Rewarding Learning

ADVANCED
General Certificate of Education
2024

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit A2 2
assessing
Organic Chemistry

MV18

[AZ021]

WEDNESDAY 5 JUNE, AFTERNOON

Time

1 hour 45 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write on blank pages.
Complete in black ink only.
Answer **all six** questions.

Information for Candidates

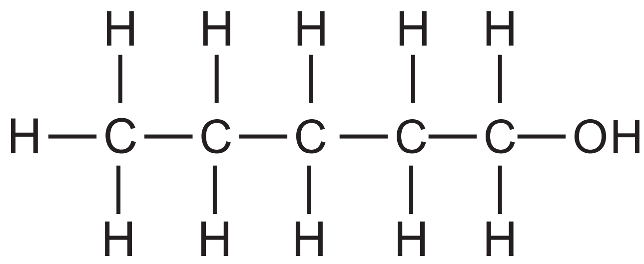
The total mark for this paper is **100**.
Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.
A Periodic Table of Elements is included in this question paper.
You may use an electronic calculator.
Quality of written communication will be assessed in question **3(c)**.

1 Three alcohols, **A**, **B** and **C**, have the same molecular formula ($C_5H_{11}OH$) but a different structural formula.

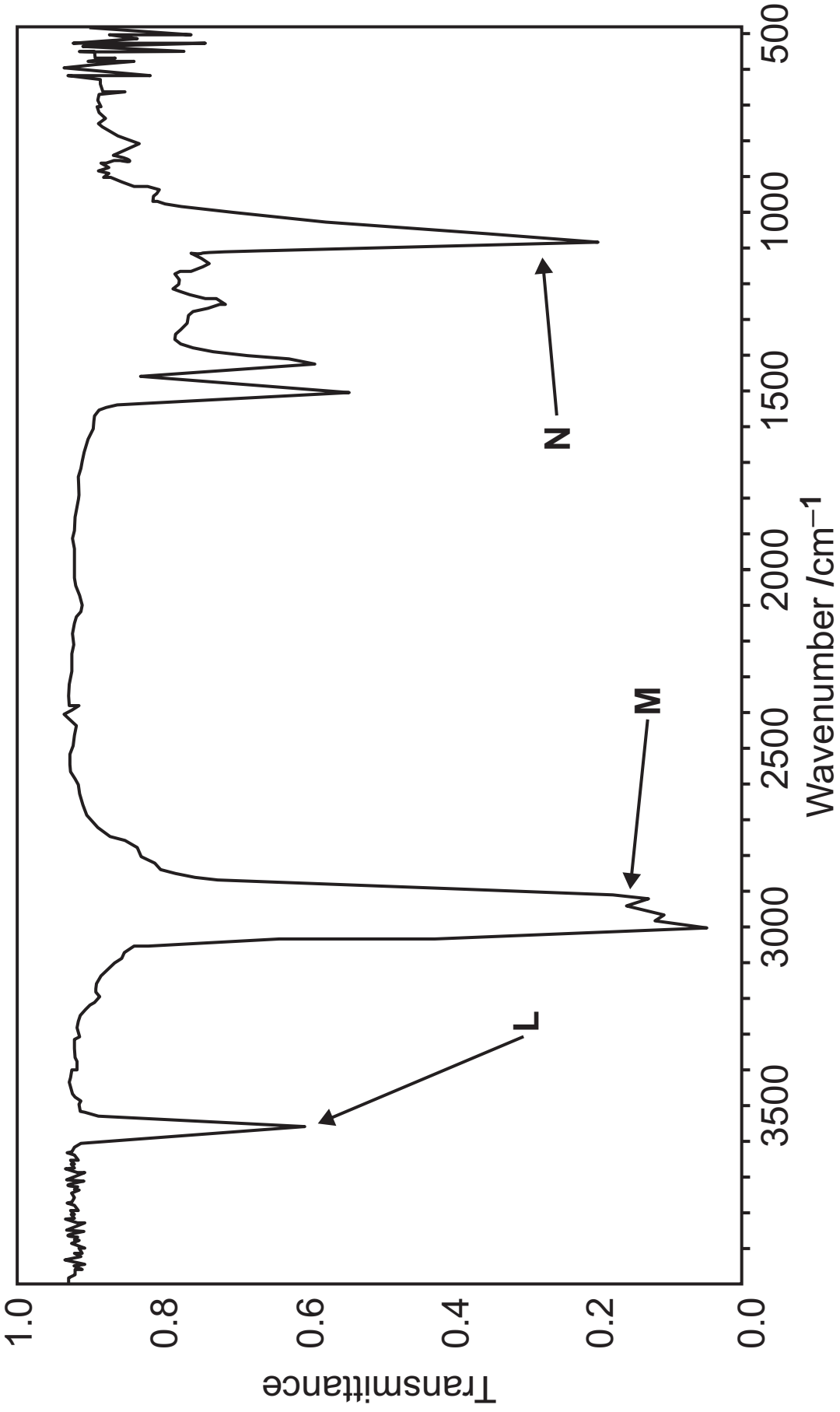
(a) What term is used to describe molecules which have the same molecular formula but a different structural formula? [1 mark]

