Candidate Name	Centre Number	Candidate Number
		2

GCE A level

1094/01

CHEMISTRY CH4

A.M. WEDNESDAY, 26 January 2011

1¾ hours

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

1094 010001

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

Use black ink or black ball-point pen.

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 (40 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 80.

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.

Examiner only

SECTION A

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

1. *(a)* Complete the following passage by inserting suitable words or formulae where required. [3]

Nitrobenzene, an aromatic yellow oil, has the molecular formula ..... .

However, in blue light, this compound appears black because .....

..... .

The ^{1}H NMR spectrum of nitrobenzene is produced as a result of interactions between the spin of the nuclei and an applied magnetic field. This spectrum is seen as a number of peaks because the protons causing the spectrum are not ..... .

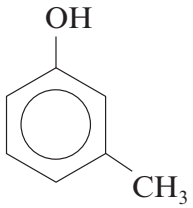
(b) Benzene reacts with chloromethane in the presence of a catalyst giving methylbenzene as the main organic product.

(i) Give the equation for this reaction. [1]

(ii) State the name of a catalyst that can be used. [1]

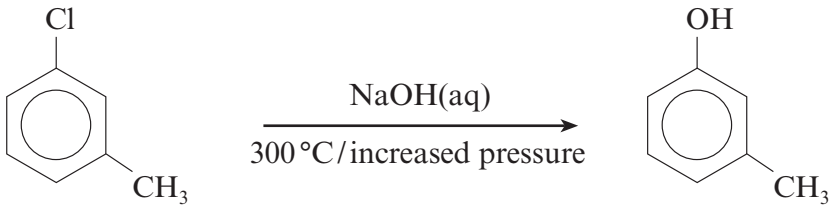
.....

(c) Creosote was once the most widely used wood preservative in the world. However, the use of this material is now severely restricted because of its high toxicity.
It is a mixture of compounds, including cresols such as 3-methylphenol.



3-methylphenol

(i) 3-Methylphenol is obtained from coal tar but another method of preparing this compound is by heating 3-chloro-1-methylbenzene with aqueous sodium hydroxide.



Explain why these conditions are needed to obtain 3-methylphenol from the chloro-compound. [3]

.....

.....

.....

.....

(ii) A number of safer wood preservatives have been developed to replace creosote.
Suggest **two** factors that companies should take into account, apart from toxicity and cost, when considering an alternative material for use as a wood preservative. [2]

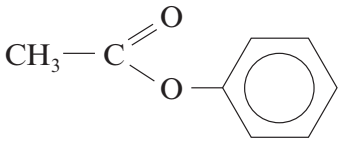
1. .....

.....

2. .....

.....

(d) The reaction between phenol and ethanoyl chloride gives the aromatic compound **W**.

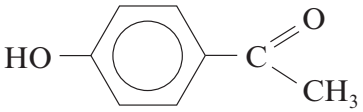


compound **W**

(i) State the name of the group of compounds to which compound **W** belongs. [1]

.....

(ii) Using a suitable catalyst, compound **W** can rearrange to give compound **Y**.



compound **Y**

Compound **Y** gives a positive triiodomethane (iodoform) test.
State the reagents used for this test and what is observed. [2]

Reagents .....

Observation .....

Total [13]

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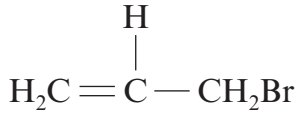
Examiner only

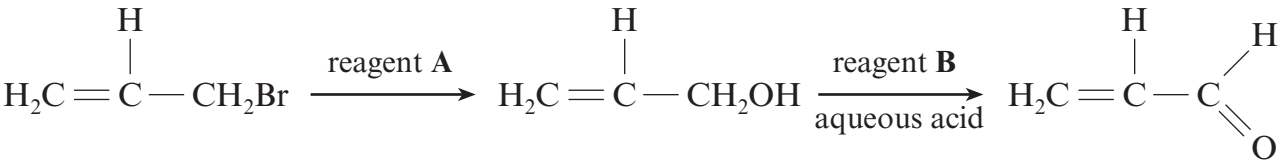
2. *(a)* Allyl bromide is the traditional name for the compound that has the following formula.



