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	
3	
4	
5	
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7	
8	
9	
10	
11	
Total	

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

Section A

For Examiner's Use

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 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 NO_2 and water.

.....

(iii) In a similar disproportionation reaction, ClO_2 reacts with aqueous NaOH to produce a solution containing two chlorine-containing sodium salts.
Suggest an equation for the reaction between ClO_2 and aqueous 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 CH_4 and C_2H_6) together with up to 25% hydrogen sulfide, H_2S.

(i) Complete and balance the following equation showing the complete combustion of a gaseous mixture consisting of 2 mol of CH_4, 1 mol of C_2H_6 and 1 mol of H_2S.

$$2CH_4 + C_2H_6 + H_2S + \_\_\_\_\_ \rightarrow SO_2 + \_\_\_\_\_ + \_\_\_\_\_$$

(ii) Explain why it is important to remove the H_2S before burning the natural gas industrially.

.....

.....

The H_2S is removed by passing the 'sour' natural gas through a solvent containing ethanolamine. The following reaction takes place.

$$HOCH_2CH_2NH_2 + H_2S(g) \rightarrow HOCH_2CH_2NH_3^+ + SH^-$$

(iii) If a sample of natural gas contains 5% by volume of H_2S, calculate the mass of ethanolamine required to remove all the H_2S from a 1000 dm^3 sample of gas, measured under room conditions.

.....

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The H_2S can be recovered by warming the solution to 120 °C, when the above reaction is reversed. The ethanolamine can then be recycled.

For Examiner's Use

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

.....

The recovered H_2S is converted to sulfur by the following two reactions.

I Part of the H_2S is burned in air.

$$H_2S + 1.5O_2 \longrightarrow SO_2 + H_2O$$

II The gas stream resulting from reaction **I** is then blended with the remaining H_2S and fed into an iron oxide catalyst bed, where sulfur and water are produced according to the following equation.

$$2H_2S(g) + SO_2(g) \longrightarrow 3S(g) + 2H_2O(g)$$

(v) Use the following data to calculate $\Delta H^{\ominus}$ for the reaction between H_2S and SO_2.

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$H_2S(g)$	–21
$SO_2(g)$	–297
$H_2O(g)$	–242
S(g)	+11

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

[8]

[Total: 12]

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

For Examiner's Use

.....

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.....

.....

.....[3]

(b) When water is added to white anhydrous $CuSO_4$, the solid dissolves to give a blue solution. The solution changes to a yellow-green colour when concentrated NH_4Cl(aq) is added to it. Concentrating the solution produces green crystals of an ammonium salt with the empirical formula $CuN_2H_8Cl_4$.
Explain these observations, showing your reasoning.

.....

.....

.....

.....

.....[3]

(c) Copper can be recovered from low-grade ores by 'leaching' the ore with dilute H_2SO_4, which converts the copper compounds in the ore into $CuSO_4$(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 $Na_2S_2O_3$(aq).

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$
$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

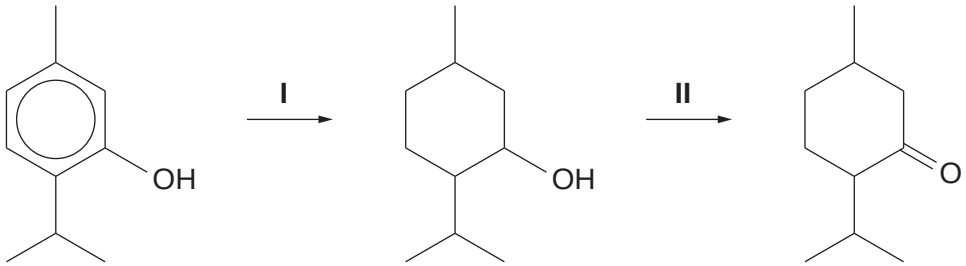
When an excess of KI(aq) was added to a 50.0 cm^3 sample of leach solution, and the resulting mixture titrated, 19.5 cm^3 of 0.0200 mol dm^{-3} $Na_2S_2O_3$(aq) were required to discharge the iodine colour.
Calculate the [Cu^{2+}(aq)], and hence the percentage by mass of copper, in the leach solution.

percentage of copper = ...% [3]

[Total: 9]

3 Menthol and menthone, the main constituents of oil of peppermint, can be made synthetically from thymol by the following route.

