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Principal: Mrs O. Tomlinson

OCR CHEMISTRY A

UNIT 4 REVISION PACK

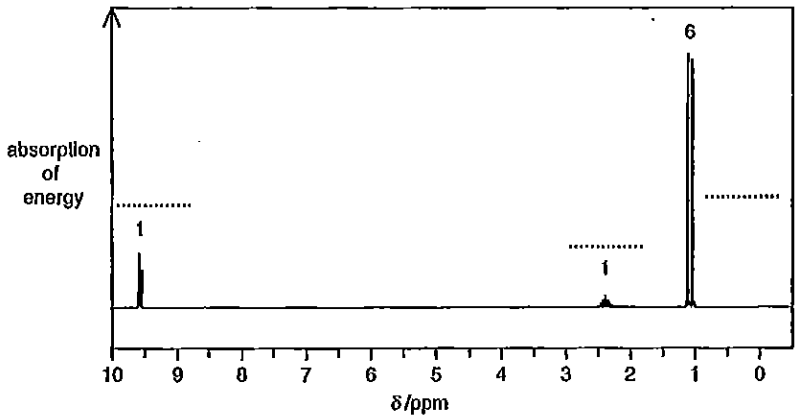
SELECTED QUESTIONS FROM 2008 - 2010

Bahati njema!

A mark scheme can be found on

www.a-levelchemistry.co.uk

(e) The n.m.r. spectrum of one of the carbonyl compounds in the table is shown below.



(i) What do the relative peak areas on the spectrum represent?

.....

.....[1]

(ii) The peaks at $\delta = 1.0$ and 9.5 ppm are both doublets.
What does this information tell you about the structure?

.....

.....

.....[1]

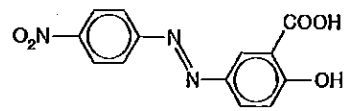
(iii) Draw the displayed formula of the compound.

[1]

(iv) Label the spectrum to show which atoms on your structure are responsible for each peak on the spectrum. [2]

[Total: 11]

2 Mordant Orange 1 is an azo-dye with the structure shown below.



Mordant Orange 1

(a) Draw a circle around the azo group that identifies this molecule as an azo-dye. [1]

(b) Describe how Mordant Orange 1 can be made starting from 4-nitrophenylamine and another suitable organic reagent.

Include in your answer:

- the structure of 4-nitrophenylamine, the intermediate diazonium ion and the other organic reagent;
- essential reagents and conditions for each stage.

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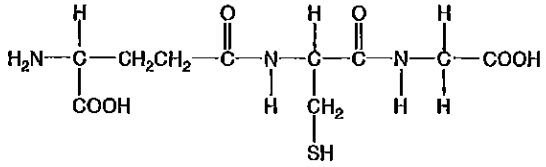
.....[6]

(c) Glutathione is a naturally occurring molecule made from glutamic acid and two other amino acids. The structure of glutathione is shown below.



glutathione

(i) Show the structures of the other two amino acids used to make glutathione.

[2]

(ii) State the type of reaction that takes place when glutathione is made from its three constituent amino acids.

.....[1]

(iii) Glutathione can be hydrolysed by enzymes. Describe one other way that this reaction can be carried out in the laboratory.

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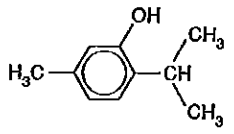
.....[1]

[Total: 9]

[Turn over

4 Thymol is a phenol that is used in mouthwashes.



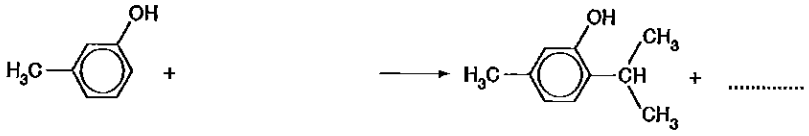
thymol

(a) Suggest why phenols are often used in mouthwashes.

.....[1]

(b) Thymol can be manufactured from 3-methylphenol by a Friedel–Crafts reaction.

(i) Complete the equation for this reaction below.



[2]

(ii) State a suitable catalyst for this reaction.

.....[1]

(c) In a typical mouthwash, the concentration of thymol is 3.0×10^{-3} mol dm^{-3}.

Calculate the mass of thymol that would be contained in a bottle containing 400 cm^3 of mouthwash. Show all your working clearly.

mass of thymol = ...g [3]

(c) Ropes can also be made from polymers such as Terylene.