(i) Give the **systematic name** for this compound. [1]

.....

(ii) Allyl bromide can be converted to acraldehyde (prop-2-en-1-al) in a two-stage reaction.



State the names of reagent **A** and reagent **B**. [2]

Reagent **A** .....

Reagent **B** .....

(b) Acraldehyde reacts with 2,4-dinitrophenylhydrazine.

(i) State the type of reaction that occurs. [1]

.....

(ii) Describe the appearance of the organic product that is produced. [1]

.....

(iii) State how the purified organic product from (ii) is used to clearly identify the starting aldehyde as acraldehyde. [1]

.....

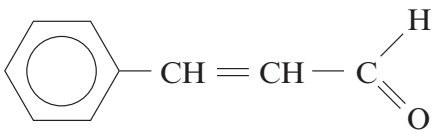
.....

(iv) The infrared spectrum of an impurity present when acraldehyde is made by the method above, shows peaks at 1725 cm^{-1} and at 2500-3550 cm^{-1}.
Suggest the displayed formula of the impurity that is responsible for these peaks and the type of reaction that has produced it from acraldehyde. [2]

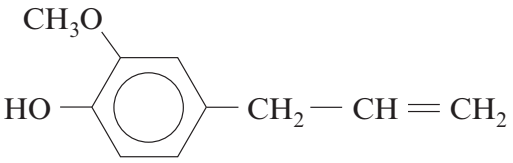
Displayed formula .....

Type of reaction .....

(c) The smell and flavour of cinnamon oil is largely due to cinnamaldehyde (3-phenylpropenal) and, to a smaller extent, eugenol.



cinnamaldehyde



eugenol

(i) Explain why only cinnamaldehyde, and not eugenol, is able to have E-Z isomers. [1]

.....

.....

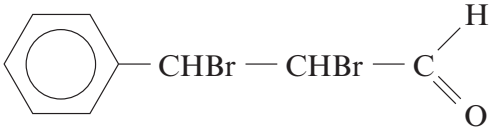
.....

(ii) Giving the reagent and an observation, state a chemical test that gives a positive result with eugenol but not with cinnamaldehyde. [2]

Reagent .....

Observation .....

(iii) Cinnamaldehyde reacts with bromine to give the chiral compound **C**.



compound **C**

Both compound **C** and cinnamaldehyde can be used to illustrate stereoisomerism. State what is meant by *stereoisomerism.* [1]

.....

.....

.....

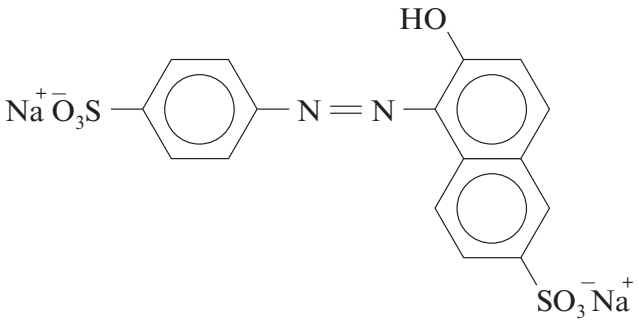
Total [12]

3. *Read the passage below and then answer the questions in the spaces provided.*

Food additives

Since 1986 manufacturers have been required, for most foods, to list their ingredients in descending proportions by mass. Food additives can be listed by their chemical names or by using an E-number. They are used for a number of reasons and as a result they are classified into different groups, some of which are discussed in this article.

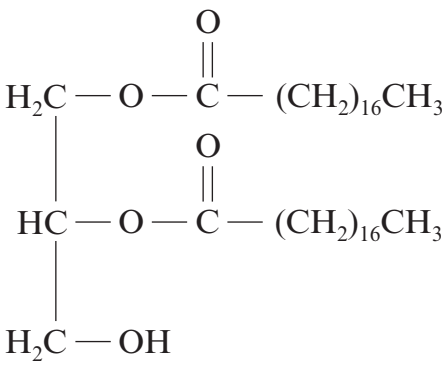
5 **Colouring agents** Consumers are probably most worried about compounds used to colour food. A number of permitted colours are synthetic azo-dyes and there are particular concerns about the effect that some of these compounds have on children. In recent years there has been a move towards safer naturally occurring dyes such as annatto and anthocyanins. However, azo-dyes such as Sunset Yellow FF (E110) continue to be used.



