Surname	Centre Number	Candidate Number
Other Names		2

GCE A Level

1094/01

S16-1094-01

CHEMISTRY – CH4

P.M. TUESDAY, 14 June 2016

1 hour 45 minutes

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1.	12	
	2.	13	
	3.	15	
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.

SECTION A

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

1. *(a)* A compound **P** of molecular formula $C_4H_{10}O$ was heated with acidified potassium dichromate(VI). The solution changed from orange to green and compound **Q**, of molecular formula C_4H_8O, was formed. Compound **Q** had no effect on Tollens' reagent.

(i) Name the **type** of reaction that occurred when compound **P** was heated with acidified potassium dichromate(VI). [1]

....

(ii) State what information the lack of reaction with Tollens' reagent gives. [1]

....

(iii) When compound **P** was heated with concentrated sulfuric acid a mixture of three isomers formed. All these isomers decolourised bromine.

I. Name the **type** of reaction that occurred when compound **P** was heated with concentrated sulfuric acid. [1]

....

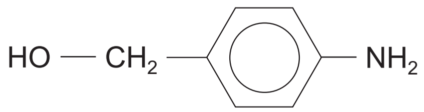
II. Draw the structural formulae of the **three** isomers formed. [3]

(iv) Draw the **skeletal** formula of compound **P**. [1]

Examiner only

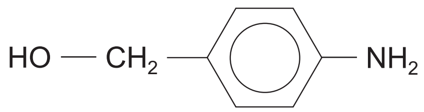
(b) Primary amines contain the functional group NH_2. For each of the reactions below identify the organic product(s).

(i) The reaction between compound **S** and cold nitric(III) (nitrous) acid. [1]



compound **S**

(ii) The reaction between compound **S** and ethanoyl chloride (CH_3COCl). [2]

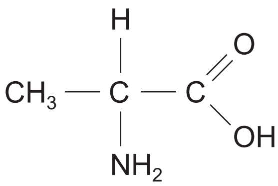


compound **S**

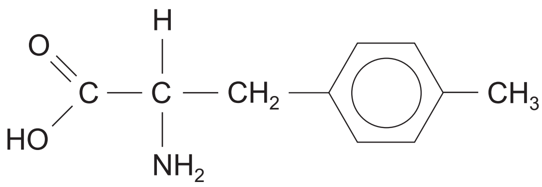
1094 010003

Examiner only

(iii) The reaction between compound **T** and compound **U** (forming two dipeptides). [2]



compound **T**



compound **U**

Total [12]

12

Examiner only

2. Students in an A level chemistry group were discussing topics that they had studied. They decided that each of the following statements was incorrect.

For each statement:

- identify the error and explain why the statement is incorrect,
- discuss the chemical principles involved, naming the products of any reaction.

(a) Ethanol and propanone can be distinguished from each other because only propanone forms a yellow solid when warmed with iodine and aqueous sodium hydroxide. [4]
QWC [1]

(b) Bubbles are formed when carboxylic acids or phenols are added to aqueous sodium carbonate. [4]

1094
010005

(c) α-amino acids are solids at room temperature whereas small carboxylic acids and small amines are liquids. The higher than expected melting temperatures of the α-amino acids is due to the presence of hydrogen bonds. [4]

Total [13]

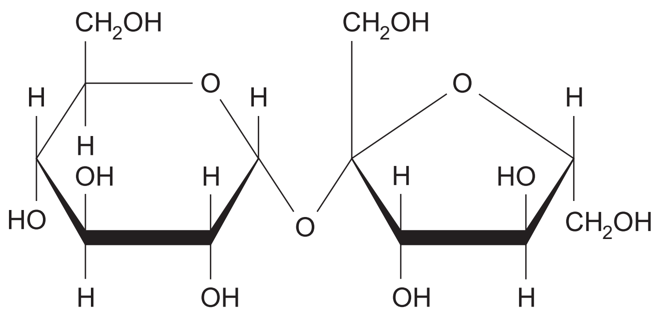
13

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

Stereoisomerism in organic compounds

Stereoisomerism in organic compounds often involves the presence of a chiral centre but this is not always the reason for different isomers being possible. The existence of stereoisomers can be useful but it can have serious effects in biological systems.

