Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1	
	2	
	3	
B	4	
	5	
TOTAL MARK		

334/01

CHEMISTRY CH4

P.M. MONDAY, 19 June 2006

(1 hour 40 minutes)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:
- a calculator;
- an 8 page answer book;
- a **Data Sheet** which contains a **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **both** questions in **Section B** in a separate answer book which should then be placed inside this question-and-answer book.

Candidates are advised to allocate their time appropriately, between **Section A (35 marks)** and **Section B (40 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 75.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication in all written answers.

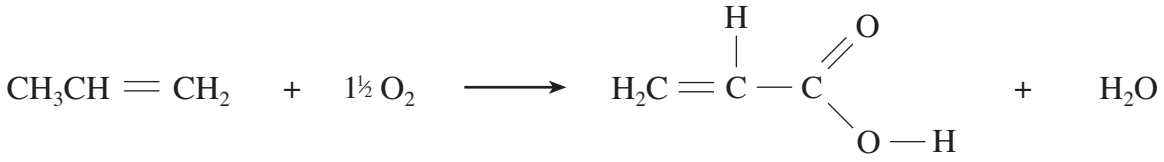
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Examiner only
Arholwr yn unig

SECTION A

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

1. *(a)* Propenoic acid (acrylic acid) is produced from propene by oxidation.



(i) Propene can be made by cracking dodecane, $C_{12}H_{26}$.
In this cracking reaction, propene and butene, C_4H_8 , are produced, together with compound **B**.

$$C_{12}H_{26} \longrightarrow C_3H_6 + C_4H_8 + \text{compound } \mathbf{B}$$

State the name of compound **B**. [1]

.....

(ii) The production of propenoic acid uses a **heterogeneous** catalyst.
State the meaning of the term **heterogeneous**. [1]

.....

.....

(iii) The yield of propenoic acid is 90%.
Calculate the mass of propenoic acid (M_r 72·0) produced in this way when $1{\cdot}5 \times 10^4$ moles of propene react with oxygen according to the above equation. [2]

.....

.....

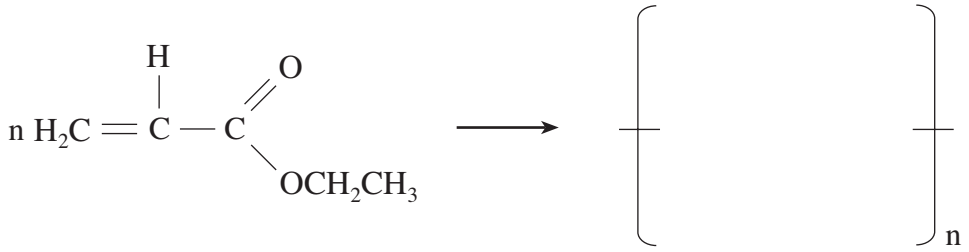
.....

(b) Propenoic acid, $CH_2 = CHCOOH$, reacts with ethanol giving ethyl propenoate, $CH_2 = CHCOOCH_2CH_3$.
Give the balanced equation for this reaction. [1]

.....

Examiner only
Arholwr yn unig

(c) Ethyl propenoate can be polymerised in an **addition** polymerisation process giving a non-toxic 'acrylic' polymer.
One use of this polymer is to coat the inside of cans to prevent their attack by acidic fruit.
Complete the equation to show the formula of the polymer produced. [1]



(d) Polyesters are made by **condensation** polymerisation.

(i) State the difference between **addition** and **condensation** polymerisation. [1]

.....

.....

(ii) Polyesters may be formed from monomers of the form

where **X** and **Y** are functional groups and R_1 and R_2 are hydrocarbon groups.

I. Draw structural formulae for the possible functional groups **X** and **Y**. [1]

II. Give the formula of the repeating unit of the resulting polymer. [1]

Examiner only
Arholwr yn unig

(e) Propenoic acid can also be produced by the hydrolysis of propenenitrile,

$$CH_2 = CH - CN$$

State the reagent used to hydrolyse nitriles in this way. [1]

.....