E110

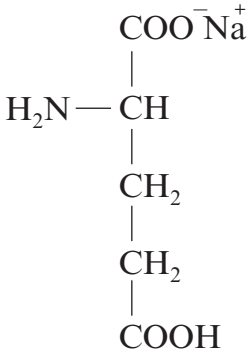
10 **Preservatives** With the move towards foods having longer shelf lives, there is a need to use preservatives to prevent spoilage. 2-Hydroxypropanoic acid (lactic acid), occurs naturally in sour milk and is used as a preservative in salad dressings. The salts of organic acids, for example sodium benzoate and sodium citrate, are used in fizzy drinks.
Calcium propanoate, $(CH_3CH_2COO)_2Ca$, is used as a preservative in bread, as it inhibits the
15 growth of mould-producing microorganisms.

Emulsifiers These are used to enable oily substances and water to mix, so that separation into two layers does not occur. These compounds generally have water-'soluble' groups and a hydrocarbon chain that is fat-'soluble'. An example is the ester E477.



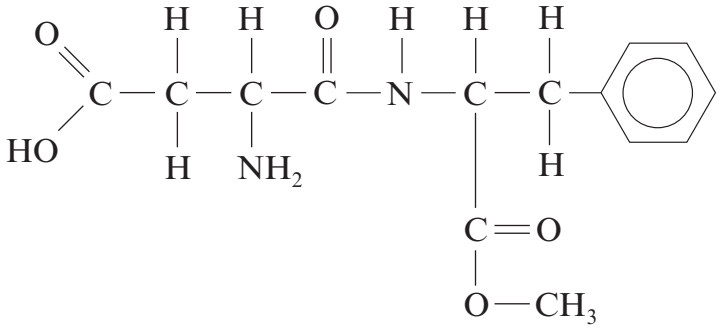
E477

Flavour enhancers Compounds such as monosodium glutamate (MSG) are added to food to increase its flavour. MSG occurs naturally in Parmesan cheese and tomatoes. Perhaps that is the reason why pizzas and soups are sometimes garnished with cheese and tomato.



MSG

Artificial sweeteners Many consumers are suspicious of food that has added sugar and manufacturers are naturally keen to label their products as containing 'no added sugar'. This may be true, but very often artificial sweetening agents are added in place of sugar to make the food more palatable. One of the commonest of these is aspartame, which is 200 times sweeter than sugar.



aspartame

The use (and misuse) of additives is an area of chemistry that has increasing importance as world population increases leading to a greater reliance on prepared, rather than fresh food.

– End of passage –

(a) (i) State the general name given to groups present in compounds such as Sunset Yellow FF that gives them their colour. [1]

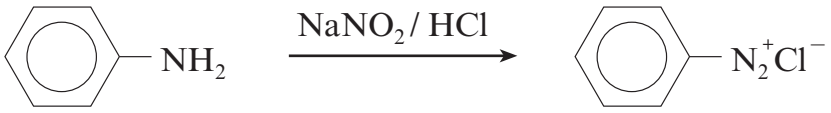
.....

(ii) Sunset Yellow FF is soluble in water. Like sodium chloride it contains sodium ions, Na^+. Explain how sodium ions interact with water molecules. [1]

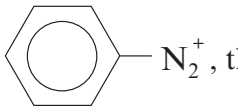
.....

.....

(iii) In the first stage of preparing an azo-dye, an aromatic amine reacts with sodium nitrate(III) (nitrite) and hydrochloric acid to give a diazonium compound.



I. State the temperature required for this reaction. ..... [1]

II. The benzenediazonium ion, 

, then reacts with a phenol to produce an azo-dye.

