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Class	Student Number	Name

CAMBRIDGE A LEVEL PROGRAMME
A2 TRIAL EXAMINATION MARCH / APRIL 2012
(January & March 2011 Intakes)

Wednesday **28 March 2012** **8.30 am – 10.30 am**

CHEMISTRY **9701/42**

PAPER 4 Structured Questions **2 hours**

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

READ THESE INSTRUCTIONS FIRST

Write your name, class and student number in the spaces at the top of this page.
Write in dark blue or black pen.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

You may lose marks if you do not show your workings 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	
6	
7	
8	
9	
10	
11	
Total	

This document consists of **22** printed pages

Section A

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

1. (a) Half a million tonnes of manganese (IV) oxide are used each year in dry cell batteries. The negative electrode of a dry cell is made of zinc, which gradually dissolves to form zinc ions as the cell supplies current. The positive electrode is a carbon rod, through which electrons are transferred to the manganese (IV) oxide in the following reaction :

$$MnO_2 + H_2O + e \rightarrow MnO(OH) + OH^-$$

(i) Calculate the oxidation number of manganese in the product , MnO(OH) , of this reaction.

Oxidation number of Mn : .....

(ii) Write an equation for the overall change that occurs in the whole dry cell as it supplies current.

.....

(iii)The e.m.f (voltage) of a dry cell is 1.5 V. By reference to the Data Booklet, calculate approximately the E^θ of the manganese half cell.

[3]

(b) Chlorine dioxide acts as a powerful oxidizing agent in acid solution :

$$ClO_2 + 4H^+ + 5e \rightleftharpoons Cl^- + 2H_2O \ , \ E^\theta = +1.50 \text{ V},$$

and disproportionates to a mixture of chlorate (III) and chlorate (V) ions in alkaline solution.

(i) Suggest an equation for the disproportionation of ClO_2 in alkaline solution.

.....

(ii) Draw a diagram of apparatus used to measure the redox potential, E^{θ} of $ClO_2(g)/Cl^-(aq)$ in the laboratory.

(iii) By using the Data Booklet, calculate the E^{θ}_{cell} and predict the reaction, if any, of chlorine dioxide in acid solution with aqueous iron (II) ions.

[6]
[Total : 9]

2. A buffer solution was made by adding 4.10 g of sodium ethanoate, CH_3COONa in 0.10 mol of ethanoic acid, CH_3COOH and making up the solution to 1 dm^3.
(K_a of ethanoic acid = 1.70 x 10^{-5} mol dm^{-3})

(a) Explain the term 'buffer solution'

.....

.....

.....

[1]

(b) Write equations to show how the ethanoic acid / sodium ethanoate buffer system regulates the pH on the addition of

(i) H^+ ions : .....

(ii) OH^- ions :.....

[2]

(c) Calculate the pH of the buffer solution formed.

[2]

(d) Calculate the new pH (assume no change in volume) if 1.00 cm^3 of 1.00 mol dm^{-3} HCl is added to 1.00 dm^3 of the buffer solution.

[2]
[Total : 7]

3. (a) What do you understand by the term *order of reaction*?

.....

.....

.....

[1]

(b) Cyanohydrins can be converted easily to useful organic acids. To form cyanohydrins, ketones are reacted with an acidified solution of sodium cyanide.

$$(CH_3CH_2)_2C{=}O + H^+ + CN^- \rightarrow (CH_3CH_2)_2C(OH)CN$$

The reaction was carried out with different concentrations of the 3 reagents, and the following results were obtained :

Experiment number	$[(CH_3CH_2)_2C{=}O]$ /mold m^{-3}	$[H^+]$ /mol dm^{-3}	$[CN^-]$ /mol dm^{-3}	Relative initial rate /mol dm^{-3} s^{-1}
1	0.040	0.060	0.060	2.000
2	0.040	0.040	0.050	1.666
3	0.040	0.050	a	4.000
4	0.050	0.080	0.050	2.084

A chemist determined that the order of reaction is zero with respect to hydrogen ions.

(i) Deduce the order of reaction with respect to ,

Pentan-3-one , $(CH_3CH_2)_2C{=}O$:

Cyanide ions :

(ii) Deduce the magnitude of **a**.

(iii) Hence write a rate equation for the reaction.

.....

(iv) State the quantitative effect on the rate of reaction when concentration of Pentan-3-one and cyanide ions are doubled simultaneously.

