Surname	Centre Number	Candidate Number
Other Names		2

GCE A level

1094/01

CHEMISTRY – CH4

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**13**	
	2.	**13**	
	3.	**14**	
Section B	**4.**	**20**	
	5.	**20**	
	Total	**80**	

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.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

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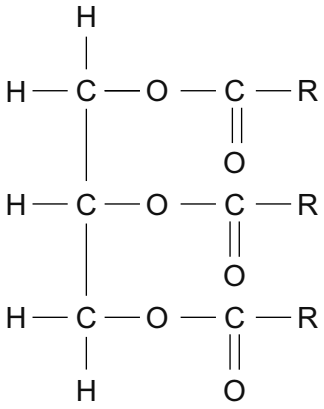
Examiner only

SECTION A

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

1. Fats and oils found in living things are esters of fatty acids and glycerol (propan-1,2,3-triol). Fatty acids are carboxylic acids with one —COOH group and a long hydrocarbon chain, often shown as R.

(a) The general structure of a fat is shown below.



The three ester groups in this molecule can be hydrolysed in the same way as other esters. Give the reagent(s) and condition(s) needed for the hydrolysis of this fat, and write a balanced equation for the reaction. [3]

Reagent(s) .....

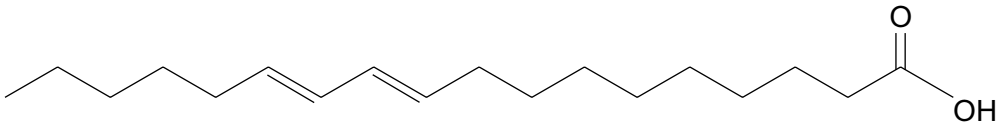
Condition(s) .....

Equation

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(b) One fatty acid is linoleic acid, whose structure is shown below.



(i) This molecule is an unsaturated fatty acid because it contains carbon-carbon double bonds. Give a chemical test to show that a molecule contains carbon-carbon double bonds. [2]

Reagent(s) .....

Observation(s) .....

(ii) Unsaturated fatty acids may be converted into saturated fatty acids by reaction with hydrogen gas in an addition reaction. Give the catalyst required for this reaction. [1]

.....

(iii) The hydrogenation of a sample of linoleic acid to the saturated fatty acid stearic acid (M_r = 284) required exactly 1.15 dm^3 of hydrogen gas for complete reaction. Calculate the maximum mass of stearic acid that could be formed in this reaction. [3]

[1 mol of a gas occupies 24.0 dm^3 at 298K and 1 atm pressure. Assume all gas volumes are measured under these conditions.]

Maximum mass = ... g

QUESTION CONTINUES ON PAGE 4

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(c) Another fatty acid with one carboxylic acid group was found to contain 69.7 % carbon, 11.7 % hydrogen and 18.6 % oxygen by mass.

(i) Calculate the **empirical** formula of this fatty acid. [2]

Empirical formula .....

(ii) Give the **molecular** formula of this fatty acid. [1]

.....

(d) There has been great interest in converting fats and oils into biodiesel as an alternative to fossil fuels produced from crude oil. Give **one** advantage of using biodiesel as an alternative to fossil fuels. [1]

.....

.....

Total [13]

13

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Turn over.

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2. Mauveine is a purple dye that was developed by Perkin in 1856 and was one of the first organic compounds to be synthesised on a large scale. He is credited with launching the synthetic chemical industry.

(a) Give the name for the part of a molecule that causes it to be coloured. [1]

.....

(b) The dye mauveine often contains a mixture of impurities. Iwan and Georgia wanted to confirm that a sample of the dye was impure.

(i) Iwan used the melting temperature of the sample to confirm that the sample was impure. Give **one** way that the melting temperature would show this. [1]

.....

.....

(ii) Georgia used gas chromatography to confirm that the sample was impure. State what information she obtained using this method that Iwan could not obtain from the melting temperature. [2]

.....

.....