Terylene is made from benzene-1,4-dicarboxylic acid and ethane-1,2-diol.

(I) Draw the structures of the two monomers used to make Terylene.

[2]

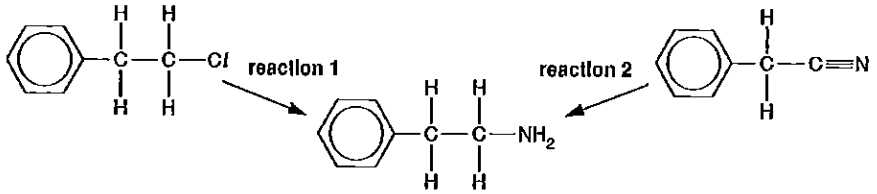
(II) Draw the structure of a section of Terylene, showing one repeat unit.

[2]

[Total: 9]

6 2-Phenylethylamine, $C_6H_5CH_2CH_2NH_2$, is a compound that is found in chocolate.

(a) 2-Phenylethylamine can be synthesised by the two reactions shown below.



2-phenylethylamine

(I) State the reagent for **reaction 1**.

.....[1]

(II) What type of reaction is **reaction 1**?

.....[1]

(III) State the reagent for **reaction 2**.

.....[1]

(IV) What type of reaction is **reaction 2**?

.....[1]

(b) 2-Phenylethylamine can be converted into $C_8H_5CH_2CH_2NHCOCH_3$ by reaction with a suitable reagent.

Write a balanced equation for the reaction.

[2]

8 There are many isomers with the molecular formula $C_6H_{12}O_2$.

(a) Ester **C**, $CH_3CH_2CH_2COOC_2H_5$, is used in the manufacture of a variety of foods and drinks. When heated, ester **C** can be hydrolysed by aqueous hydrochloric acid or aqueous sodium hydroxide.

(i) State the name of this ester.

.....[1]

(ii) Write a balanced equation for the hydrolysis of ester **C** with aqueous hydrochloric acid.

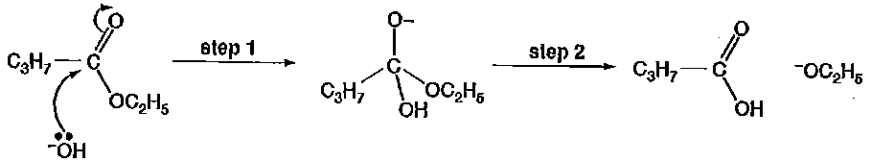
.....[1]

(iii) The hydrolysis of ester **C** is carried out with aqueous sodium hydroxide.
Identify the products.

.....

.....[1]

(b) Part of the mechanism for the reaction of ester **C** with aqueous sodium hydroxide is shown below.



Intermediate 1

(i) Add curly arrows to **Intermediate 1** to show how the products of **step 2** are formed. [2]

(ii) State what the curly arrows represent.

.....

.....[1]

(iii) Why is the OH^- ion acting as a nucleophile?

.....

.....[1]

(c) The structural isomers **D**, **E** and **F** are all carboxylic acids with the molecular formula $C_6H_{12}O_2$.

Each structural isomer has one chiral carbon atom.

Draw the structural formulae of the structural isomers **D**, **E** and **F**.

[3]

TURN OVER FOR QUESTION 8(d) AND (e)

Answer all the questions.

1 An unknown aldehyde A, $C_5H_{10}O$, was analysed using different techniques.

(a) (i) Describe a chemical test that could be used to confirm that compound A is an aldehyde.

.....

.....

.....

.....[2]

(ii) Identify the functional group formed in this chemical test.

.....[1]

(b) Describe a chemical method that could be used to confirm the presence of the carbonyl group in compound A.

Explain how you would use the product of this test to identify compound A.

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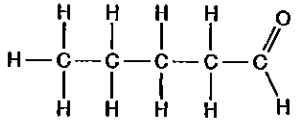
.....[3]

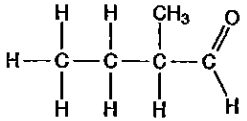
(c) In a mass spectrum of compound A, determine the *m/e* value of the molecular ion peak.

.....[1]

(d) There are the four possible structural isomers for the aldehyde A, $C_5H_{10}O$. Two structures are shown below.