(f) State the names of reagents **E** and **F** used to produce propenylamine by the two routes shown below. [2]

$$CH_2 = CH - CN \xrightarrow{\text{reagent } \mathbf{E}} CH_2 = CH - CH_2NH_2 \xleftarrow{\text{reagent } \mathbf{F}} CH_2 = CH - CH_2I$$

propenylamine

Reagent **E** .....

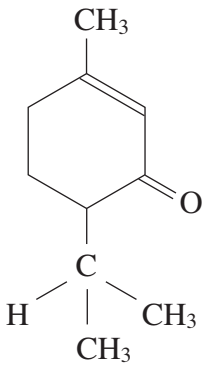
Reagent **F** .....

Total [12]

BLANK PAGE

Examiner only
Arholwr yn unig

2. *(a)* One component of eucalyptus oil is piperitone.



piperitone

In its reactions, piperitone behaves both as an alkene and a ketone.

(i) State what is **seen**, if anything, when piperitone is treated with

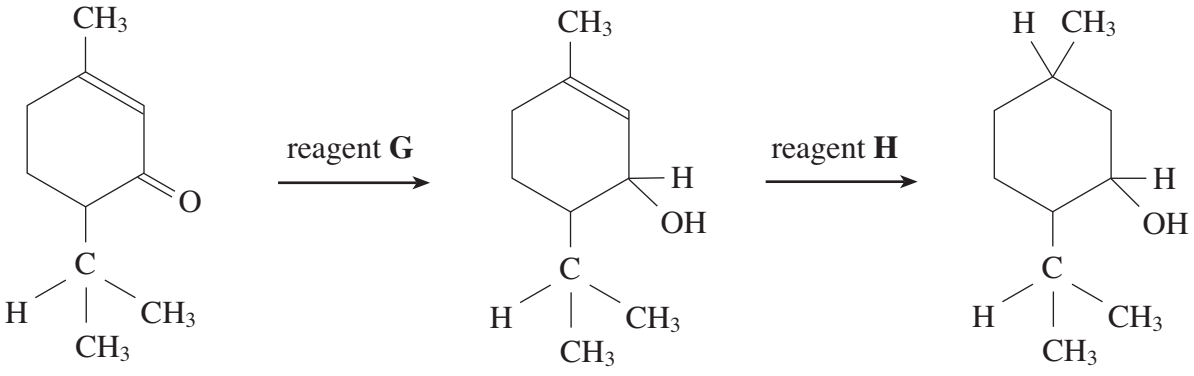
I. aqueous bromine, ... [1]

.....

II. Tollens' reagent. ..... [1]

.....

(ii) Piperitone can be converted into menthol in two stages.



menthol

Examiner only
Arholwr yn unig

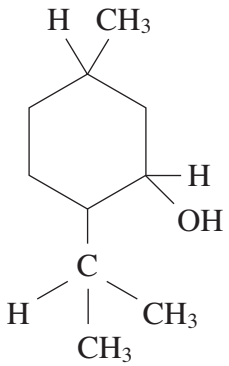
I. State the name of reagent **G**. ..... [1]

II. State the name of reagent **H** and the catalyst used. [2]

Reagent **H** .....

Catalyst .....

III. Menthol contains several chiral centres.
Identify **one** chiral centre in the structure of menthol below by using an asterisk (*). [1]



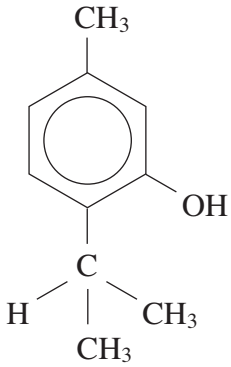
menthol

IV. Menthol exists as enantiomers.
State how an enantiomer of menthol affects plane polarised light. [1]

.....

.....

(iii) Using suitable reagents, piperitone may be converted to the phenol, **thymol**.



thymol

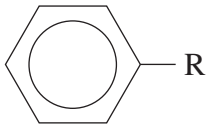
I. Both phenol and thymol can be distinguished from alcohols by the use of iron(III) chloride solution.
State what is seen during this reaction. [1]

.....