.....

[5]
[Total : 6]

4. A solution **A** is saturated with both calcium hydroxide and calcium sulphate. Both are only sparingly soluble.

(a) The pH of solution **A** is 12.3. Calculate the hydroxide ion concentration in mol dm^{-3}.

[1]

(b) (i) Write an expression for the solubility product, K_{sp}, of calcium hydroxide.

.....

(ii) The numerical value of the solubility product of calcium hydroxide is 4.0×10^{-6}. Calculate the concentration, in mol dm^{-3}, of calcium ions in solution A.

[2]

(c) (i) Write an expression for the solubility product, K_{sp}, of calcium sulphate.

.....

(ii) The numerical value of the solubility product of calcium sulphate is 2.5×10^{-5}. What is the molar concentration of sulphate ions in solution A?

(iii) The concentration of sulphate ions in solution A is less than 5.0×10^{-3} mol dm^{-3}, i.e the square root of the K_{sp} value of calcium sulphate. Explain why this is so.

.....

.....

[3]
[Total : 6]

5. The following questions are about copper, which is an element in the first transition series.

(a) Explain what is meant by the term *transition element*.

.....

.....

.....

[2]

(b) Describe **two** physical properties of transition metals in which they differ from a typical s- block metal such as calcium.

.....

.....

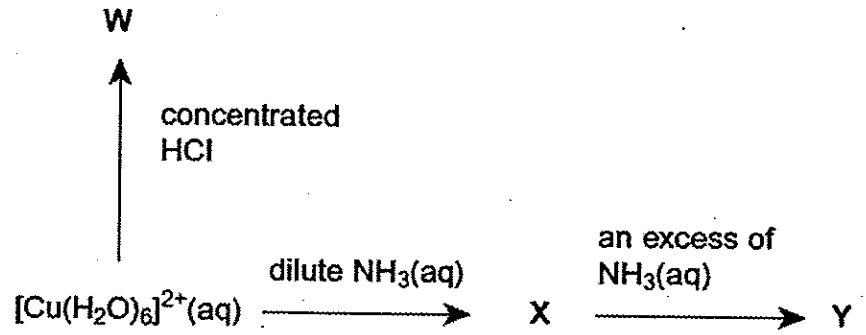
.....

[2]

(c) Give the electronic configuration of the copper(II) ion.

.....[1]

(d) The scheme below shows some reactions of copper(II) ions in aqueous solution. W, X and Y are all copper-containing species.



(i) Identify ion **W**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}$ (aq) ions.

Ion **W**: .....

Observation: .....

Equation: .....

(ii) Identify compound **X** and ion **Y**. Describe their appearances and explain their formation with the aid of equations.

Compound **X**:..... Ion **Y**: .....

Observation: Compound **X**:.....

Ion **Y**: .....

Explanation:.....

.....

.....

[9]

(e) Explain why copper(I) complex is not coloured.

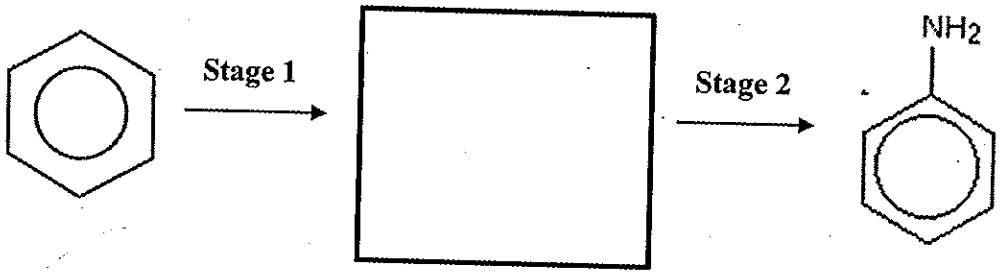
.....

.....

.....

[2]
[Total:16]

6. Phenylamine is used in the large-scale production of a variety of dyes, pesticides and pharmaceuticals.
It can be manufactured from benzene in two stages shown below.



(a) State the reagents **and** conditions needed in **Stage 1**.

.....[2]

(b) Draw the structure of the compound formed in **Stage 1**. [1]

(c) Name the mechanism involved in **Stage 1**.