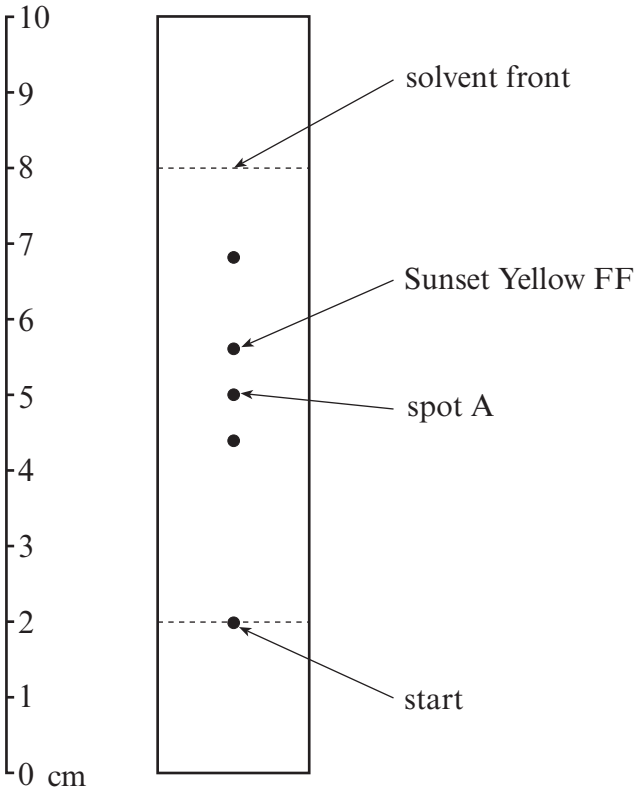
The benzenediazonium ion reacts as an electrophile.
State what is meant by the term *electrophile*. [1]

.....

.....

Examiner only

(b) A government chemist was using thin layer chromatography to identify the colours found in some imported sweets. She obtained the chromatogram below.



The R_f values for some of the expected colours are given in the following table.

Colour	R_f value
Sunset Yellow FF	0.60
Brilliant Blue FF	0.80
Fast Green FF	0.90

(i) Use the table of R_f values to state which other colour, apart from Sunset Yellow FF, is definitely present. Use the chromatogram to show how you arrived at your answer. [2]

.....

.....

(ii) The chemist suspected that spot A was due to amaranth or indigo carmine. This spot was removed from the plate and dissolved in a suitable solvent. Suggest **two** methods that she could then use to decide which of these two dyes was present. [2]

1. .....

.....

2. .....

.....

Turn over.

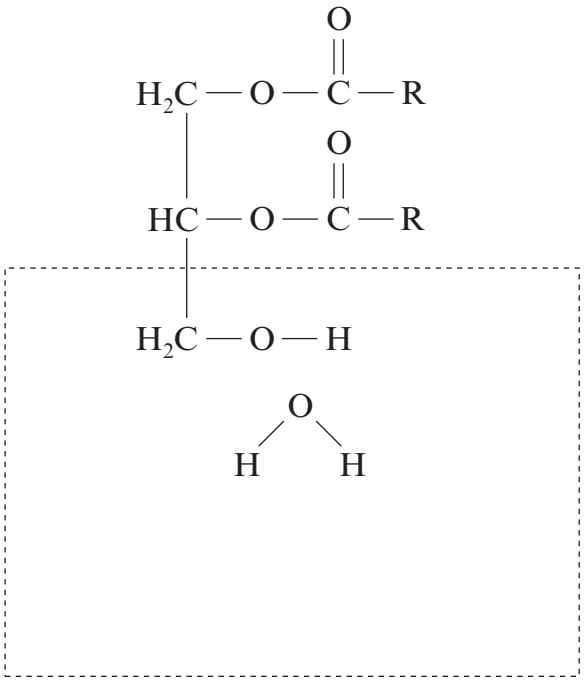
Examiner only

(c) Calcium propanoate *(line 14)* is used to inhibit mould growth in bread.
Salts of carboxylic acids, such as calcium propanoate, undergo decarboxylation when heated with calcium hydroxide or sodalime.
Complete the equation by giving the formula of the only organic product and balance the equation. [2]

$(CH_3CH_2COO)_2Ca + Ca(OH)_2 \rightarrow \square\ CaCO_3 + \square$ .....