Sucrose is a sugar with the formula below.



Sucrose can be hydrolysed to produce two simpler sugars – glucose and fructose. The hydrolysis of sucrose can be carried out by merely heating the sugar with water but it is much quicker if an enzyme or an acid is used as a catalyst. The extent to which hydrolysis has occurred can be followed using the fact that sucrose does not contain an aldehyde group but glucose and fructose both exist in a form that includes this functional group.

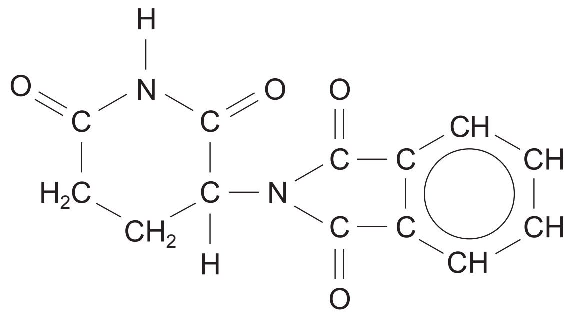
The hydrolysis can also be monitored by using the fact that sucrose, glucose and fructose all exist in forms that are optically active. The table shows data for this optical activity.

Sugar	Angle of rotation for 1 mol dm^{-3} solution
sucrose	+66.5°
glucose	+52.8°
fructose	−92.0°

The solution that is formed after the complete hydrolysis of sucrose is called invert sugar.

Examiner only

15 Thalidomide is a drug that has a wide range of valuable medical uses. Its formula is below.



This molecule contains a chiral centre and therefore has two optical isomers. One of the isomers is safe but the other one is dangerous to the foetus if taken by pregnant women. It is possible to prepare only the safe isomer but, in the body, a racemic mixture is produced.

- End of passage -

(a) What is *stereoisomerism*? *(line 1)* [1]

....

....

(b) Suggest a chemical method by which an analytical chemist could identify that sucrose has been hydrolysed. *(line 8)* [2]

....

....

....

(c) (i) Explain what is meant by *optical activity* and the significance of the sign in the table of data. *(line 12)* [2]

....

....

....

(ii) Use the data to explain why a rotation of −39.2° is seen when the hydrolysis of sucrose is complete. [2]

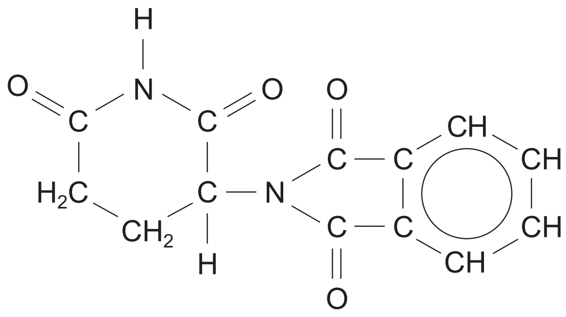
....

....

....

Examiner only

(d) Mark with an asterisk (*) the chiral centre on the thalidomide molecule below. [1]



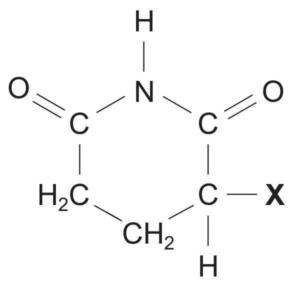
(e) State what happens when a racemic mixture is formed from a sample containing only one isomer. *(lines 17-19)*

You should include suitable diagrams of a simple molecule of your choice. [2]

....