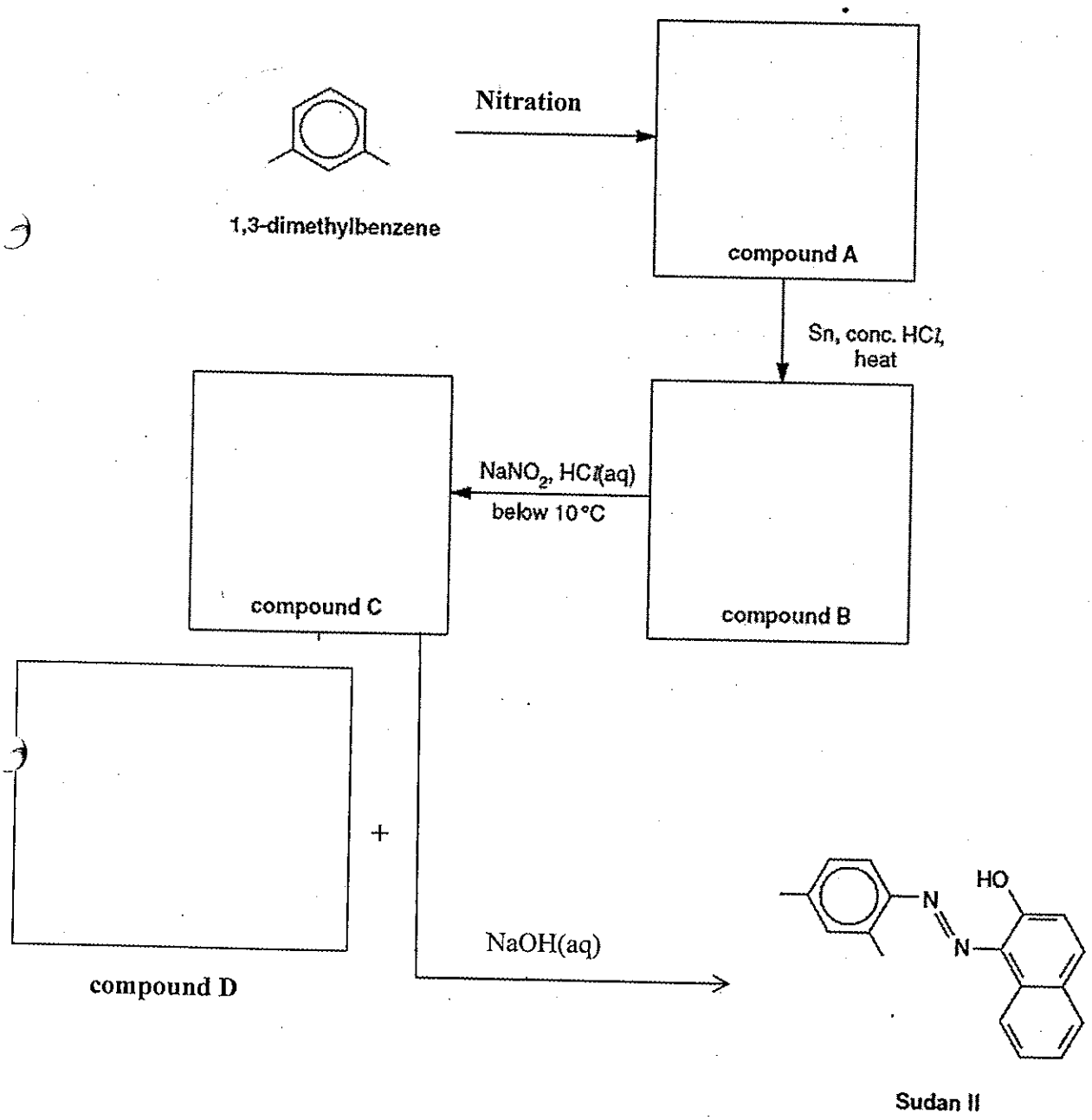
.....[1]

(d) With aid of curly arrows, write out the mechanism involved in **Stage 1**.

[3]

(e) Sudan II is an azo dye which was used as a colourant in chilli powder. However, scientists advised the Food Standard Agency that Sudan II was linked to an increased risk in cancer and it is now no longer used as food colourant.

The flowchart below shows how Sudan II can be prepared in laboratory from 1.3-dimetylbenzene. Draw the structures of compounds **A**, **B**, **C** and **D** in the boxes below. Display the functional group in compound **C**.