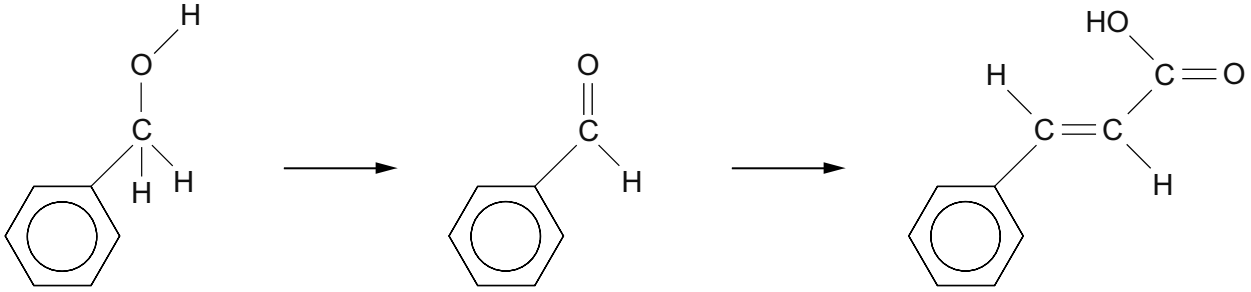
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(c) Another compound synthesised by Perkin was cinnamic acid. Cinnamic acid can be produced in two steps from phenylmethanol as shown below.



phenylmethanol benzenecarbaldehyde cinnamic acid

(i) Give the reagent(s) and condition(s) required to obtain a sample of benzenecarbaldehyde from phenylmethanol. [2]

Reagent(s) .....

Condition(s) .....

(ii) The conversion of phenylmethanol to benzenecarbaldehyde has a yield of 86 %. Calculate the mass of benzenecarbaldehyde that could be produced from 10.0 g of phenylmethanol. [3]

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Mass = ... g

(iii) The ^{1}H NMR high resolution spectrum of cinnamic acid contains peaks in the area 7.0-7.5 with an area of 5 due to the benzene ring. Describe what other features you would expect to see in the spectrum. [4]

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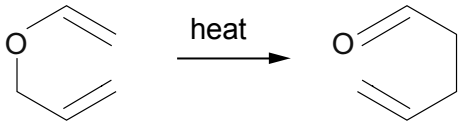
Total [13]

13

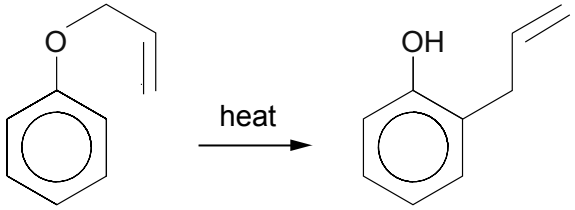
3. *Read the passage below and then answer the questions in the spaces provided.*

Rearrangement reactions

The many different chemical reactions that occur for organic compounds can be classified in different ways, and reaction types such as addition, substitution and elimination are familiar to all students of organic chemistry. A different group of organic reactions is the rearrangement reactions, where the product has the same molecular formula as the starting material. One of the first rearrangement reactions to be identified was the Claisen rearrangement and two examples of this are given below.



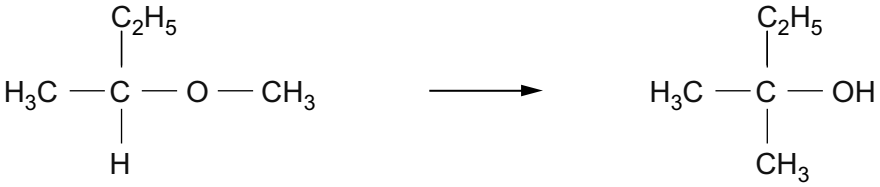
Claisen rearrangement



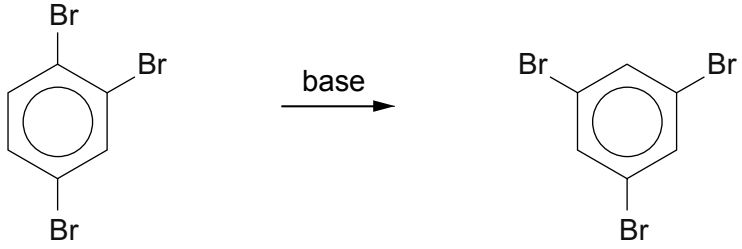
aromatic Claisen rearrangement

This rearrangement can occur in a wide range of molecules, and so it is used in the production of a number of biologically active molecules including *Pancratistatin* and *Halomon*, both of which have antitumour activity. The rates of these reactions are much higher in polar solvents, especially those that can form hydrogen bonds, and the rate can also be increased by using catalysts containing aluminium compounds.