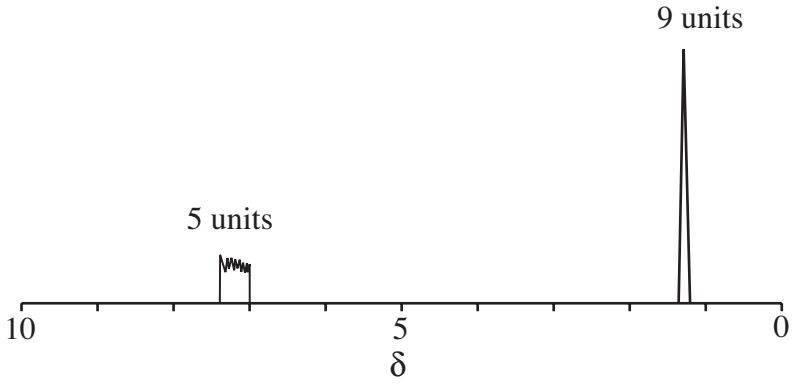
Examiner only
Arholwr yn unig

II. Thymol reacts with aqueous bromine.
Suggest a formula for the organic product of this reaction. [1]

(b) Compound **J** is an aromatic hydrocarbon of formula



where R is an alkyl group.
The molecular formula of compound **J** is $C_{10}H_{14}$.
The NMR spectrum of compound **J** is shown below.



The aromatic protons give a chemical shift, δ, at 7·0 to 7·3 and the side chain protons give a singlet chemical shift, δ, at 1·3.

Deduce a graphic formula for this hydrocarbon giving a reason for your choice. [2]

.....

.....

.....

Total [11]

BLANK PAGE

Examiner only
Arholwr yn unig

3. *(a)* Butylamine is one of the compounds responsible for the smell of rotting fish.

$CH_3CH_2CH_2CH_2NH_2$
butylamine

(i) Explain why butylamine is a base. [1]

.....

(ii) Butylamine is soluble in water, mainly because of hydrogen bonding.
Sketch a diagram that shows how a molecule of butylamine is able to form hydrogen bonds with water. [1]

(b) Describe the reaction of a primary aliphatic amine such as butylamine with nitrous acid, HNO_2.

Compare this reaction with the corresponding reaction of a primary aromatic amine with nitrous acid and state how the product of the latter reaction can then be used to make azo dyes.

In both cases, your answer should describe what is **seen**, as well as any essential conditions.

The formulae of the products are not required. [5]

.....

.....

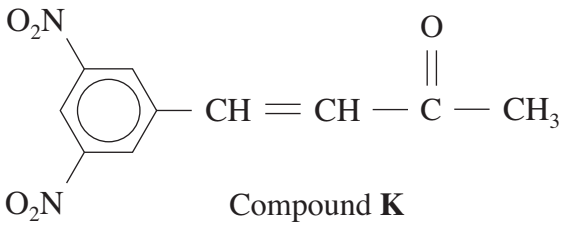
.....

.....

.....

Examiner only
Arholwr yn unig

(c) (i) I. Compound **K** absorbs strongly at a wavelength of 430 nm in the visible region of the electromagnetic spectrum.



Compound **K**

State the name given to groups present in organic compounds that absorb in the visible or ultraviolet region of the electromagnetic spectrum. [1]

.....

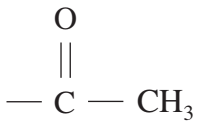
II. A similar compound to compound **K** absorbs at 480 nm in the visible region.
State and explain which of the two wavelengths, 430 nm and 480 nm, corresponds to a frequency of higher energy. [2]

.....

.....

.....

III. Compound **K** contains the group shown below.



Describe how you would test a solution of compound **K** to show the presence of this group. [2]

Reagent(s) .....

Observation .....