For Examiner's Use



thymol menthol menthone

(a) State the *type of reaction* of

- reaction **I**, ...
- reaction **II**. .....

[2]

(b) Suggest **one** test for **each** of the three compounds that would give a positive result with the stated compound but a negative result with **both** the other two compounds.

thymol

test .....

observation .....

menthol

test .....

observation .....

menthone

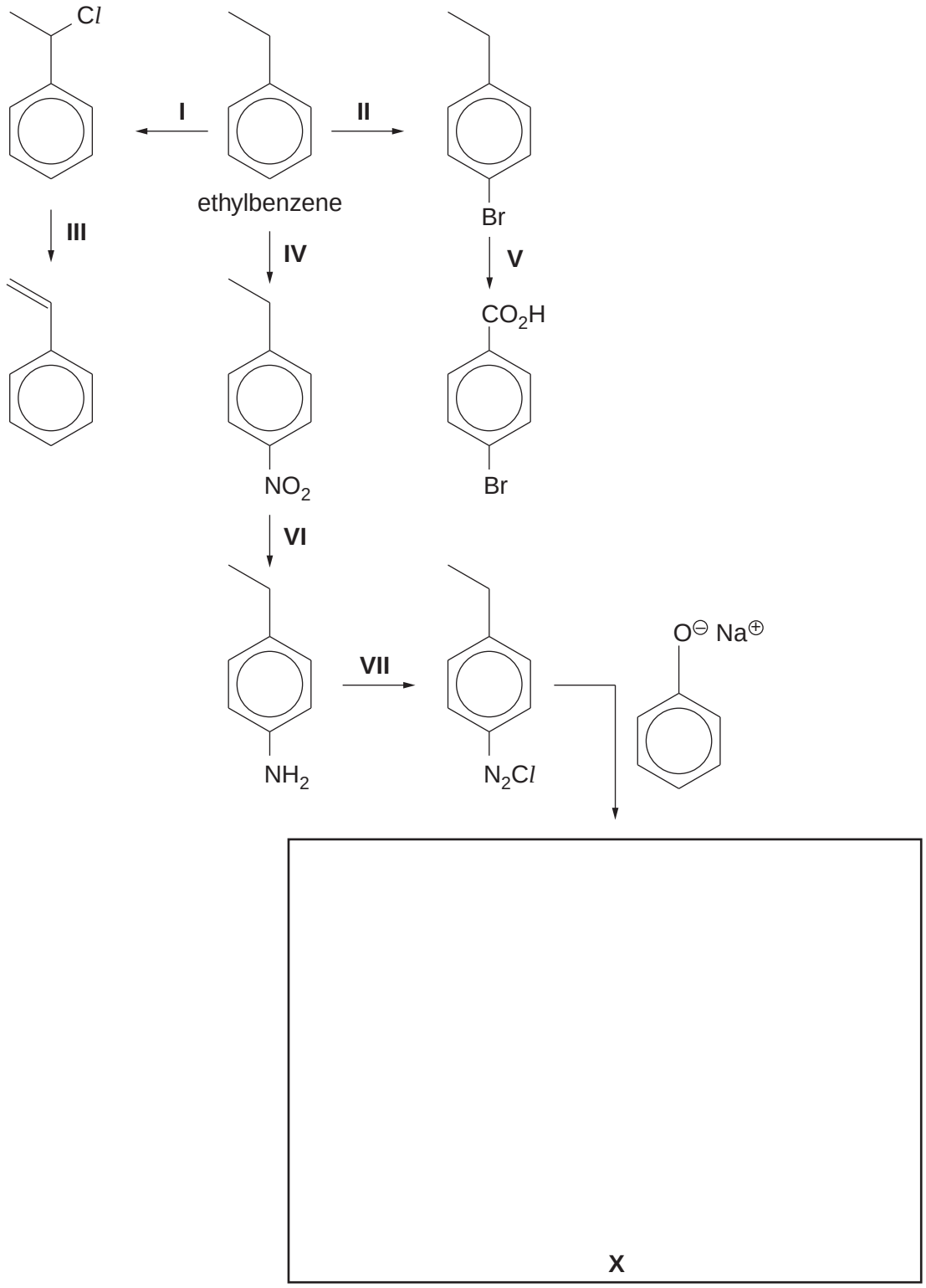
test .....