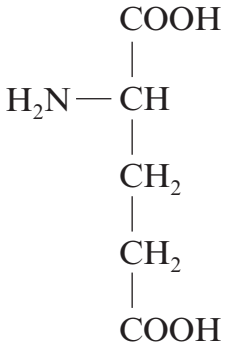
(d) E477 *(line 18)* forms hydrogen bonds with water molecules.

Working inside the box only, complete the diagram below by showing the polarity in E477 and the water molecule and the hydrogen bonds between them. For simplicity the hydrocarbon chain in E477 is shown as R. [2]



Examiner only

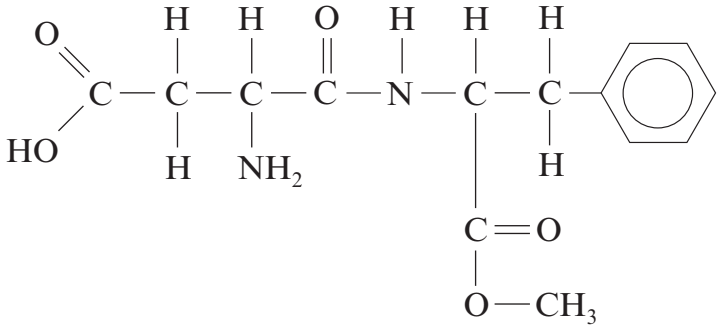
(e) MSG *(line 19)* is the monosodium salt of the α-amino acid glutamic acid.



glutamic acid

Give the **structural** formula of the organic species produced when glutamic acid is dissolved in excess alkali. [1]

(f) The artificial sweetener aspartame is a common sweetener in soft drinks. However, these should not be kept for any length of time as the **ester group** slowly hydrolyses.



aspartame

Give the structural formula of the two organic compounds produced from this hydrolysis of the ester group. [2]

Total [15]

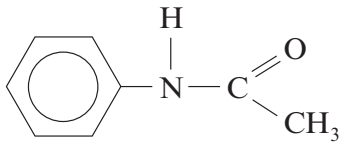
Section A Total [40]

Turn over.

SECTION B

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

4. *(a)* Phenylamine reacts with ethanoyl chloride to produce N-phenylethanamide.



These two reactants are mixed together under suitable conditions and the products are poured into a large excess of cold water, when N-phenylethanamide is formed as impure white crystals. After filtering, N-phenylethanamide is recrystallised from hot water. The pure product melts at 113 °C.

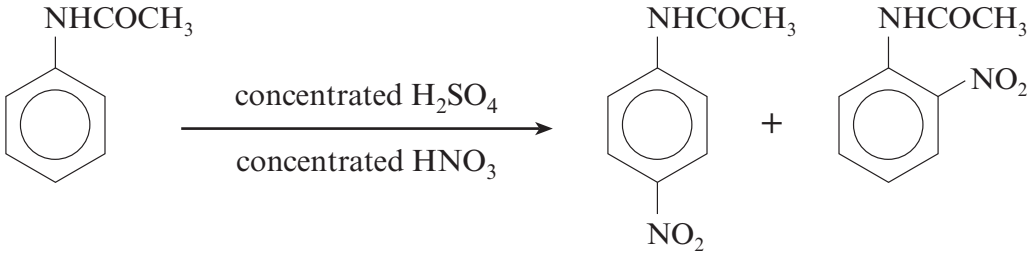
(i) Write the chemical equation for the reaction of phenylamine and ethanoyl chloride. [1]

(ii) When filtering the mixture containing impure N-phenylethanamide, the material in the filter paper is washed several times with cold water.
State why this is done. [1]

(iii) Use the account above to help you describe how you would obtain pure, dry crystals of N-phenylethanamide from the impure white crystals. [4]

(QWC) [1]

(b) N-phenylethanamide can be nitrated using a mixture of concentrated nitric and sulfuric acids, giving mainly 4-nitro-N-phenylethanamide as colourless crystals, together with small quantities of the yellow 2-nitro-N-phenylethanamide.