[4]

(f) Circle the part of the molecule in **Sudan II** that identifies it as azo dye. [1]

[Total:12]

7. (a) (i) Describe the appearance of the organic product obtained when an aqueous solution of bromine is added to aqueous phenol.

.....

(ii) Give the equation for the reaction in **(a)(i)**.

(iii) Phenol reacts with ethanoyl chloride. Draw the structural formula of the product in this reaction.

(iv) Name the functional group of the product in **(iii)**.

.....

[5]

(b) Two chlorine-containing compounds below **B** and **C** can be made from ethanoic acid **A**.

CH_3COOH	$CH_2ClCOOH$	CH_3COCl
A	**B**	**C**

When compounds **A**, **B** and **C** (not necessarily in that order) are added to separate portions of water, solutions are formed with pH values of 0.5, 2.5 and 3.0.

(i) Fill in the boxes provided above with the correct pH value associated with each of **A**, **B** and **C**.

(ii) Write a balanced equation when compound **C** is dissolved in water.

.....

(iii) Explain the pH difference between compounds **A** and **B**.

.....

.....

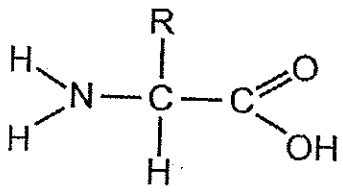
[4]

(c) Some of the amino acids found in human sweat are shown in the table below.

Amino acid	R group
glycine	H
alanine	CH_3
lysine	$(CH_2)_4NH_2$
glutamic acid	$(CH_2)_2COOH$

Table 1

The general formula of an amino acid is as below:



(i) Amino acids form different ions at different pH values. Zwitterions are formed when the pH is equal to the isoelectric point of the amino acid.

The isoelectric points of three amino acids are given below :

alanine, pH = 6.0 **glutamic acid, pH = 3.2** **lysine, pH = 9.7**

Draw the structures of the ions formed by these amino acids at the pH values below. Refer to **Table 1** on page 13.

alanine at pH = 6.0	**glutamic acid at pH = 10**	**lysine at pH = 2.0**

[3]

(ii) Draw a displayed structure of a dipeptide formed from an alanine molecule and a glycine molecule. Refer to **Table 1** on page 13.

[2]

[Total:14]

Section B – Application of Chemistry
Answer **all** questions in the spaces provided.

8. A fragment of protein is coded for by the m – RNA sequence.

-CGGUUUAGGGUA-

(a) How do you know that this is an RNA sequence and not DNA?

..... [1]

(b) Deduce the amino acid sequence in the protein coded for this stretch of m-RNA. Use the genetic code provided in **Table 2.**

First base in triplet	Second base in triplet				Third base in triplet
	G	U	C	A	
U	Phe Phe Leu Leu	Ser Ser Ser Ser	Tyr Tyr Stop Stop	Cys Cys Stop Trp	U C A G
C	Leu Leu Leu Leu	Pro Pro Pro Pro	His His Gln Gln	Arg Arg Arg Arg	U C A G
A	Ile Ile Ile Met	Thr Thr Thr Thr	Asn Asn Lys Lys	Ser Ser Arg Arg	U C A G
G	Val Val Val Val	Ala Ala Ala Ala	Asp Asp Glu Glu	Gly Gly Gly Gly	U C A G

Table 2

.....

.....

[1]

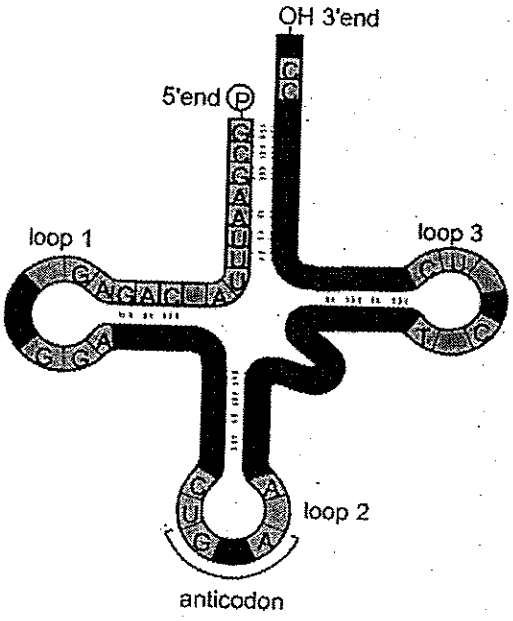
(c) Write the sequence of the part of the DNA strand from which this stretch of m- RNA is obtained by transcription.