Isomer 1



Isomer 2

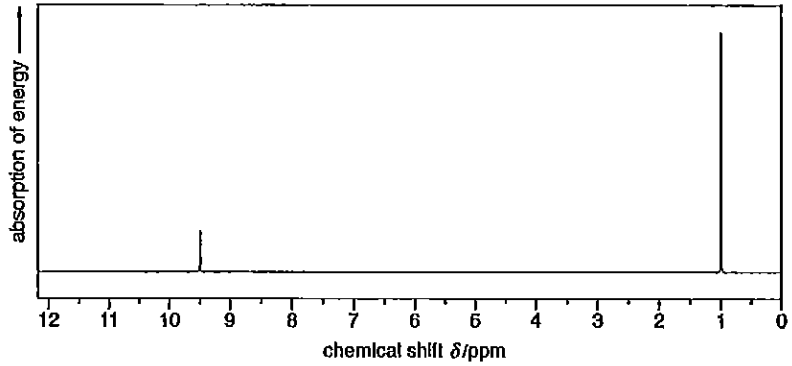
(i) Draw the skeletal formula for structural isomer 2.

[1]

(ii) Draw the two other possible structural isomers of the aldehyde A, $C_5H_{10}O$.

[2]

(e) The n.m.r. spectrum of aldehyde A is shown below.



Identify aldehyde A. Explain your reasoning.

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.....[2]

[Total: 12]

[Turn over

3 Alanine, $CH_3CH(NH_2)COOH$, and valine, $(CH_3)_2CH(NH_2)CHCOOH$, are both α-amino acids that occur naturally.

(a) Draw the zwitterion structure of alanine.

[1]

(b) Draw the structures of two different dipeptides that could be formed from the reaction of one molecule of alanine with one molecule of valine.

[3]

(c) Aqueous sodium hydroxide was added to valine.

Draw the structure of the ion formed.

[1]

(d) Hydrochloric acid was added to alanine. The resulting solution was concentrated and crystals of a compound **B** were separated.
Draw the displayed formula of compound **B**.

[2]

(e) Phosphorus pentachloride, PCl_5 was added to alanine forming an acyl chloride.
The acyl chloride was then reacted separately with methanol and with ammonia.

Draw the structure of the acyl chloride and the organic compounds formed from the acyl chloride.

acyl chloride	product with methanol	product with ammonia

[3]

(f) Compounds **C** and **D** are also α-amino acids.
Compound **C** has the molecular formula $C_4H_9NO_3$.
Compound **D** has the molecular formula $C_6H_{14}N_2O_2$.

Suggest structures for amino acids **C** and **D**.

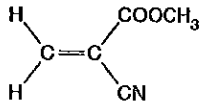
C	D

[2]

[Total: 12]

[Turn over

5 Compound **E** is used by forensic scientists to investigate fingerprints.



compound **E**

(a) Compound **E** forms a polymer when its vapour comes into contact with the fingerprint.

Draw a short section of this polymer showing **two** repeat units.

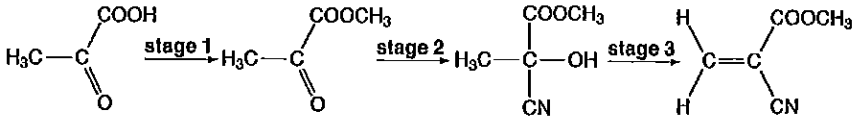
[1]

(b) Compound **E** reacts with hot aqueous hydrochloric acid to form an unsaturated organic compound.

Suggest the structure of this compound.

[2]

(c) Compound **E** can be manufactured from 2-oxopropanoic acid in three stages as shown below.



2-oxopropanoic acid

(i) Identify the reagents and conditions required for **stage 1**.

.....

.....[2]

(ii) Identify the reagents required for **stage 2**.

.....[1]

(iii) State the name of the mechanism for **stage 2**.

.....[1]

(iv) Deduce the other product formed in **stage 3**.

.....[1]

(d) A typical yield of compound **E** from 2-oxopropanoic acid is 30%.

Calculate the mass of compound **E** you would expect to produce from 10 kg of 2-oxopropanoic acid. Give your answer to two significant figures.

Show your working.

mass of compound **E** = ... kg [4]

[Total: 12]

7 In this question, one mark is available for the quality of spelling, punctuation and grammar.

(a) Cyclohexene reacts with bromine at room temperature. Benzene reacts with bromine only in the presence of a halogen carrier. Phenol rapidly decolourises bromine at room temperature.

Explain the different reactivities of bromine with cyclohexene, with benzene and with phenol. In your answer, include balanced equations and state the reaction type in each case.