_____

(b) Complete the table opposite for alcohols **A**, **B** and **C**. [6 marks]

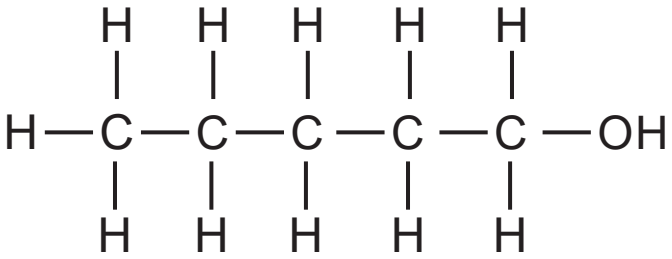
Alcohol	IUPAC name	Structural formula	Classification
A			
B	3-methylbutan-2-ol		
C			tertiary

(c) The infrared (IR) spectrum of alcohol **A** and the table of characteristic absorbances in IR spectroscopy are shown below and opposite.



Wavenumber /cm^{-1}	Bond	Compound
550 – 850	C—X (X = Cl,Br,I)	Halogenoalkanes
750 – 1100	C—C	Alkanes, alkyl groups
1000 – 1300	C—O	Alcohols, carboxylic acids
1600 – 1700	C=C	Alkenes
1650 – 1800	C=O	Carboxylic acids, aldehydes, ketones
2500 – 3200	O—H	Carboxylic acids
2750 – 2850	C—H	Aldehydes
2850 – 3000	C—H	Alkanes, alkyl groups, alkenes
3200 – 3600	O—H	Alcohols

Using the structural formula of alcohol **A** as shown below, identify the bonds responsible for the absorbances **L**, **M** and **N**. [3 marks]



L _____

M _____

N _____

2 This question is about alkenes and some of their reactions.

(a) (i) State the general formula of the homologous series of alkenes. [1 mark]

_____

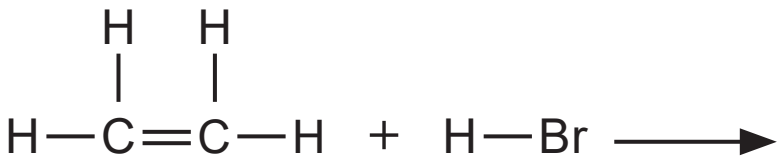
(ii) State the name of the bond present in alkenes that causes them to be more reactive than alkanes. [1 mark]

_____

(b) Ethene is an alkene that reacts with hydrogen bromide.

(i) Complete the structural equation for the reaction of ethene with hydrogen bromide.

State the IUPAC name of the organic product formed. [2 marks]



IUPAC name of organic product

_____

(ii) Name the type of mechanism occurring when ethene reacts with hydrogen bromide. [2 marks]

_____

(c) Propene forms an addition polymer, polypropene.

(i) Draw a section of the polymer polypropene showing three repeating units. [2 marks]

(ii) Polypropene is chemically inert and its disposal, in landfill or by incineration, can lead to environmental problems.

State two ways chemists are limiting the problems associated with polymer disposal. [2 marks]

1. _____

_____

2. _____

_____

(d) Hex-1-ene reacts with water in an addition reaction.

(i) Name this type of addition reaction. [1 mark]

_____

(ii) Draw the structural formula of hex-1-ene. [1 mark]

(iii) State the name of the catalyst used in the reaction of hex-1-ene with water and suggest the IUPAC name of the product formed. [3 marks]

Catalyst _____

IUPAC name _____

3 This question is about hydrocarbons and their reactions.

(a) Three reactions involving hydrocarbons, some of which are saturated, are shown below.