observation .....[6]

[Total: 8]

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

For Examiner's 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 Examiner's 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, NaC*l*(aq). At the cathode, $H_2(g)$ and $OH^-(aq)$ are produced, but the product at the anode depends on the [NaC*l*(aq)] in the solution. Either $O_2(g)$ or $Cl_2(g)$ is produced.

For Examiner's Use

(a) The equation for the cathode reaction is $2H_2O(l) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$.

Starting from **neutral** NaC*l*(aq), write equations for the production at the anode of

(i) $O_2(g)$, ...

(ii) $Cl_2(g)$. .....

[2]

(b) For electrolysis to occur, the voltage applied to the cell must be at least as large as the $E^{\ominus}_{cell}$, as calculated from standard electrode potentials.
Use the *Data Booklet* to calculate $E^{\ominus}_{cell}$ for the production at the anode of

(i) $O_2(g)$, ...

(ii) $Cl_2(g)$. .....

[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 [$Cl^-(aq)$] on

- the E_{anode} for the production of $O_2(g)$, ...
- the E_{anode} for the production of $Cl_2(g)$. .....

(ii) Hence explain why the $Cl_2(g) : O_2(g)$ ratio increases as [NaC*l*(aq)] increases.

.....

.....[3]

(d) Sodium chlorate(V) is prepared commercially by electrolysing NaC*l*(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

$$Cl^-(aq) + 6OH^-(aq) - 6e^- \longrightarrow ClO_3^-(aq) + 3H_2O(l)$$

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

.....

(ii) Calculate the mass of $NaClO_3$ that is produced when a current of 250 A is passed through the cell for 60 minutes.