.....[11]

Quality of Written Communication [1]

(b) Compound K is an aromatic hydrocarbon with the molecular formula C_8H_{10}.
When compound K reacts with bromine in the presence of a halogen carrier, only one organic product, L, is formed.

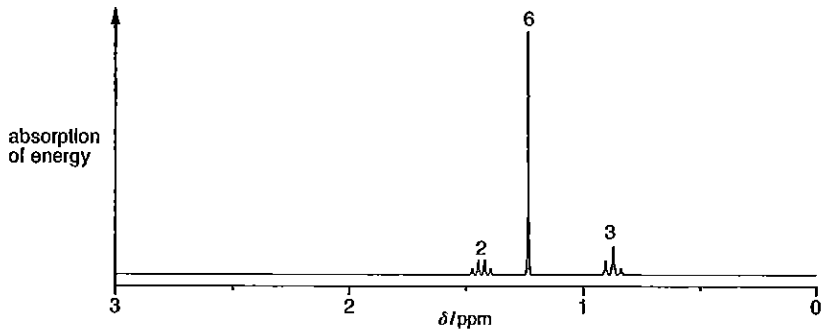
Identify compounds K and L by drawing their structures below.

[2]

[Total: 14]

END OF QUESTION PAPER

(c) The section of the n.m.r. spectrum, in D_2O, of another alcohol with the molecular formula $C_5H_{12}O$ is shown below.



(I) Complete the table below to help you identify the protons responsible for each peak.

δ/ ppm	relative peak area	splitting pattern	number of H on the adjacent C	type of proton
0.9	3	triplet		$R-CH_3$
1.2	6			
1.4	2			

[3]

(II) Deduce the structure of this alcohol.

[1]

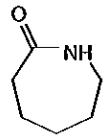
(III) Explain how the n.m.r. spectrum would differ from the one above if it was re-run **without** D_2O.

.....

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

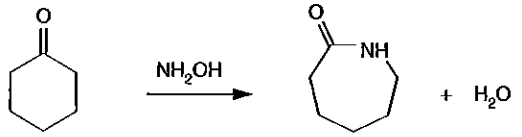
[Total: 11]

2 Caprolactam is a cyclic amide used in the manufacture of one type of nylon. Over 4 million tonnes of caprolactam are produced annually worldwide.



caprolactam

(a) Caprolactam can be synthesised from cyclohexanone using NH_2OH.



cyclohexanone **caprolactam**

(I) Describe a simple chemical test to show that cyclohexanone contains a carbonyl group.

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..... **[1]**

(II) Describe a simple chemical test to show that cyclohexanone is **not** an aldehyde.

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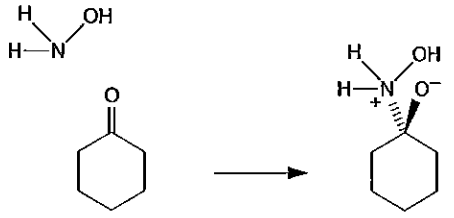
..... **[2]**

(III) The reaction of NH_2OH with cyclohexanone begins with a nucleophilic addition mechanism. Complete the first part of this mechanism by adding relevant dipoles, lone pairs and curly arrows to the reactants. **[3]**



cyclohexanone **Intermediate**

(iii) Oleocanthal reacts with hot aqueous sodium hydroxide.

Draw structures to show the two organic products formed in this reaction.

[3]

(c) The structure of oleocanthal, $C_{17}H_{20}O_5$, was determined using spectroscopy.

(i) Deduce the *m/e* value of the molecular ion peak in the mass spectrum of oleocanthal.

.....[1]

(ii) Identify the wavenumber ranges of **three** absorptions you would expect to see on the infrared spectrum of oleocanthal. For each range, state the bond responsible.

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.....[3]

(d) Oleocanthal has shown pharmacological activity as an anti-inflammatory drug. Chemists have attempted to synthesise oleocanthal in the laboratory.

The product from this synthesis had a lower pharmacological activity than oleocanthal extracted from olive oil. Suggest why.

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.....[2]

[Total: 15]

4 Organic bases are used widely in the manufacture of drugs and other chemicals.

(a) Ethylamine, $CH_3CH_2NH_2$, can be made from ethanenitrile, $CH_3C{\equiv}N$.

(i) Name a suitable reagent you could use to carry out this reaction in the laboratory.

.....

.....[1]

(ii) State the type of reaction occurring.

.....[1]

(b) Organic bases such as ethylamine can be neutralised by acids to form salts.