Reaction 1

$$C_{10}H_{22} \longrightarrow C_4H_8 + C_6H_{14}$$

Reaction 2

$$CH_3(CH_2)_7CH_3 \longrightarrow CH_3CH(CH_3)C(CH_3)_2CH(CH_3)_2$$

Reaction 3

$$C_5H_{10} + \mathbf{X} \longrightarrow C_5H_{12}$$

(i) Define the term **saturated**. [1 mark]

_____

_____

(ii) Name the process that is occurring in **Reaction 1**. [1 mark]

_____

(iii) State the IUPAC name of both products in **Reaction 1**. [2 marks]

C_4H_8 _____

C_6H_{14} _____

(iv) Name the process that is occurring in **Reaction 2**. [1 mark]

_____

(v) Draw the skeletal formula of the product of **Reaction 2**. [1 mark]

(vi) In **Reaction 3**, name the reagent **X** and the catalyst used. [2 marks]

Reagent **X** _____

Catalyst _____

(vii) Name the homologous series to which C_5H_{12} in **Reaction 3** belongs. [2 marks]

Explain your answer.

Homologous series _____

Explanation _____

_____

(viii) Describe a practical method used to distinguish between C_5H_{10} and C_5H_{12}. [3 marks]

_____

_____

_____

_____

_____

_____

(b) Hydrocarbons such as octane are found in crude oil and have traditionally been used as fuels.

(i) Name the process used to separate hydrocarbon fuels from crude oil. [1 mark]

_____

(ii) Write a balanced symbol equation for the combustion of octane (C_8H_{18}) in a plentiful supply of air. [2 marks]

_____

(iii) State the names of two **other** products that may form if the combustion of C_8H_{18} is carried out in a **limited** supply of air. [2 marks]

1. _____

2. _____

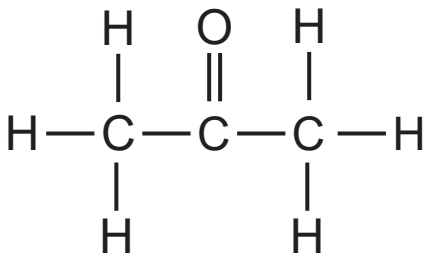
(c) Alternative fuels derived from renewable resources such as plants are increasingly being used to replace traditional non-renewable fossil fuels composed mostly of hydrocarbons.

- State the names of two alternative fuels which are derived from plants.
- Explain why alternative fuels derived from plants are described as renewable.
- Compare and contrast the use of alternative fuels and traditional fossil fuels and their effect on the environment. [6 marks]

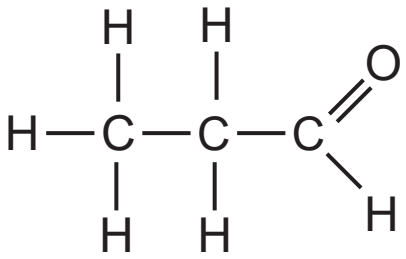
Quality of written communication will be assessed in this question.

4 The structural formula of five compounds, **P**, **Q**, **R**, **S** and **T**, are given below.

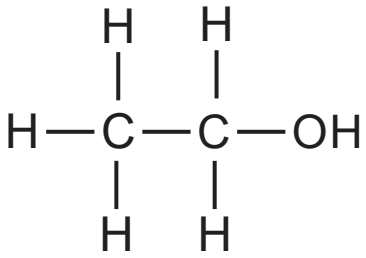
P



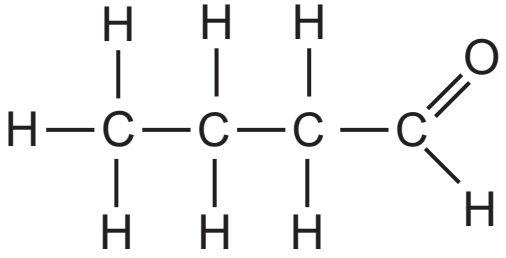
Q



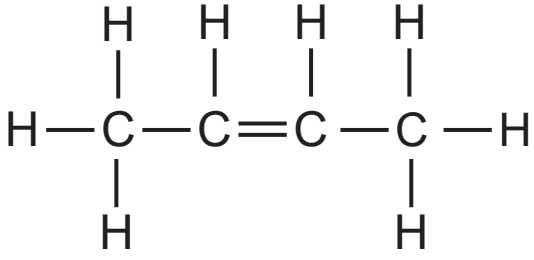
R



S



T



(a) Compounds **P** and **Q** both contain a C═O bond.