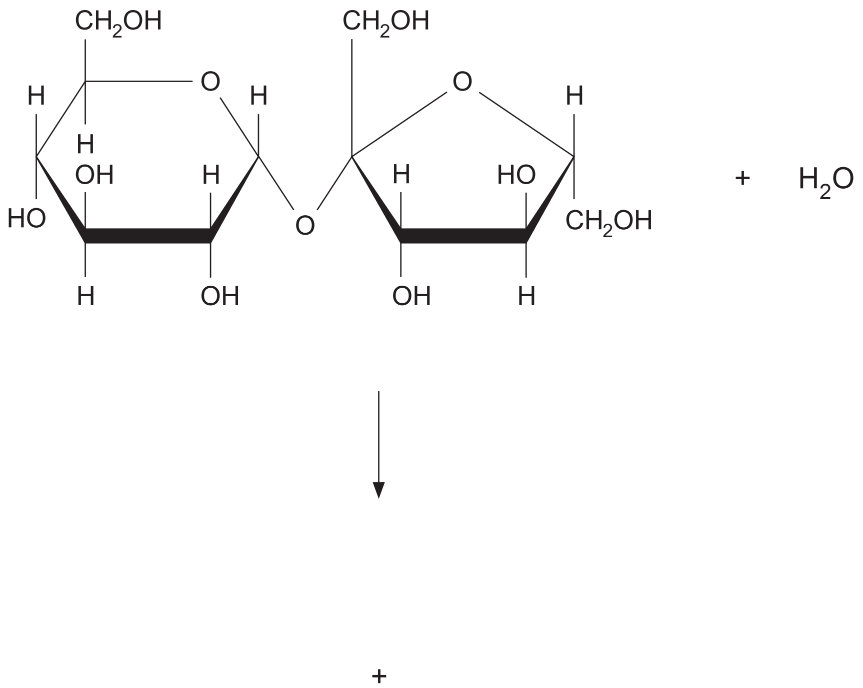
....

(f) The formula below shows part of the thalidomide molecule (with the other part being replaced by the letter **X**). Draw the structural formula of a product formed when this molecule is heated with dilute aqueous hydrochloric acid. [2]



Examiner only

(g) (i) Complete the equation to show clearly the difference in structure between glucose and fructose. You do **not** need to state which structure is which isomer. *(line 6)* [1]



(ii) Explain why sucrose, glucose and fructose are all very soluble in water. [2]

....

....

....

Total [15]

15

Total Section A [40]

SECTION B

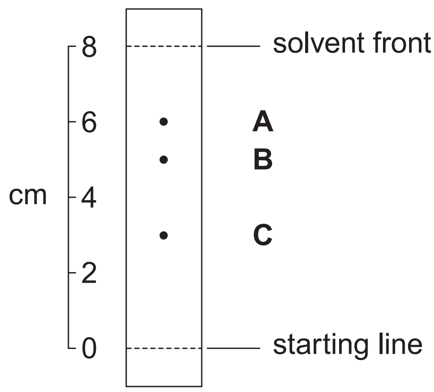
Answer **both** *questions in the separate answer book provided.*

4. There are many different types of chromatography and spectroscopy that can be used to investigate the identity and structure of unknown substances. In this question you will consider some of these techniques.

(a) Explain briefly how the peaks in NMR spectra and the absorptions in IR spectra are formed. [3]