Give the formula of the salt formed when ethylamine is neutralised by:

(i) dilute hydrochloric acid,

[1]

(ii) dilute ethanoic acid.

[1]

(c) In this question, one mark is available for the quality and use of technical terms.

Explain the relative basicities of ethylamine and phenylamine.

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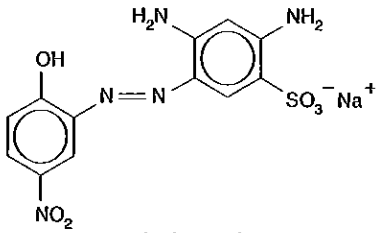
.....[4]

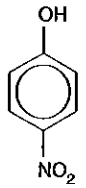
Quality of Written Communication [1]

(b) The structure of a dye called solochrome brown is shown below.



solochrome brown

Outline how this compound can be made in two stages from a suitable amine and the phenol shown below.



In your answer:

- draw the structure of the amine;
- the product formed after the first stage;
- identify the essential reagents and conditions for each stage.

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..... **[5]**

[Total: 11]

7 **(a)** In this question, one mark is available for the quality of spelling, punctuation and grammar.

Benzene and cyclohexene have different reactions with bromine.

Describe and explain the relative reactivity of bromine with cyclohexene and with benzene.

Include the type of reaction occurring and an equation for each reaction in your answer.

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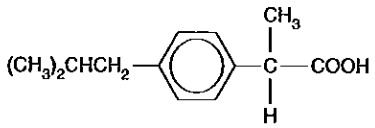
..... **[8]**

Quality of Written Communication **[1]**

Answer **all** the questions.

1 Ibuprofen is a highly successful anti-inflammatory drug. The structure of ibuprofen is shown below.



(a) Ibuprofen is sometimes sold as the sodium salt of the compound shown above.

(i) State a reagent that would convert the structure above into the sodium salt.

..... [1]

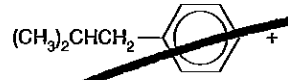
(ii) Draw the structure of the sodium salt of ibuprofen.

[1]

(b) Ibuprofen is synthesised by the drug company from smaller molecules.

Starting from the molecule shown below, complete the equation to show how you could synthesise ibuprofen in one step by a Friedel–Crafts reaction.

Identify any essential reagents and conditions.



..... [3]

(c) In this question, one mark is available for the quality of spelling, punctuation and grammar.

Ibuprofen is a chiral drug that is usually produced as a mixture of stereoisomers.

- Using ibuprofen as an example, explain what is meant by the term *chiral*;
- Discuss the possible disadvantages of producing a chiral drug as a mixture of stereoisomers.

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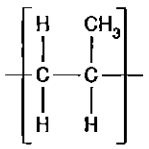
..... [6]

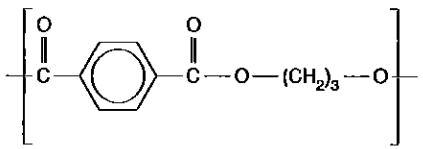
Quality of Written Communication [1]

[Total: 12]

3 Poly(propene) and PTT are two polymers used in the manufacture of carpets. The repeat units of these two polymers are shown below.



poly(propene)



PTT

(a) Draw each repeat unit as a skeletal formula.

[2]

(b) State and explain the type of polymerisation used to make poly(propene) and PTT from their monomers.

poly(propene) .....

.....

PTT .....

..... [2]

(c) Draw the structures of two monomers that could be combined to give PTT.

[2]

(d) The properties of poly(propene) fibres can be improved by blending strands of isotactic and syndiotactic forms of the polymer.

Draw 3-D diagrams to show the difference between isotactic and syndiotactic poly(propene).

[3]

(e) Forensic scientists can use infra-red spectroscopy to identify small amounts of carpet fibres left on the shoes of people at the scene of a crime.

Give the wavenumber ranges of **two** absorptions you could use to distinguish between the infra-red spectra of poly(propene) and PTT.

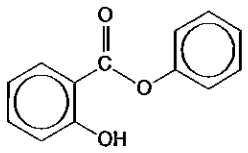
.....

.....

..... [2]

[Total: 11]

6 Phenyl 2-hydroxybenzoate is an ester used in the manufacture of cleaning products. It has also been used as an antiseptic in cosmetics.



phenyl 2-hydroxybenzoate

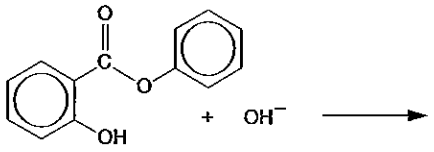
(a) Circle the part of the molecule responsible for the antiseptic properties of phenyl 2-hydroxybenzoate. **[1]**

(b) Phenyl 2-hydroxybenzoate can be made from 2-hydroxybenzoic acid and phenol by heating the two compounds strongly together.