Another group of rearrangement reactions is the 1,2-shift reactions where a side chain or a functional group moves from one atom to an adjacent carbon atom. An example is the 1,2-Wittig rearrangement where an alkoxy compound rearranges to form an alcohol. An alkyl lithium compound is used to initiate the reaction.



1,2-rearrangement reactions can also occur in benzene compounds, and one example is the halogen dance reaction which is shown below.



Rearrangement reactions are of great interest in modern chemistry as they meet the aims of green chemistry and provide an alternative to multistep processes where each part of a molecule is added in turn. They also provide a straightforward route to the formation of carbon-carbon covalent bonds.

– End of passage –

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(a) The products of rearrangement reactions have the same molecular formulae as the reactants *(lines 3-4)*. State the term given to different molecules that share the same molecular formula. [1]

.....

(b) A chemist used infrared spectroscopy to study the factors that affect the rate of the aromatic Claisen rearrangement shown in *line 7*.

(i) Give the difference(s) between the infrared spectra of the reactant and product. [1]

.....

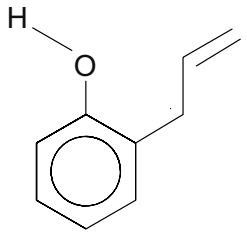
.....

(ii) Give the reagent(s) and observation(s) for a chemical test that would show that the product is a phenol. [2]

Reagent(s) .....

Observation(s) .....

(iii) The reaction is faster in solvents that can form hydrogen bonds, such as methanol or water *(lines 10-11)*. Draw the hydrogen bonding that can occur between the product shown and a molecule of water. [2]



(c) The products of the aromatic Claisen and 1,2-Wittig rearrangements shown *(lines 7* and *17)* both contain —OH groups. Explain why the acidity of the two molecules is very different. [3]

QWC [1]

.....

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(d) Many of these rearrangement reactions are useful as they create carbon-carbon covalent bonds *(lines 23-24)*. Another way of forming carbon-carbon covalent bonds is the reaction of hydrogen cyanide, HCN, with a carbonyl compound.

Draw the mechanism of the reaction of ethanal with hydrogen cyanide and classify the mechanism. [4]

Classification of mechanism .....

Total [14]

Total Section A [40]