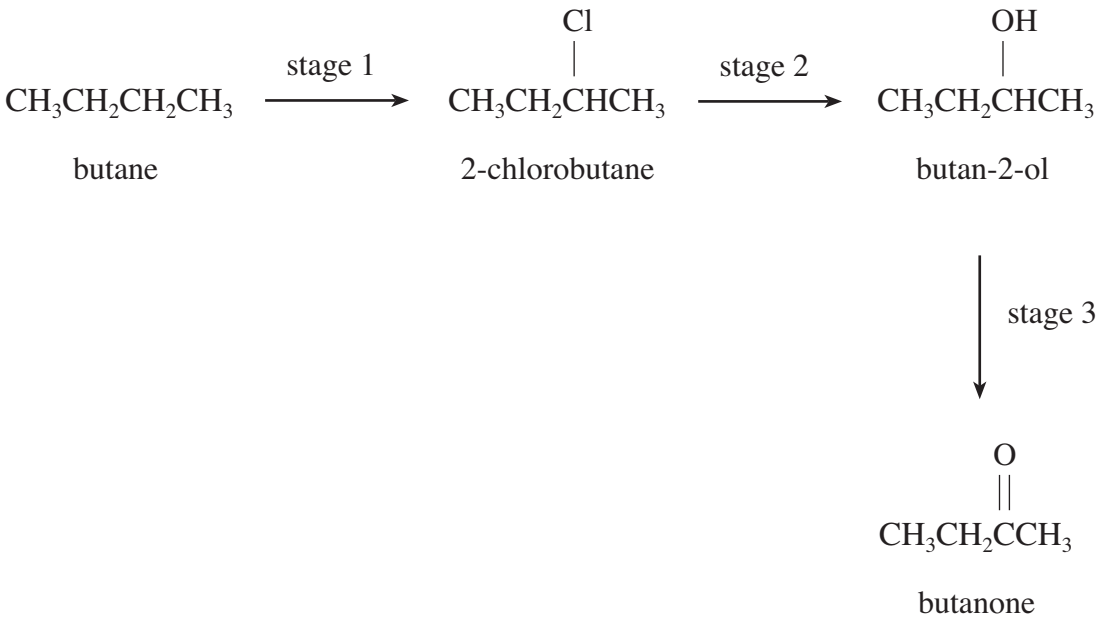
Total [12]

Total Section A [35]

SECTION B

Answer **both** *questions in the separate answer book provided.*

4. *(a)* The flow chart shows how butanone can be made from butane in three stages.



(i) Stage 1 involves the chlorination of butane in the presence of ultraviolet light. State the type of bond fission that occurs during this reaction and give a graphic formula for the reactive carbon-containing intermediate in this process. [2]

(ii) I. The mass spectrum of 2-chlorobutane shows molecular ion peaks at *mass / charge* values of 92 and 94.
Give the formulae of the ions responsible for these values. [1]

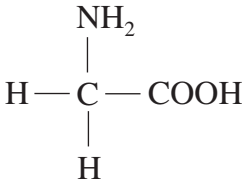
II. The mass spectrum of the products of chlorination of butane shows the presence of an impurity with a molecular ion value of 126.
Suggest a graphic formula for this impurity. [1]

(iii) Butan-2-ol is produced by the attack of a hydroxide ion on 2-chlorobutane.
Give the mechanism for this reaction and state the type of mechanism occurring.
You should assume that the mechanism is similar to the reaction of a hydroxide ion with 1-bromobutane. [3]

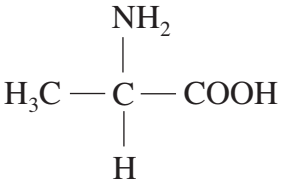
(iv) I. State the reagents necessary to produce butanone in stage 3. [1]

II. Use the absorption frequencies in the Data Sheet to describe how the infrared spectrum of the reaction mixture would change as butanone was being produced from butan-2-ol. [2]

(b) Milk proteins are broken by enzymes to give a mixture of α-amino acids such as aminoethanoic acid (glycine) and 2-aminopropanoic acid (alanine).