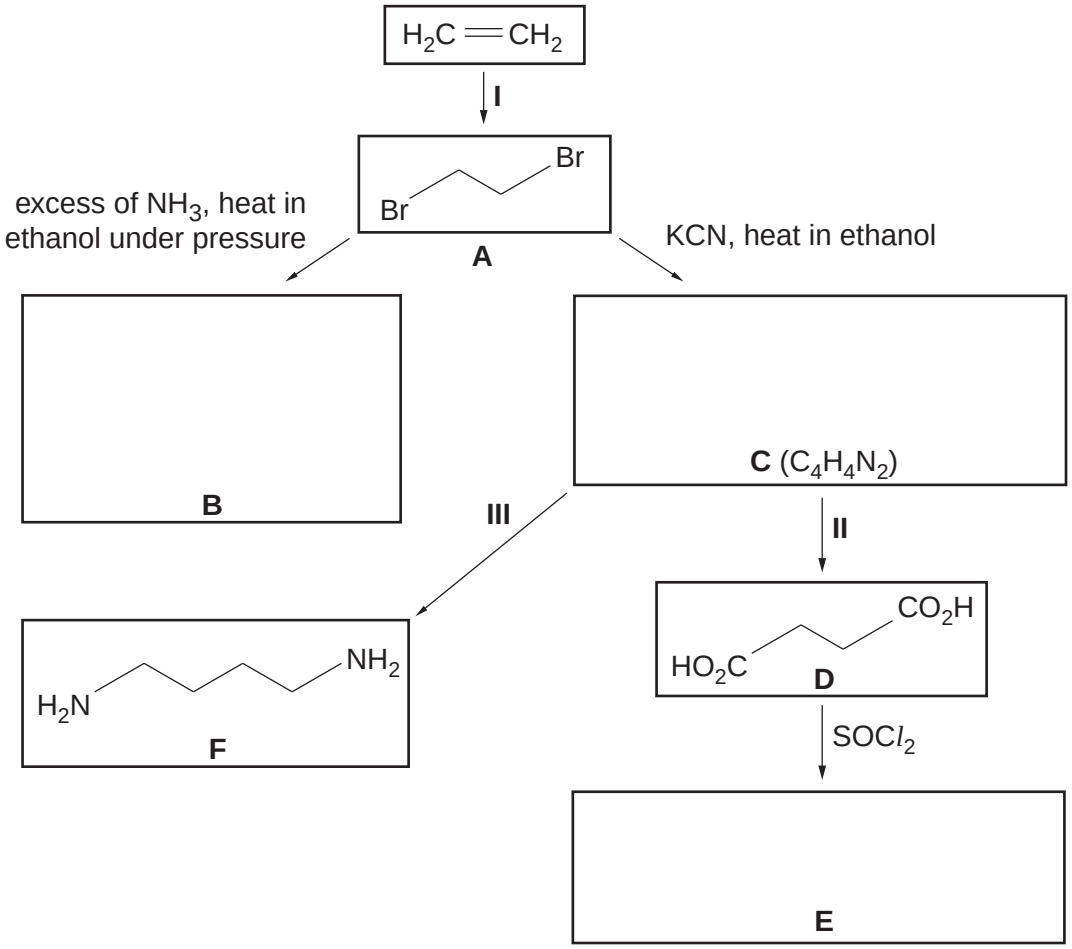
For Examiner's Use

mass of $NaClO_3$ = ... 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]

For Examiner's Use

(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 mol dm^{-3} solution of compound **D** has a pH of 2.60.

(i) Calculate the $[H^+]$ 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**, $NH_2CH_2CH_2CH_2NH_2$, is titrated with HC*l*(aq), two successive acid-base reactions take place.

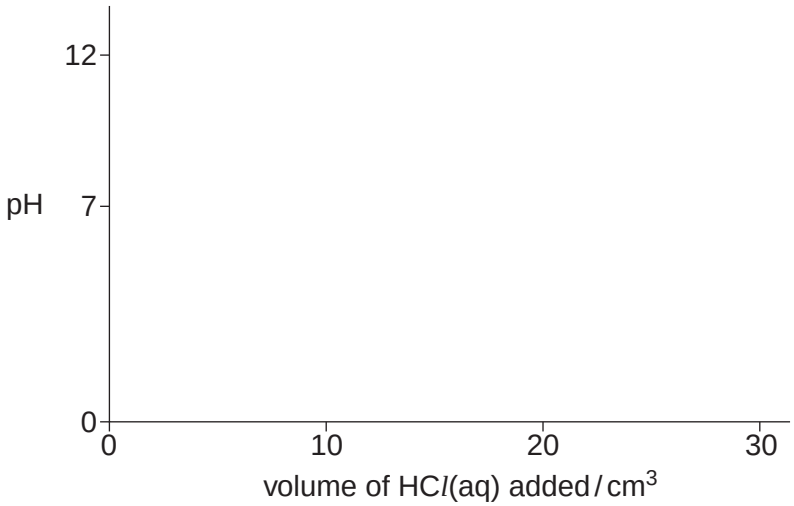
For Examiner's Use

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

.....

..... [2]

(b) A 0.10 mol dm^{-3} solution of **G** has a pH of 11.3. When 30 cm^3 of 0.10 mol dm^{-3} HC*l* is added to 10 cm^3 of a 0.10 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 HC*l*(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