14

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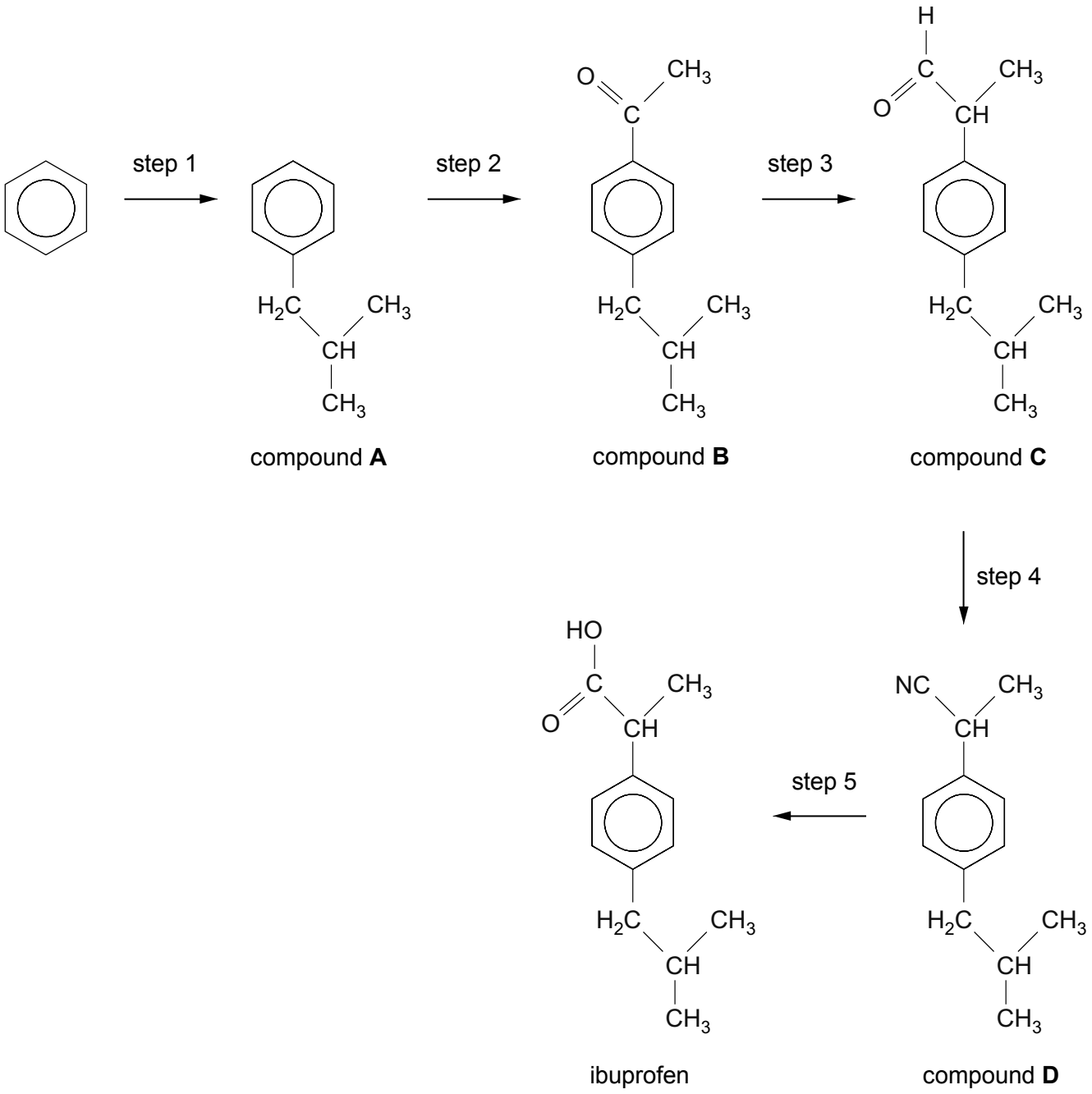
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SECTION B

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

4. Ibuprofen is a common drug taken as an analgesic and anti-inflammatory treatment.

A possible route to the synthesis of ibuprofen is shown below.



(a) Step 1 is a Friedel-Crafts alkylation reaction. Give the reagent(s) and condition(s) required for this step. [3]

(b) Compounds **B** and **C** can be analysed using chemical tests.

(i) Give a chemical test that would give a positive result for **both** compound **B** and compound **C**. Include reagent(s) and the observation(s) expected for a positive result. [2]

(ii) Give a chemical test that would give a positive result for compound **C** but **not** for compound **B**. Include reagent(s) and the observation(s) for both compounds. [2]

(c) Compound **C** shows optical isomerism. Discuss this statement.
Your answer should include:

- What is meant by optical isomerism.
- What feature of compound **C** allows it to exhibit optical isomerism.
- Diagrams to show the two optical isomers of compound **C**.
- How the two optical isomers of compound **C** can be distinguished. [4]

QWC [1]

(d) Give the reagent(s) and condition(s) required for step 5 and classify the reaction that occurs. [3]

(e) A student investigating alternative methods of producing ibuprofen suggests that it would be better to convert compound **C** into ibuprofen in a one-step process. Discuss whether this is correct.
Your answer should include:

- The reagent(s) and condition(s) for a reaction expected to convert compound **C** directly into ibuprofen.
- Why it is generally better to use one step rather than two or more steps when producing a desired compound.
- A suggestion of why a two-step process is chosen for the synthesis of ibuprofen from compound **C** rather than a one-step process. [4]

QWC [1]

Total [20]

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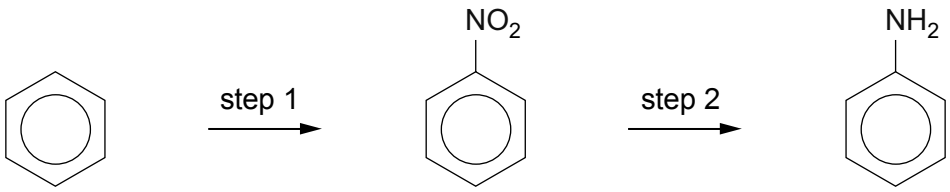
5. This question focuses on molecules that contain the $-NH_2$ group.