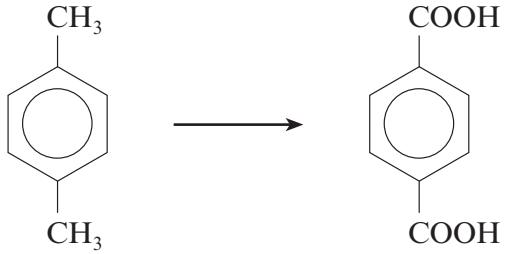
colourless solid yellow solid

(i) The mechanism for this reaction is similar to the nitration of benzene.
Give the reaction mechanism for the production of 4-nitro-N-phenylethanamide, starting from N-phenylethanamide and the nitronium ion (nitryl cation), NO_2^+.
Your answer should also state the type of reaction mechanism occurring. [4]

(ii) The two isomers are separated by recrystallisation from ethanol, in which the 2-isomer is much more soluble.
Use the information provided to state and explain how you would know when the 4-isomer is no longer contaminated with traces of the 2-isomer. [2]

(iii) In an experiment 8.10 g of N-phenylethanamide (M_r 135) produced 6.48 g of pure 4-nitro-N-phenylethanamide (M_r 180).
Calculate the percentage yield of 4-nitro-N-phenylethanamide. [3]

(c) One stage in the preparation of the polyester PET is the oxidation of 1,4-dimethylbenzene to benzene-1,4-dioic acid.



This is carried out in the laboratory by refluxing 1,4-dimethylbenzene and an alkaline solution (containing sodium hydroxide) of an oxidising agent **G**, giving an intermediate product, which is then acidified.

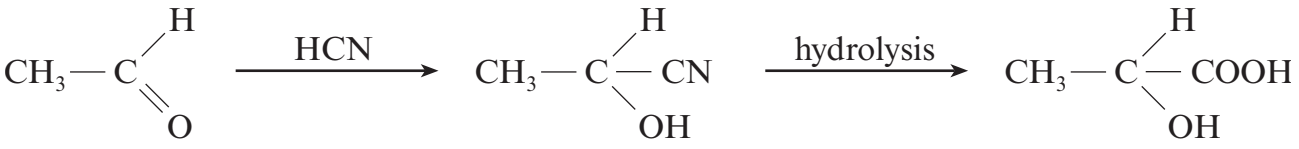
(i) State the name of oxidising agent **G**. [1]

(ii) Explain why it is then necessary to acidify the intermediate product to give the required acid. [1]

(d) The polyester PET is produced by reacting benzene-1,4-dioic acid and ethane-1,2-diol.
Draw the formula of the repeating unit found in PET and state why this reaction is described as condensation polymerisation. [2]

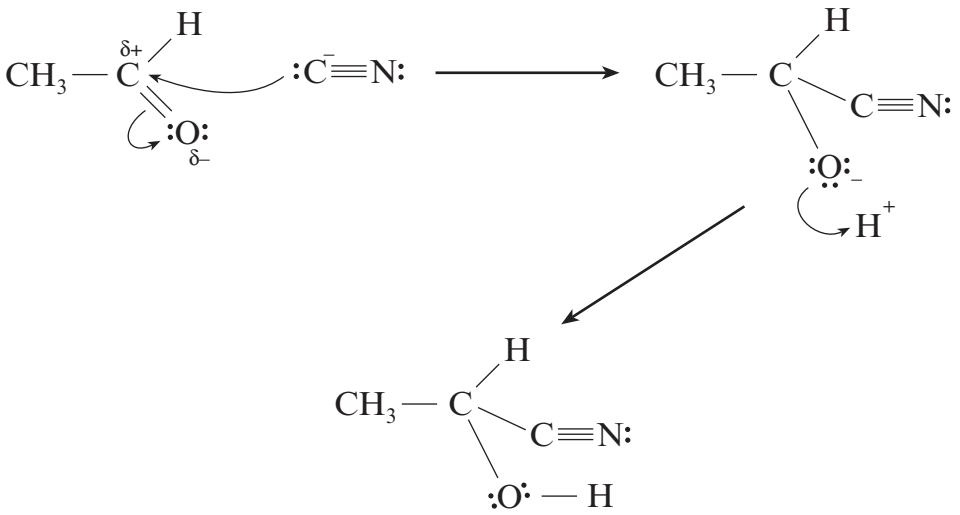
Total [20]

5. *(a)* 2-Hydroxypropanoic acid (lactic acid) can be made from ethanal by reaction with hydrogen cyanide and the subsequent hydrolysis of the 2-hydroxypropanenitrile.