For Examiner's Use

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

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

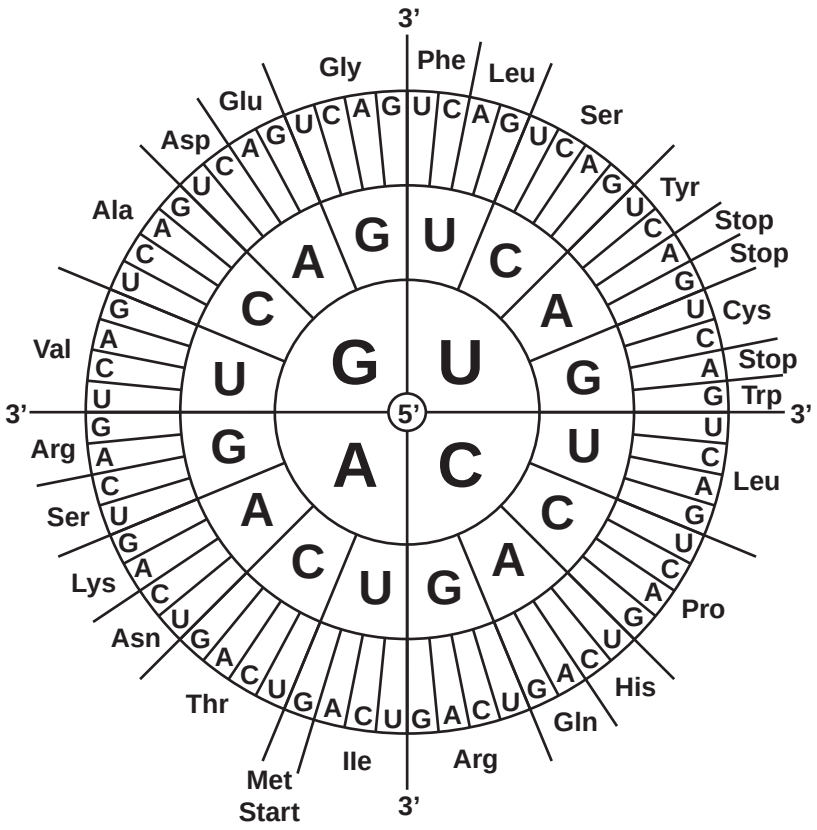
mRNA

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.

For Examiner's Use



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 11th 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.

For Examiner's Use

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

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

partition .....

.....

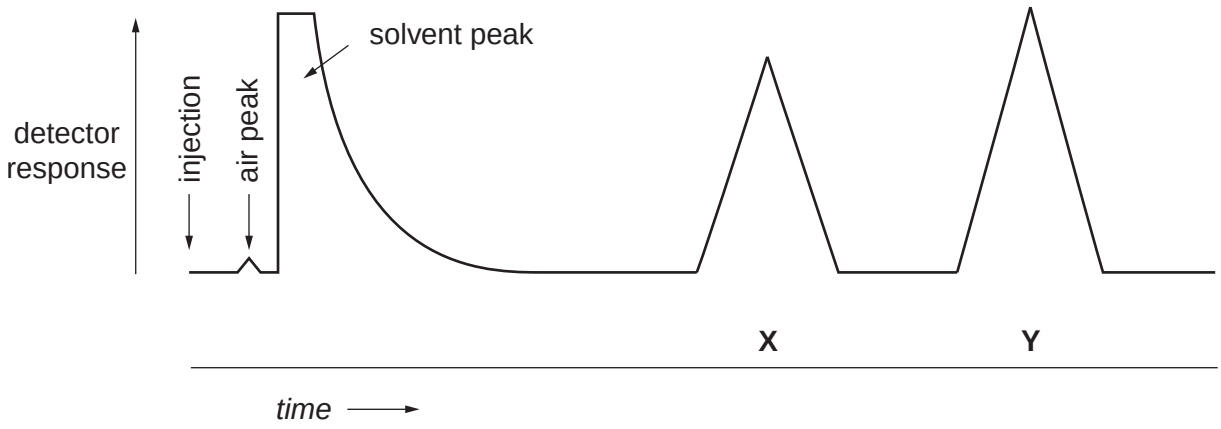
adsorption .....

.....

(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.

.....

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.....

.....

[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 Examiner's 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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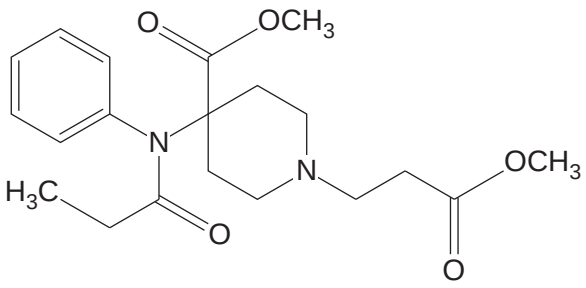
.....

.....

.....[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.

For Examiner's Use

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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