(a) Phenylamine and propylamine are both bases, with phenylamine being a weaker base than propylamine.

(i) Explain why both propylamine and phenylamine can act as bases. [2]

(ii) Give a reason why phenylamine is a weaker base than propylamine. [2]

(iii) Phenylamine can be prepared from benzene in a two-step process.



I. Step 1 uses a mixture of concentrated nitric and sulfuric acids to produce NO_2^+ during the reaction. Draw the mechanism of the reaction between NO_2^+ and benzene. [3]

II. During step 1, some dinitrobenzene is produced. Suggest a method of separating the different compounds in the product mixture. [1]

III. Give the reagent(s) required to produce phenylamine from nitrobenzene in step 2. [2]

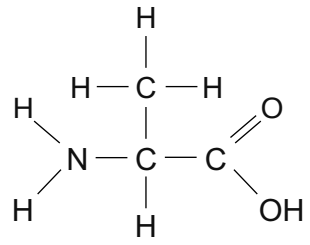
(b) 1,6-diaminohexane is used to make Nylon-6,6, which is a polyamide.

(i) Draw the **skeletal** formula for the molecule that would be combined with 1,6-diaminohexane to make Nylon-6,6. [1]

(ii) Nylon is an example of a condensation polymer. Give **two** differences between condensation polymerisation and addition polymerisation. [2]

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(c) Amino acids contain both — NH_2 and — COOH groups, such as in the molecule below.



alanine *(2-aminopropanoic acid)*

(i) Alanine dissolves in strong acid. Draw the carbon-containing species that would be present in this solution. [1]

(ii) When two molecules of alanine react together they make a dipeptide. Draw the structure of this dipeptide, circling the peptide link. [2]

(iii) Alanine has a melting temperature of 258 °C. This is much higher than compounds with molecules of a similar size such as butanoic acid, which has a melting temperature of −8 °C. Explain why the melting temperatures of these two compounds are so different. [2]

(iv) Alanine can undergo decarboxylation. Give the reagent(s) required for this reaction and identify the organic product formed. [2]

Total [20]

Total Section B [40]

END OF PAPER

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GCE A level

1094/01-A

CHEMISTRY – DATA SHEET
FOR USE WITH CH4

P.M. MONDAY, 13 January 2014

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Infrared Spectroscopy characteristic absorption values

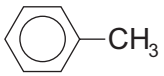
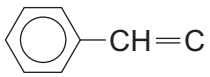
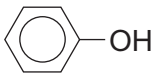
Bond	Wavenumber / cm^{-1}
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C═C	1620 to 1670
C═O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H	2500 to 3550
N—H	3300 to 3500

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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