Write an equation for this reaction.

[2]

(c) Complete and balance the equation for the alkaline hydrolysis of phenyl 2-hydroxybenzoate.



[3]

(d) Cleaning products based on phenol have occasionally caused bad tasting water. This is because phenol reacts readily with the chlorine used in water purification.

(i) State the type of reaction that occurs between phenol and chlorine.

.....**[1]**

(ii) Suggest the structure of the product that forms that causes bad tasting water.

[1]

(iii) Explain why chlorine reacts much more readily with phenol than it does with benzene.

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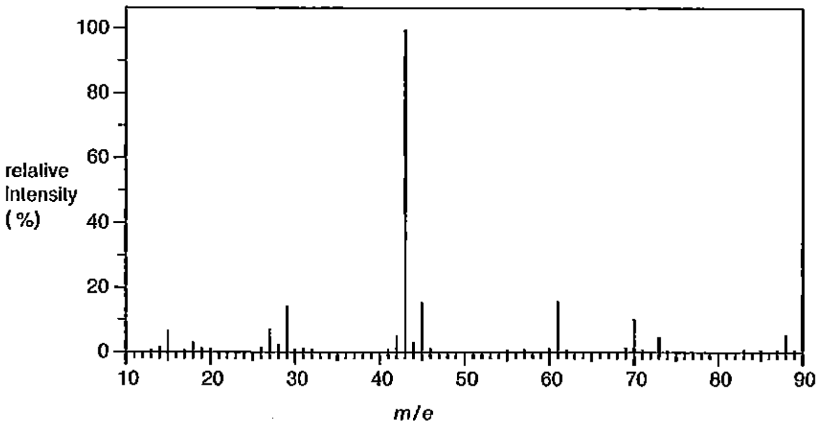
.....**[4]**

[Total: 12]

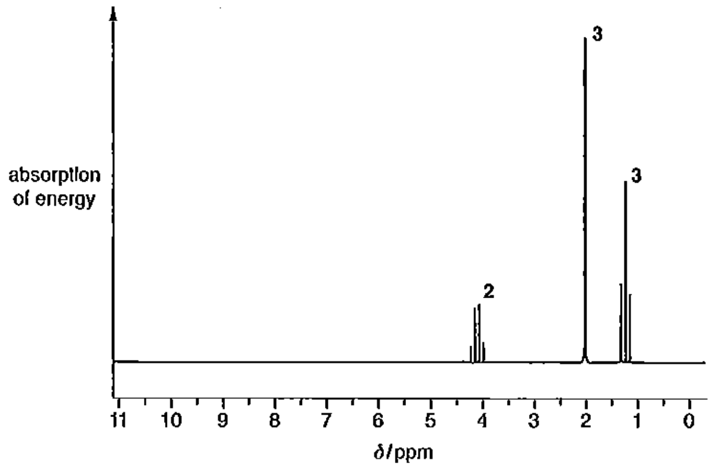
8 In this question, one mark is available for the quality of use and organisation of technical terms.

An unknown compound X containing 54.5% carbon, 9.1% hydrogen and 36.4% oxygen was analysed by different spectroscopic methods.

The mass spectrum of compound X is shown below.



The high resolution n.m.r. spectrum of compound X is shown below.



Use the information above to identify compound X by deducing:

- its molecular formula;
- its structural formula.

Show all your working and account for the chemical shifts and splitting of each peak on the n.m.r. spectrum.

.... [9]

Quality of Written Communication [1]

[Total: 10]

END OF QUESTION PAPER

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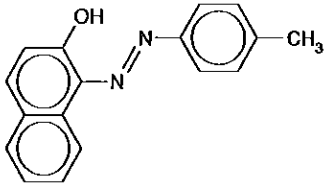
..... **[11]**

Quality of Written Communication **[1]**

(c) 4-Methylphenylamine can be converted into the azo dye, shown below, via a diazonium ion.



(i) Draw the structure of the diazonium ion.