2-hydroxypropanenitrile 2-hydroxypropanoic acid

(i) The mechanism for the reaction between ethanal and hydrogen cyanide is shown below.



Describe what is happening at each stage of this reaction mechanism and use your answer to explain why this reaction is described as nucleophilic addition. [4]

(QWC) [1]

(ii) During the second stage of the reaction 2-hydroxypropanenitrile is hydrolysed to 2-hydroxypropanoic acid.
Describe what is meant by the term *hydrolysis* and give the reagent used for this hydrolysis. [2]

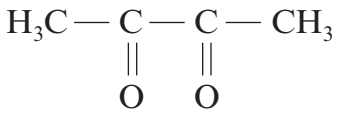
(b) (i) Yoghurt contains lactic acid that has been produced from lactose by certain bacteria.
The percentage of lactic acid in yoghurt can be found by an acid-base titration.
A sample of plain yoghurt of mass 50.0 g was titrated with sodium hydroxide solution of concentration 0.250 mol dm^{-3}. The lactic acid in the yoghurt was exactly neutralised by 20.0 cm^3 of the sodium hydroxide solution.

$$\underset{M_r\,90}{CH_3CH(OH)COOH} + NaOH \rightarrow CH_3CH(OH)COONa + H_2O$$

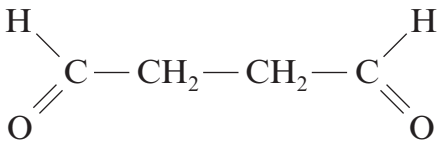
Use the information above and the equation to calculate the percentage of lactic acid present in the yoghurt. [3]

(ii) Some students suggested that it would be less wasteful if just a 10 g sample of yoghurt was used, rather than a 50 g sample, in this titration.
Explain why this would be likely to give a less accurate result. [1]

(c) Butan-2,3-dione (found in yoghurt) and butan-1,4-dial are isomers.



butan-2,3-dione



butan-1,4-dial

Describe the observations made when both compounds are tested with Fehling's reagent. [2]

(d) You are provided with the following information about aliphatic ester **T**.

- the empirical formula is $C_2H_3O_1$
- the relative molecular mass is 172
- all the oxygen atoms are present in ester groupings
- it decolourises aqueous bromine
- methanol is the only alcohol produced on hydrolysis of ester **T**
- the ^1H NMR spectrum consists of two unsplit peaks of equal size

Use **all** this information to deduce the structural formula of ester **T**, showing your reasoning. [6]

(QWC) [1]

Total [20]

Section B Total [40]

WJEC
CBAC

GCE A level

1094/01-A

CHEMISTRY CH4
DATA SHEET

A.M. WEDNESDAY, 26 January 2011

Infrared Spectroscopy characteristic absorption values

Bond	Wavenumber/cm^{-1}
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C═C	1620 to 1670
C═O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H	2500 to 3550
N—H	3300 to 3500