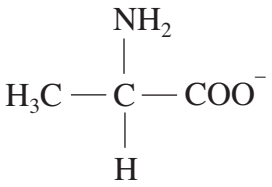
glycine



alanine

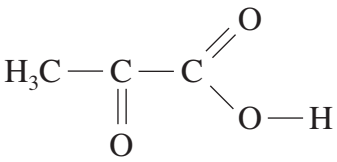
(i) Glycine exists largely as its zwitterion form.
Give the graphic formula of the zwitterion form of glycine. [1]

(ii) Explain why, in alkaline solution, alanine produces the ion shown below. [1]



(iii) Draw the graphic formula of a dipeptide formed between glycine and alanine. [1]

(iv) Alanine is further decomposed to give 2-oxopropanoic acid (pyruvic acid).



pyruvic acid

Pyruvic acid acts both as a ketone and as a carboxylic acid.

I. Give a test, stating the reactant(s) and observation(s), that would show that pyruvic acid acts as a ketone. [2]

II. Give a test, other than the use of indicators, that shows that pyruvic acid acts as a carboxylic acid.
State all the reagent(s) and observation(s). [2]

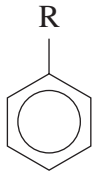
(v) Pyruvic acid undergoes a reaction to give ethanal.

I. State the name of a reagent that is used to reduce ethanal and state the name of the organic compound produced. [2]

II. Give the graphic formula of the compound produced by the decarboxylation of propanoic acid. [1]

Total [20]

5. *(a)* Compound **Y** is a hydrocarbon of formula

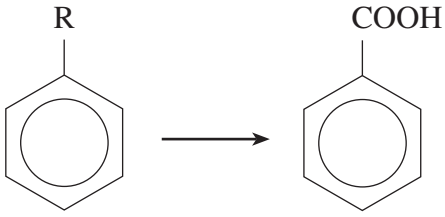


where R is an alkyl group.
The signal for the R group in the NMR spectrum of compound **Y** consists of a triplet and a quartet in the proton ratio of 3:2.
The compound contains 90·6% of carbon by mass.

(i) Use **all** this information to deduce a graphic formula for compound **Y**. [3]

(ii) I. State the reagent(s) and conditions necessary to oxidise the methyl group in methylbenzene to benzenecarboxylic acid (benzoic acid). [2]

II. Compound **Y** is also oxidised to benzenecarboxylic acid.



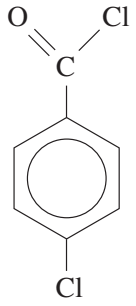
In an experiment, 9·55 g of compound **Y** was oxidised and produced 0·027 mole of benzenecarboxylic acid.
Calculate the percentage yield of benzenecarboxylic acid. [2]

(b) Benzenecarboxylic acid can also be made by hydrolysing the ester, ethyl benzenecarboxylate (ethyl benzoate).
The liquid ester is heated under reflux with sodium hydroxide solution.
This produces an aqueous solution of sodium benzenecarboxylate (benzoate).
The mixture is then acidified with hydrochloric acid giving benzenecarboxylic acid as a solid, which is filtered off.

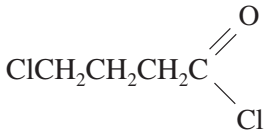
(i) Give the equation for the reaction of ethyl benzenecarboxylate with aqueous sodium hydroxide. [1]

(ii) Describe how you would purify the crude benzenecarboxylic acid by recrystallisation from water.
Benzenecarboxylic acid is soluble in hot water but almost insoluble in cold water.
It has a melting temperature of 122 °C. [3]

(c) 4-Chlorobenzenecarbonyl chloride and 4-chlorobutanoyl chloride are compounds that are hydrolysed by aqueous alkali.



4-chlorobenzenecarbonyl chloride



4-chlorobutanoyl chloride

Use your knowledge of the comparative hydrolysis of chlorobenzene and 1-chlorobutane to give the formula of the final organic compounds produced, in each case, by alkaline hydrolysis followed by subsequent acidification, explaining your choice of these compounds. [4]

(d) Colour can be explained by the absorption / emission of visible light.

(i) In terms of light energy, explain why an azo dye is red in white light. [1]

(ii) The most prominent line in the Balmer series of the emission spectrum of atomic hydrogen is red.
Explain in terms of electron energy levels how this red line is produced. [2]

(e) Explain how the convergence limit in the Lyman series of the spectrum of atomic hydrogen relates to the ionisation energy of atomic hydrogen. [2]

Total [20]

Section B Total [40]