[1]

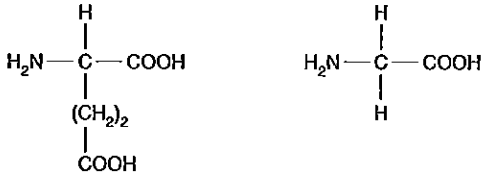
(ii) Deduce the number of carbon and the number of hydrogen atoms in the azo dye.

number of C atoms ..... number of H atoms ..... **[2]**

[Total: 16]

2 Glutamic acid and glycine are both α-amino acids that occur widely in living organisms.

The structures of the amino acids are shown below.



glutamic acid **glycine**

(a) State the general formula of an α-amino acid.

..... **[1]**

(b) Glutamic acid has optical isomers but glycine does not.

Explain why.

Include suitable 3-D diagrams in your answer.

.....

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[4]

(c) Amino acids form different ions at different pH values.

(i) Draw the structure of the ion formed by glycine at pH 2.

[1]

(II) Write a balanced equation for the oxidation of compound **X** to form $HOOC(CH_2)_4COOH$.

Use [O] to represent the oxidising agent.

..... [1]

(III) Explain how infra-red spectra of compound **X** and $HOOC(CH_2)_4COOH$ could be used to confirm that the oxidation had taken place.

.....

.....

..... [1]

(d) Poly(but-1-ene) can be made from the monomer but-1-ene, $CH_3CH_2CH=CH_2$.

Draw a section of poly(but-1-ene) to show **two** repeat units.

[1]

(e) Ecoflex® and poly(but-1-ene) are both polymers but the type of polymerisation reaction used to make each one is different.

State the type of polymerisation reaction used to make each polymer.

ecoflex®.....

poly(but-1-ene) ..... [1]

(f) Describe how the structure of atactic poly(but-1-ene) differs from isotactic poly(but-1-ene).

.....

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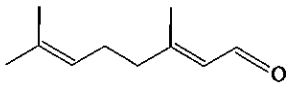
..... [2]

[Total: 12]

5 Neral, $C_{10}H_{16}O$, is a naturally occurring compound found in many plants. It has a sweet lemon smell and is used extensively in perfumery. The skeletal formula of neral is shown below.



(a) Name the two functional groups in neral.

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

(b) Neral has stereoisomers.

(I) What is meant by the term *stereoisomers*?

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..... [1]

(II) The stereoisomerism in neral is caused by one of the double bonds.

On the skeletal formula above, circle the double bond that gives rise to stereoisomerism.

Explain why this double bond causes stereoisomerism.

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..... [3]

(c) Neral is used in scented candles. When burnt it produces carbon dioxide and water vapour.

Write a balanced equation for the complete combustion of neral.

..... [1]

(i) Identify the type of protons responsible for peak **X**.

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..... [1]

(ii) Explain how D_2O can be used to help confirm which protons are responsible for peak **X**.

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..... [2]

(iii) Use peaks **Y** and **Z** to decide whether structure **E** or structure **F** is correct for Feist's acid.

Explain your reasoning and state how the n.m.r. spectrum for the other structure would differ.

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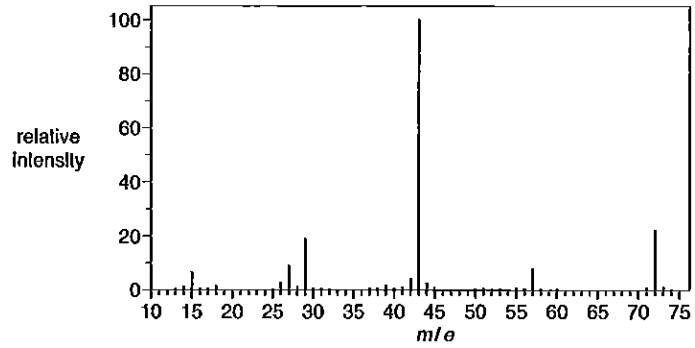
..... [3]

[Total: 10]

6 Compounds **A**, **B** and **C** all have the same relative molecular mass. The mass spectrum of compound **A** is shown below.



- Compound **A** reacts with 2,4-dinitrophenylhydrazine to give an orange precipitate but does **not** give a positive result with Tollens' reagent.
- Compound **B** is a saturated hydrocarbon and the n.m.r. of compound **B** contains just one peak.
- The infra-red spectrum of compound **C** contains a broad absorption between 2500–3300 cm^{-1} as well as an absorption between 1680–1750 cm^{-1}.

Identify compounds **A**, **B** and **C**.