.....[1]

(d) Write the sequence of the DNA strand complementary to the one you wrote in part (c).

.....[1]

(e) The diagram shows a t-RNA molecule with the triplet of bases (anticodon) that will bind to m-RNA.



(i) Name the base represented by the letter **G**.

.....

(ii) Write down the sequence of the base triplet on m-RNA to which this t-RNA molecule will bind.

.....

(iii) How are the two base triplets attracted to each other?

.....

(iv) Why are there many different t-RNA molecules in cells?

.....

.....

[4]

(f) Explain what is meant by the statement that DNA is a condensation polymer of nucleotides.

.....

.....

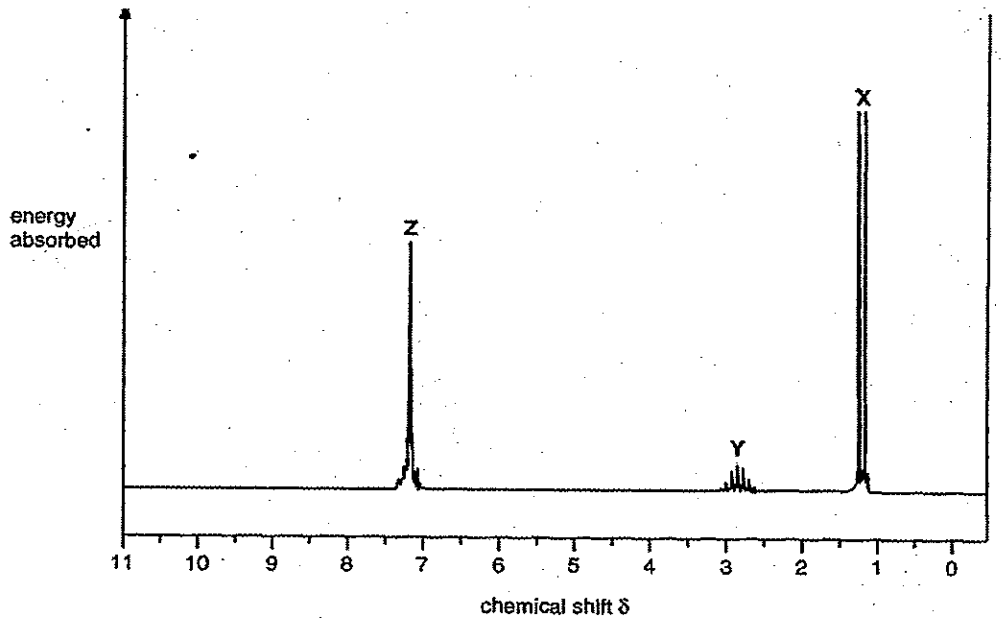
.....

.....

[1]

[Total:9]

9. The NMR spectrum of $C_6H_5CH(CH_3)_2$ is shown below.



(a) Suggest the identity of the protons responsible for the groups of peaks X,Y and Z.

.....

.....

.....

.....

[3]

(b) Explain why peak X is split into a doublet?

.....

.....

.....

[1]

(c) Suggest a reason why peak Y is split into many lines.

.....

.....

.....

[1]

[Total:5]

