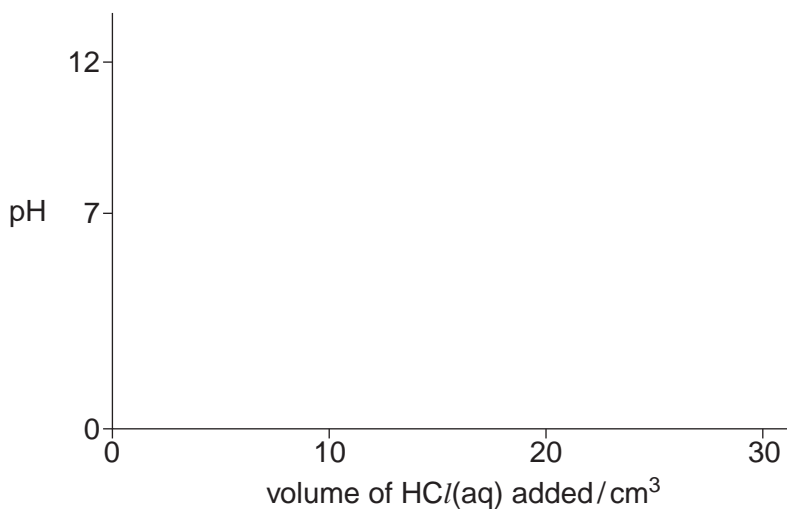
- 7 When an aqueous solution of compound **G**,  $\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ , is titrated with  $\text{HCl}(\text{aq})$ , two successive acid-base reactions take place.

For  
Examiner's  
Use

- (a) Write equations for these two acid-base reactions.

.....  
.....[2]

- (b) A  $0.10\text{mol dm}^{-3}$  solution of **G** has a pH of 11.3. When  $30\text{cm}^3$  of  $0.10\text{mol dm}^{-3}$   $\text{HCl}$  is added to  $10\text{cm}^3$  of a  $0.10\text{mol dm}^{-3}$  solution of **G**, the final pH is 1.6. Using the following axes, sketch the pH changes that occur during this addition of  $\text{HCl}(\text{aq})$ .



[2]

[Total: 4]

8 (a) (i) By means of a clear, labelled diagram, describe the shape of the tin(IV) chloride molecule.

For  
Examiner's  
Use

(ii) Explain the shape of the tin(IV) chloride molecule in terms of its bonding.

.....  
.....

[2]

(b) (i) What would you expect to observe when tin(IV) chloride reacts with water? Suggest an explanation for your answer.

.....  
.....  
.....

(ii) Write an equation for the reaction between tin(IV) chloride and water.

.....

[3]

[Total: 5]

## Section B

Answer **all** questions in the spaces provided.

For  
Examiner's  
Use

- 9 DNA is an extremely important chemical in human cells. It has been described as the 'blueprint of life'.

(a) What **three** types of compound are linked together in DNA?

..... [1]

(b) DNA consists of two strands linked together. Draw a **block diagram** to illustrate this and showing **two** repeat units in the backbones, labelling the components and showing and labelling the bonds between the strands.

[4]

(c) DNA is used to encode for the production of a particular protein. Put the following biochemical structures in the correct sequence from the use of DNA as a template to the formation of the protein by writing their names in the relevant box below.

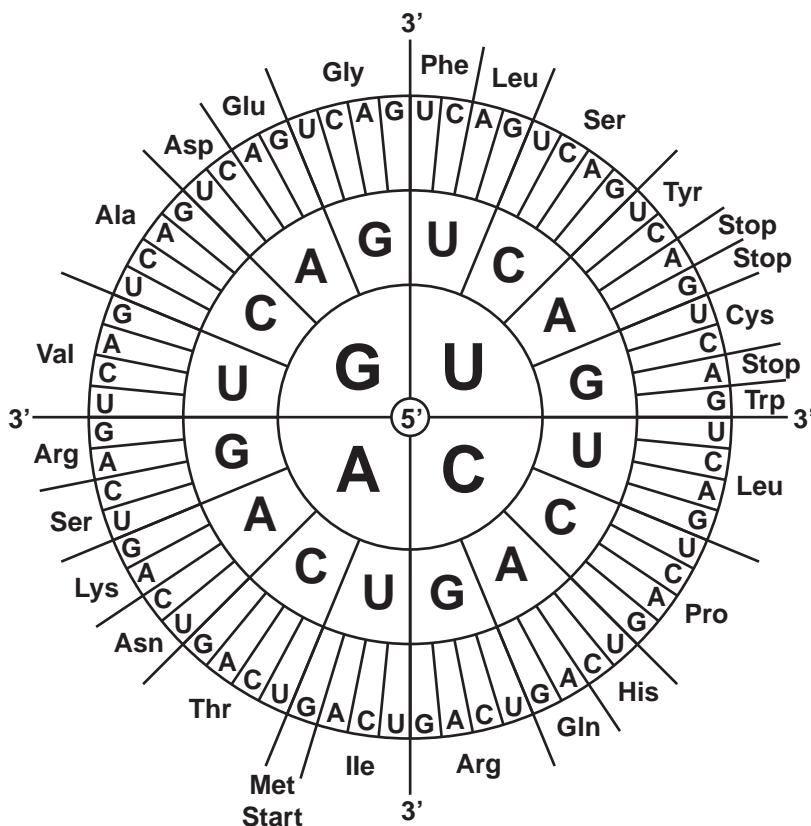
tRNA

mRNA

ribosomes

DNA →  →  →  → protein [2]

- (d) In order to produce proteins, the information stored in the DNA molecules has to be translated to produce an mRNA strand. A sequence of three bases, called a triplet, on the mRNA describes a particular amino acid. These amino acids are then combined together to form proteins. The amino acid specified by each triplet is shown below.