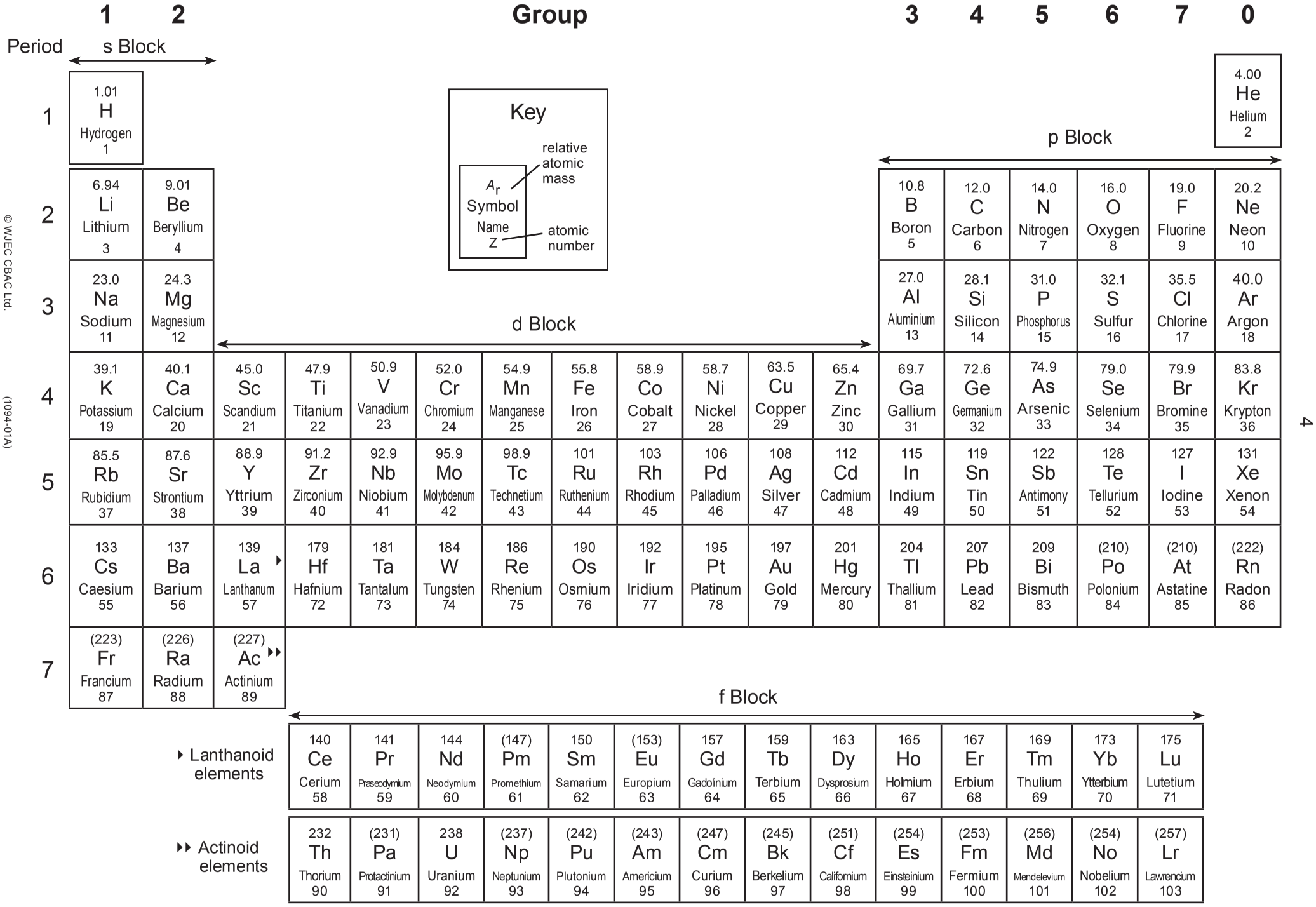
Type of proton	Chemical shift / ppm
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
$CH_3-C(=O)-$	2.0 to 2.5
$-CH_2-C(=O)-$	2.0 to 3.0
	2.2 to 2.3
$R-CH_2Cl$	3.3 to 4.3
$R-OH$	4.5 *
$-C=CH-CO$	5.8 to 6.5
	6.5 to 7.0
	7.0 *
$R-C(=O)-H$	9.8 *
$R-C(=O)-OH$	11.0 *

*variable figure dependent on concentration and solvent

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Turn over.

THE PERIODIC TABLE



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GCE A level

1094/01-A

CHEMISTRY – DATA SHEET
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P.M. MONDAY, 13 January 2014

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Infrared Spectroscopy characteristic absorption values

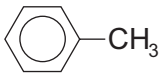
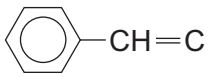
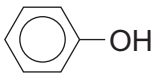
Bond	Wavenumber / cm^{-1}
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C═C	1620 to 1670
C═O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H	2500 to 3550
N—H	3300 to 3500

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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