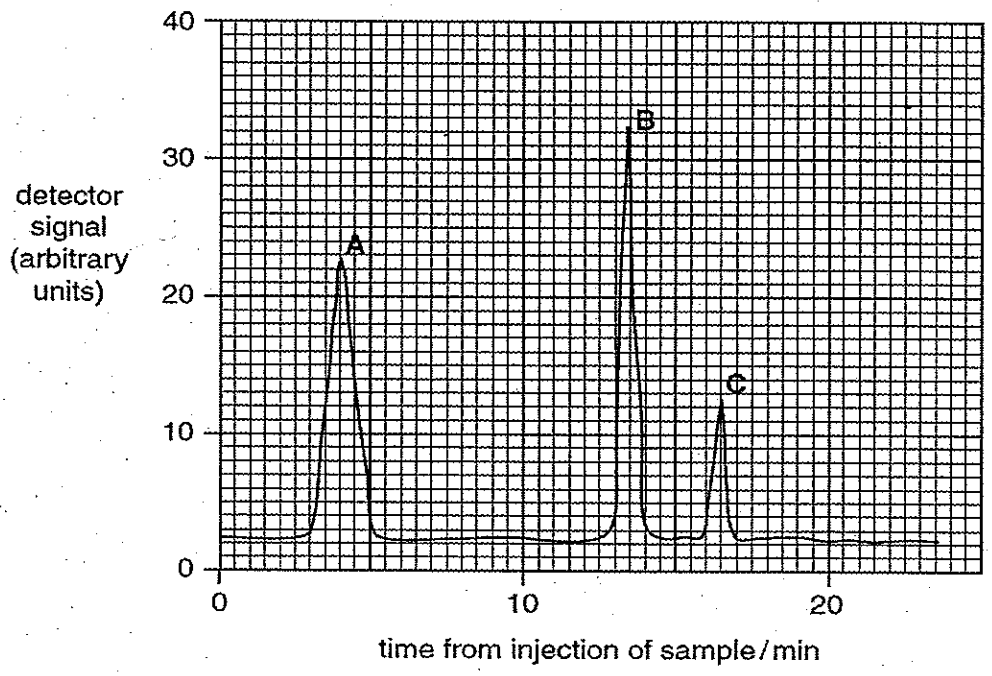
10. Chromatography is the separation of the components of a mixture. There are several different types of chromatography but there is always a mobile phase and a stationary phase. The components in the mixture are separated either by adsorption or by partition.

(a) Complete the table below.

	Paper Chromatography	Thin – Layer Chromatography	Gas/ Liquid Chromatography
Mobile Phase		Solvent	
Stationary Phase			A non volatile solvent on a solid support
Method of separation	Partition		

[6]

(b) The diagram below shows a gas/liquid chromatogram obtained from a mixture containing three components **A, B & C.**



(i) Which component is the most volatile? Explain your reasoning.

.....

.....

.....

[2]

(ii) Calculate the percentage abundance of component **B** in the mixture.

.....

.....

.....

.....

.....

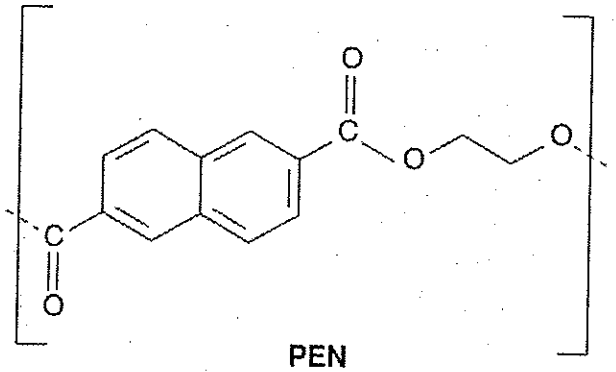
[2]
[Total:10]

11. A student was researching the development of polymers and discovered three polyesters PET, PEN and PGA, that are used in the manufacture of plastic bottles. The student discovered that the first polyester developed was Terylene, which is also called PET. PET can be made by reacting benzene-1,4 dicarboxylic acid with ethane-1,2 diol.

(a) Draw the **displayed** formula of **one** repeat unit in PET.

[1]

(b) PEN is a new kind of polyester. PEN is rigid at high temperature whereas PET readily softens.
The repeat unit of PEN is shown below.



PEN

(i) What is the empirical formula of the repeat unit in PEN?

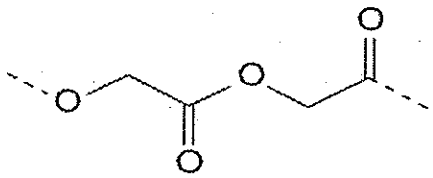
.....

(ii) Draw the structures of two monomers that could be used to make PEN.

[3]

(c) Polyglycolic acid, PGA, is a polymer that is being developed as an inner coating for PET bottles.

A short section of PGA is shown below.



PGA

(i) Compared with other synthetic polymers, PGA can be easily hydrolysed.
Draw the **skeletal** formula of the organic product formed from the complete hydrolysis of PGA by NaOH(aq).

(ii) Explain why scientists now think that polymers such as PGA are better for the environment than hydrocarbon-based polymers.

.....

.....

[2]
[Total:6]