Show all of your reasoning.

compound **A**	compound **B**	compound **C**

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..... **[10]**

Quality of Written Communication **[1]**

[Total: 11]

END OF QUESTION PAPER

THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

CHEMISTRY

Chains, Rings and Spectroscopy

2814/01

Candidates answer on the Question Paper
A calculator may be used for this paper

OCR Supplied Materials:
- *Data Sheet for Chemistry* (inserted)

Other Materials Required:
- Scientific calculator

Thursday 17 June 2010
Afternoon

Duration: 1 hour 30 minutes

* 2 8 1 4 0 1 *

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer all the questions.
- Do not write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- This document consists of **16** pages. Any blank pages are indicated.

Examiner's Use Only:			
1			
2			
3			
4			
5			
6			
Total			

OCR is an exempt Charity

2 Azo dyes can be made from amines and phenols.

(a) Describe how you could prepare a sample of an azo dye in the laboratory from phenylamine, phenol and any other reagents.

Include in your answer:

- essential reagents and conditions for each stage;
- the displayed formula of the organic products in each stage.

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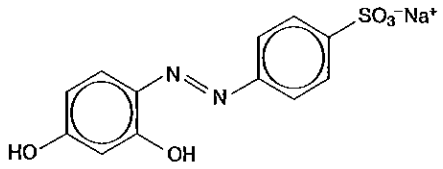
..... [6]

(b) Resorcinol Yellow, **E103**, is an azo dye which was used as a colouring agent in food.

The structure of **E103** is shown below.



E103

(I) On the structure above, draw a circle around the functional group that identifies **E103** as an azo dye. [1]

(II) How many carbon and hydrogen atoms are there in the structure of **E103** shown above?

carbon atoms, ...

hydrogen atoms. .....

[2]

(III) In the boxes below, draw the structures of a phenol and an amine that could have been used to make **E103** by the method described in **(a)**.

phenol	amine

[2]

(c) **E103** can also be used as an acid-base indicator. At high pH, **E103** turns red.

Suggest the structure of **E103** at high pH.

[1]

[Total: 11]

4 All α-amino acids have the general formula $H_2NCH(R)COOH$.

(a) The α-amino acid, ornithine, has the formula $H_2NCH(CH_2CH_2CH_2NH_2)COOH$.

(i) Identify the R group in ornithine.

..... [1]

(ii) Draw the skeletal formula of ornithine.

[2]

(b) Ornithine reacts with both acids and bases.

(i) Identify the organic product when ornithine reacts with **excess** $HCl(aq)$.

[2]

(ii) Identify the organic product when ornithine reacts with $NaOH(aq)$.

[1]

(c) In the laboratory ornithine can be converted into an acyl chloride.

An incomplete equation for this conversion is shown below.

$H_2NCH(CH_2CH_2CH_2NH_2)COOH$ + ... → $H_2NCH(CH_2CH_2CH_2NH_2)COCl$ + ... + ...

Complete the equation above.

[3]

(d) Ornithine, orn, and alanine, ala, can be reacted to form a mixture of dipeptides.

Analysis of the mixture revealed that four different dipeptides had been formed.

The four dipeptides are:

orn–orn
orn–ala
ala–orn
ala–ala.

- The formula of ornithine is $H_2NCH(CH_2CH_2CH_2NH_2)COOH$.
- The formula of alanine is $H_2NCH(CH_3)COOH$.

Draw the two dipeptides: orn–ala and ala–orn.

orn–ala

ala–orn

[3]

[Total: 12]

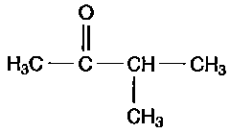
(c) Another unknown compound **C** is an aldehyde with the molecular formula $C_5H_{10}O$.

Show the four structural isomers of $C_5H_{10}O$ that are aldehydes.

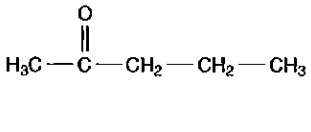
[4]

(d) In this question, one mark is available for the quality of spelling, punctuation and grammar.

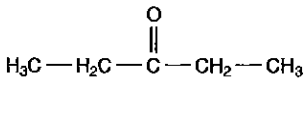
The three ketones **D**, **E** and **F** are structural isomers.



D



E



F

Explain how the three isomers **D**, **E** and **F** can be distinguished by their n.m.r. spectra.

For each isomer, describe:

- the number of peaks and their relative peak areas;
- the chemical shift of each peak;
- the splitting pattern of each peak.

[9]

Quality of Written Communication [1]

[Total: 22]

END OF QUESTION PAPER