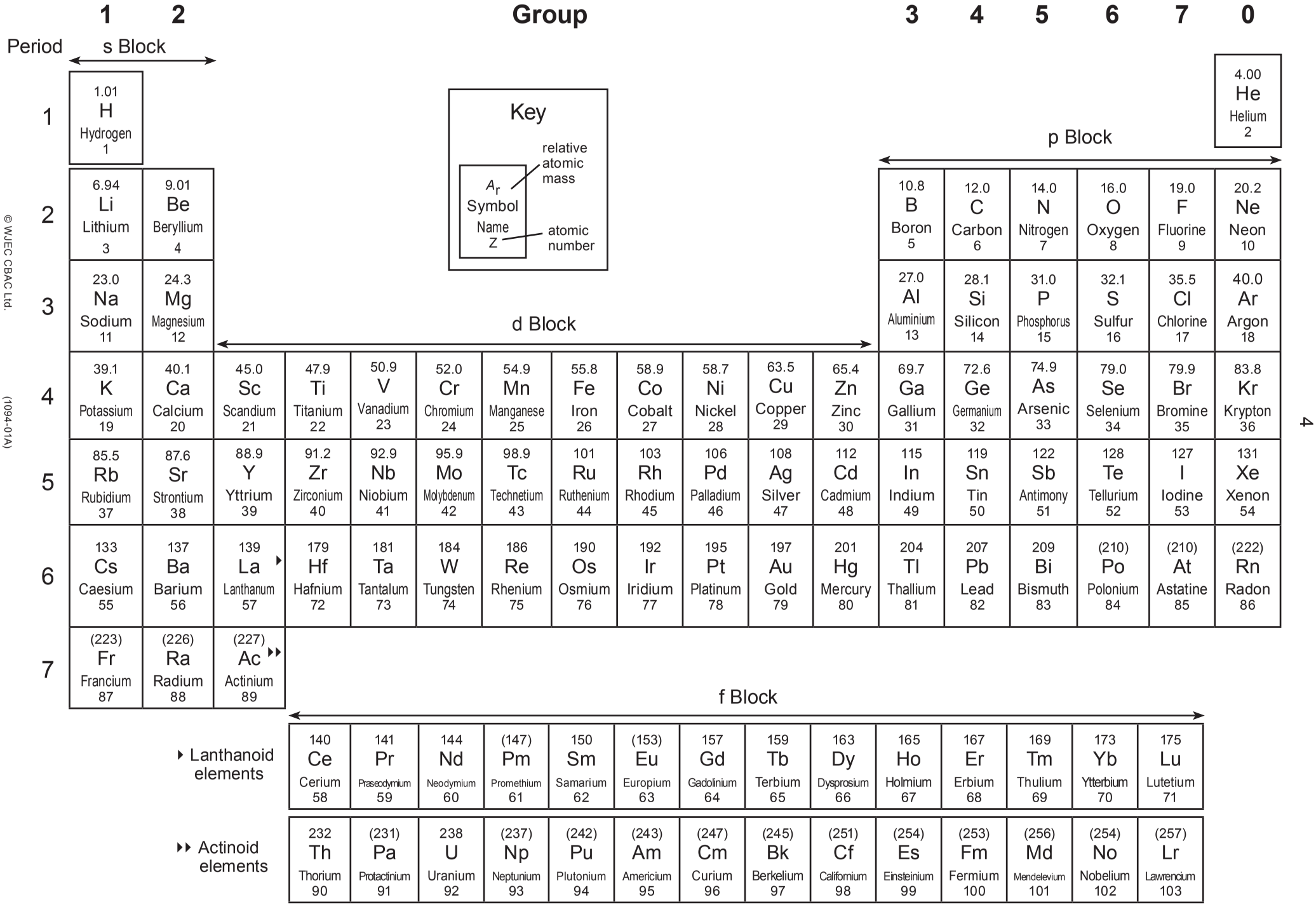
Type of proton	Chemical shift / ppm
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
$CH_3-C(=O)-$	2.0 to 2.5
$-CH_2-C(=O)-$	2.0 to 3.0
	2.2 to 2.3
$R-CH_2Cl$	3.3 to 4.3
$R-OH$	4.5 *
$-C=CH-CO$	5.8 to 6.5
	6.5 to 7.0
	7.0 *
$R-C(=O)-H$	9.8 *
$R-C(=O)-OH$	11.0 *

*variable figure dependent on concentration and solvent

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Turn over.

THE PERIODIC TABLE



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