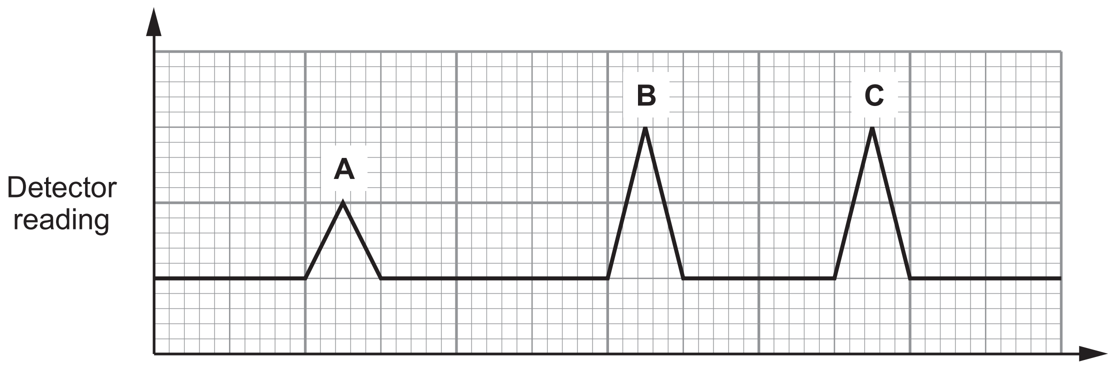
(b) A sample of unknown substances was investigated using different chromatographic techniques.

(i) Thin layer chromatography gave the chromatogram shown below.



Calculate the R_f value for the substance that gives the spot labelled **B**. [1]

(ii) Gas chromatography gave the chromatogram shown below.

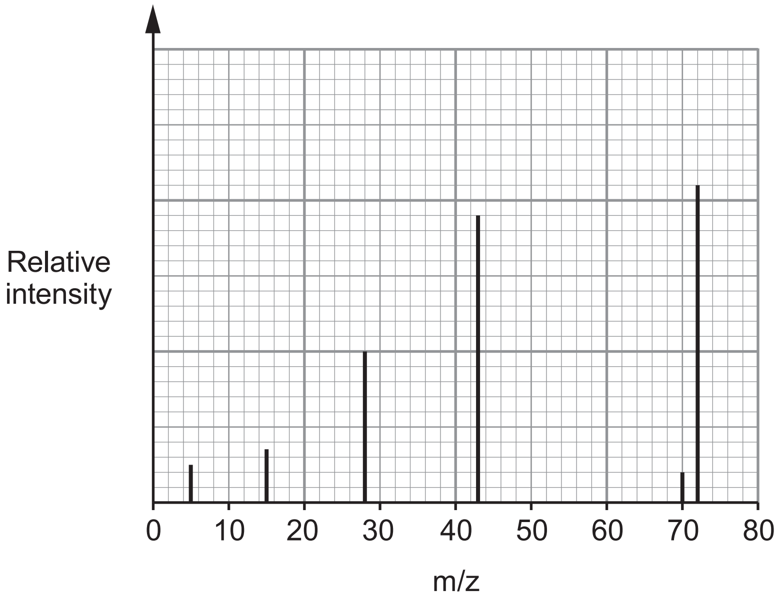


I. What label should be used for the x-axis? [1]

II. Use the chromatogram to estimate the percentage of compound **A** in the sample. Explain how you reached this conclusion. [2]

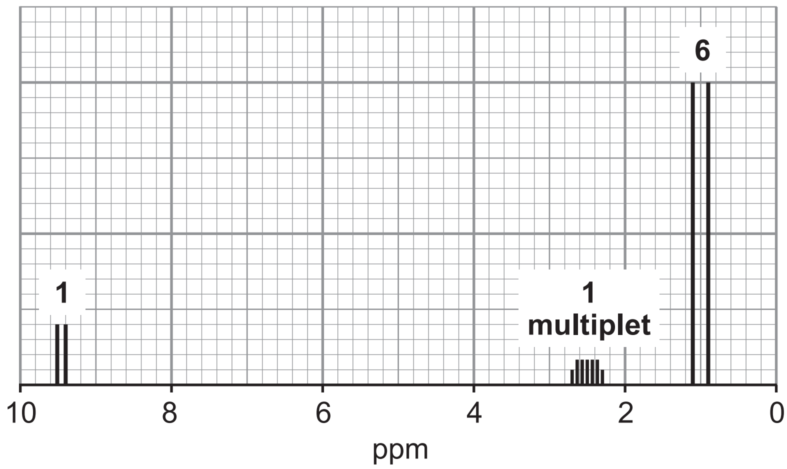
(iii) Thin layer chromatography and gas chromatography give different information about unknown substances. Describe what information can be obtained from each type of chromatography. [2]

(c) (i) A compound **Y** contains carbon, hydrogen and oxygen. It has 66.7 % by mass of carbon. The mass spectrum of compound **Y** is below.