Nuclear Magnetic Resonance Spectroscopy

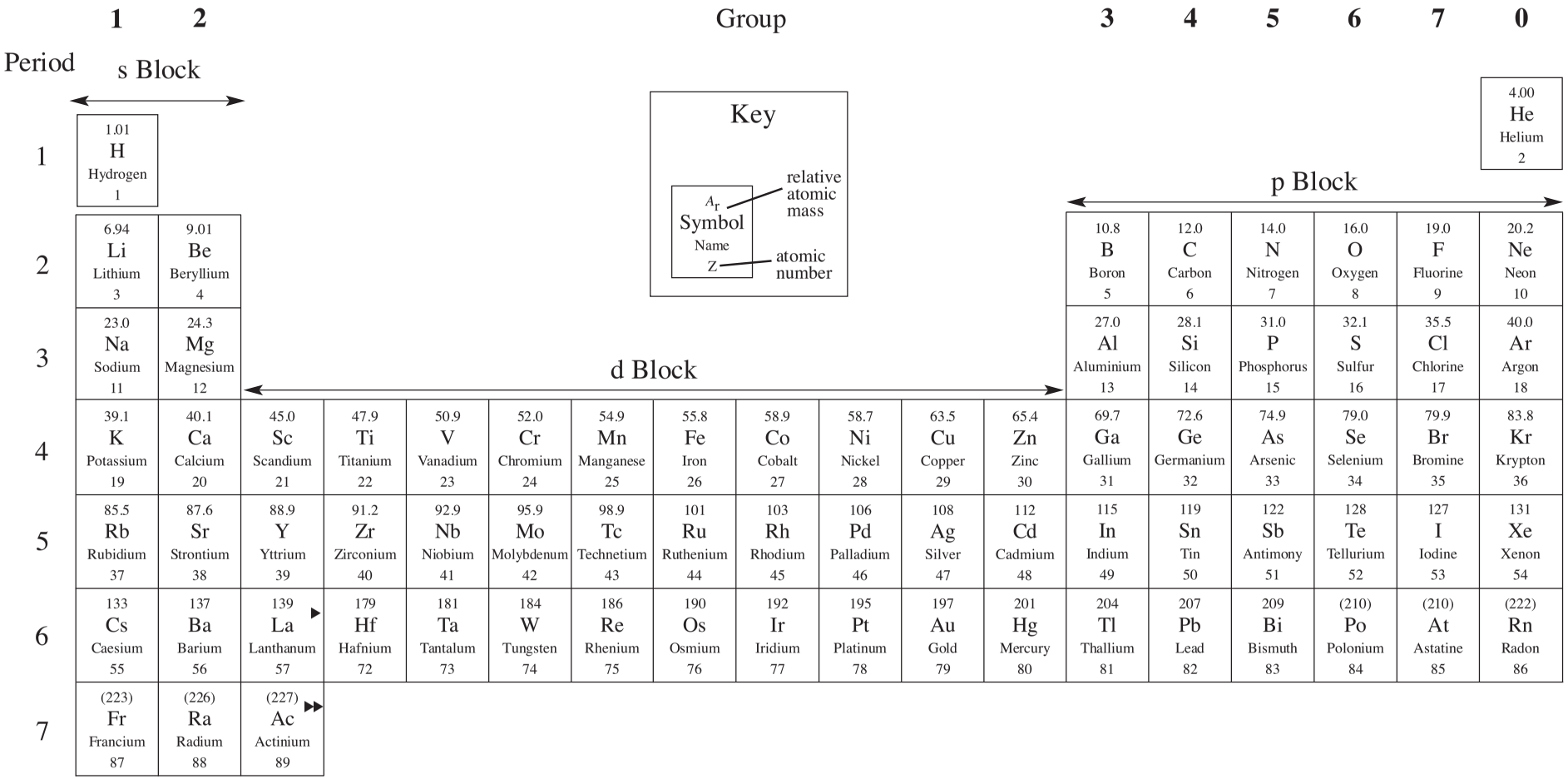
Candidates are reminded that the splitting of any resonance into **n** components indicates the presence of **n–1** hydrogen atoms on the **adjacent** carbon, oxygen or nitrogen atoms.

Typical proton chemical shift values (δ) relative to TMS = 0

Type of proton	Chemical shift (ppm)
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
$CH_3-C(=O)-$	2.0 to 2.5
$-CH_2-C(=O)-$	2.0 to 3.0
$-O-CH_3$, $-OCH_2-R$, $-O-CH=C<$	3.5 to 4.0
R—OH	4.5 *
$CH_2=C<$	4.8
$R-C(=O)-H$	9.8 *
$R-C(=O)-OH$	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE



f Block

▶ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
▶▶ Actinoid elements	232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103