The sequence of three bases in a triplet is read from the middle outwards e.g. UGG specifies Trp.

- (i) There are four different bases present in mRNA. How many different triplets are possible using these four bases.

.....

- (ii) What peptide fragment would the following sequence code for when read from left to right? (Use 3-letter abbreviations for amino acids.)

5' – A U G A G C C G A C U U G A C G U G – 3'

.....

- (iii) What would be the effect of changing the 11<sup>th</sup> base from U to C?

.....

[4]

[Total: 11]

10 Instrumental methods of analysis have become increasingly important in recent years. The use of chromatography to separate substances, and NMR spectroscopy to identify them, has become routine in many laboratories.

(a) Chromatography relies on either partition or adsorption to help separate substances.

(i) Briefly explain how each method brings about separation.

partition .....

.....

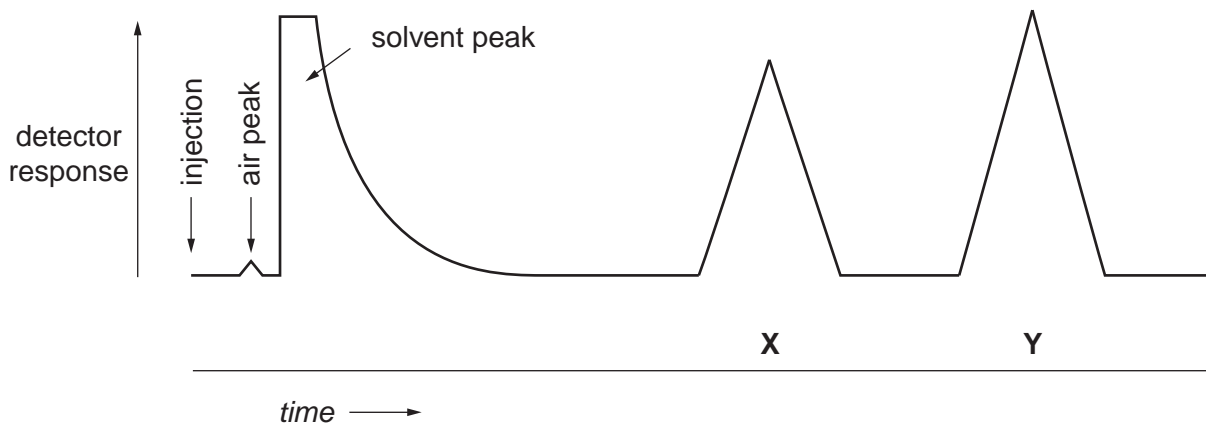
adsorption .....

.....

(ii) The table shows three different techniques of chromatography. Identify which separation method, *partition or adsorption*, applies to each.

technique	separation method
paper chromatography	
thin-layer chromatography	
gas/liquid chromatography	

(iii) The diagram represents the output from gas/liquid chromatography carried out on a mixture.



Determine the percentage of each of the two components X and Y in the mixture.

[5]



(b) NMR spectroscopy is a very important analytical technique for use with organic compounds.

For  
Examiner's  
Use

(i) Why is NMR spectroscopy particularly useful for organic compounds?

.....  
.....

(ii) Two molecules, propanal and propanone, have the same molecular formula,  $C_3H_6O$ . Draw the displayed formula of each compound and explain briefly how NMR spectroscopy can distinguish between the two structures.

.....  
.....  
.....  
.....

[4]

[Total: 9]

- 11 One of the greatest challenges facing scientists today is the development of effective drugs to treat different forms of cancer.

For  
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Use

- (a) Drugs can be introduced into the body by injection or by mouth. Taking drugs by injection avoids the drug being broken down in the digestive system.  
State **two** other advantages of giving drugs by injection.

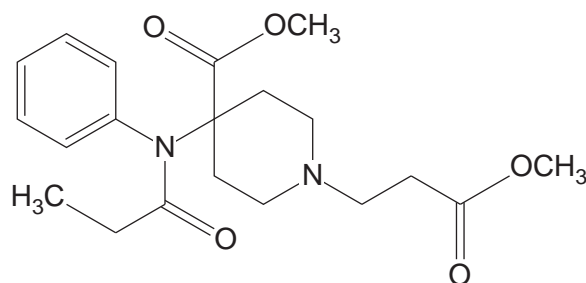
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.....

.....

..... [2]

- (b) The drug *Ultiva* has been developed to treat ovarian cancer, and is usually given by injection.



*Ultiva*

Study the structure of *Ultiva* and draw a **circle** around **two different** functional groups that could be broken down in the digestive system. [2]

- (c) One way of avoiding the breakdown of drugs in the body is to use a specially designed nanoparticle which encloses the drug. If the nanoparticles are made of a particular sort of polymer, they absorb water at the slightly acidic pH inside some cells, increasing their diameter from around 100 nm to around 1000 nm. This spreads out the polymer chains allowing release of the drug.

- (i) Other than absorbing water, suggest a property this polymer would need to possess for its use in drug delivery.

.....

.....

- (ii) Why would this method of release **not** work if the nanoparticles were taken by mouth?

..... [2]

- (d) Polymers may be formed by two different types of chemical reaction.  
Name the two types of reaction and write an equation to illustrate each reaction type.

**name** .....

equation .....

**name** .....

equation .....

[3]

- (e) The breakdown of polymers, such as carbohydrates and proteins in the body is important for digestion. What type of reaction is generally involved?

..... [1]

[Total: 10]

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