Use these data to determine the molecular formula of compound **Y**. Explain your reasoning. [4]

(ii) The NMR spectrum of compound **Y** is below.



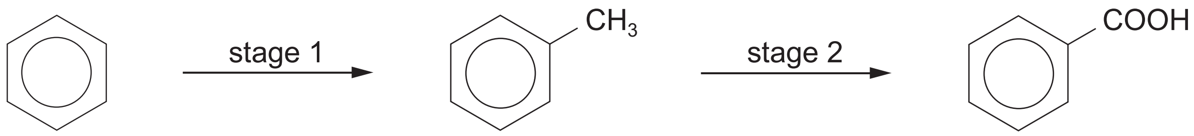
Use this spectrum to determine as much information as possible about the structure of compound **Y**. [4]

QWC [2]

(iii) Use your answers to parts (i) and (ii) to give the structural formula of compound **Y**. [1]

Total [20]

5. Benzene can be made into benzenecarboxylic acid (benzoic acid) using a two-stage process.



(a) Stage 1 proceeds using a mechanism that is similar to that of the halogenation of benzene. Describe the reaction in stage 1. You should include

- the reagent(s) needed
- the type of reaction
- the conditions needed
- details of the mechanism. [7]

(b) Stage 2 involves refluxing methylbenzene with alkaline potassium manganate(VII), filtering the mixture whilst it is still hot and then adding hydrochloric acid. This produces a white precipitate of benzoic acid.

(i) Explain what is meant by *reflux*. [2]

(ii) Write the **balanced** equation for the reaction in stage 2 – the oxidation of methylbenzene to benzoic acid. Use [O] to represent alkaline potassium manganate(VII). [1]

(iii) Apart from neutralising any excess alkali, why is hydrochloric acid added after filtration? [1]

(iv) Benzoic acid is very much more soluble in hot water than it is in cold water. Use this fact to describe how you would purify the benzoic acid produced in stage 2. [3]

(v) Describe a method to show if the benzoic acid is now pure. [1]

(vi) A student used 10.0 g of benzene to prepare benzoic acid as described above. He obtained 3.8 g of pure benzoic acid. Calculate the percentage yield of this process. [3]

(vii) The percentage yield obtained in this particular preparation is usually low. Describe **two** reasons why this percentage yield is low, even if the reaction is carried out carefully. [2]

Total [20]

Total Section B [40]

END OF PAPER

GCE A level

1094/01-A

S16-1094-01A

CHEMISTRY – DATA SHEET
FOR USE WITH CH4

P.M. TUESDAY, 14 June 2016

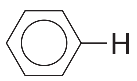
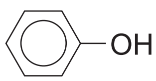
Infrared Spectroscopy characteristic absorption values

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_3-CCl_2-	2.0 to 2.5
$-CH_2-C(=O)-$	2.0 to 3.0
$R-CCl_2-CH_2-C(=O)Cl$	2.5 to 3.0
$R-CH_2-Cl$	3.3 to 4.3
$R-OH$	4.5 *
$CH_2=C<$	4.8
	6.5 to 7.5
	7.0 *
$R-C(=O)H$	9.8 *
$R-C(=O)OH$	11.0 *

*variable figure dependent on concentration and solvent

THE PERIODIC TABLE

Group

s Block · d Block · p Block

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La ▸ Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

Key

A_r — relative atomic mass Symbol Name Z — atomic number

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