(i) State the IUPAC name of compounds **P** and **Q**.
[2 marks]

P _____

Q _____

(ii) Benedict's solution can be used to distinguish between compounds **P** and **Q**.

State what is observed when compounds **P** and **Q** are each warmed with Benedict's solution.
[3 marks]

_____

_____

_____

(b) Compound **R** is an alcohol.

(i) State the general formula of the homologous series of alcohols. [1 mark]

_____

(ii) What name is given to the OH functional group present in alcohols? [1 mark]

_____

(iii) Write a balanced symbol equation for the dehydration of compound **R** and state the IUPAC name of the organic product formed. [2 marks]

IUPAC name _____

(c) Compound **R** undergoes an oxidation reaction.

(i) Define the term **oxidation**. [1 mark]

(ii) Describe practically how compound **R** could be oxidised in the laboratory. [3 marks]

(iii) Write a structural equation for the **complete** oxidation of compound **R**. [2 marks]

Use [O] to represent a suitable oxidising agent.

(d) Compound **S** can be prepared by the oxidation of an alcohol.

(i) Name the homologous series to which compound **S** belongs. [1 mark]

_____

(ii) Draw the skeletal formula of the alcohol that can be oxidised to form compound **S**. [1 mark]

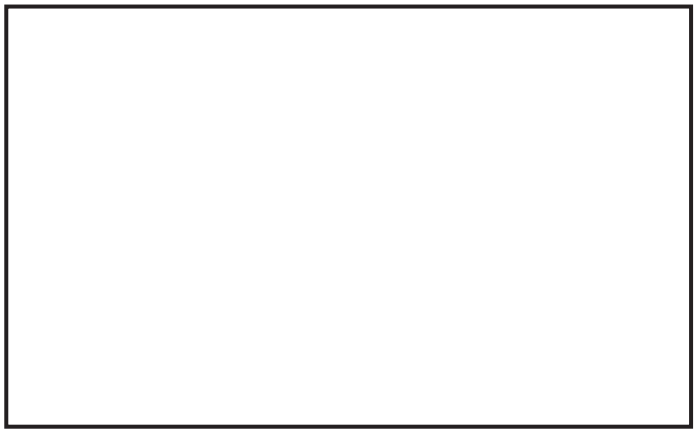
(e) Compound **T** exists as two geometric isomers.

(i) State the IUPAC name of **T**. [1 mark]

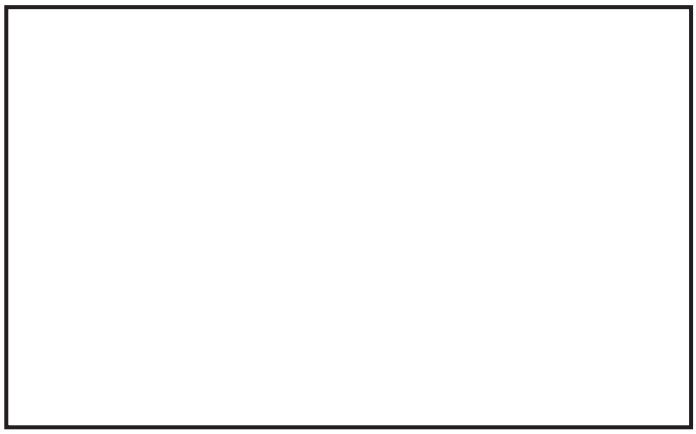
_____

(ii) Draw the structural formula of the E and Z forms of the two geometric isomers of compound **T**.
[2 marks]

E



Z



5 This question is about the preparation of alcohols.

(a) (i) Name the process used to prepare alcoholic drinks from a solution of sugars. [1 mark]

_____

(ii) State three of the conditions needed for this process to be successful. [3 marks]

1. _____

2. _____

3. _____

(b) Alcohols can also be prepared by refluxing halogenoalkanes with an excess of sodium hydroxide solution.

(i) Define the term **reflux**. [1 mark]

(ii) Write a balanced structural equation for the preparation of propan-2-ol from 2-bromopropane and sodium hydroxide. [2 marks]

(iii) Suggest how the propan-2-ol prepared in this reaction can be separated from the reaction mixture. [1 mark]

(c) The alcohol methanol can be prepared in a two step process.

Step 1: methane and chlorine react to form chloromethane.
Step 2: catalytic hydrolysis of chloromethane forms methanol.

(i) Write a balanced symbol equation for **Step 1**. [1 mark]

_____

(ii) Define the term **hydrolysis**. [1 mark]

_____

_____

6 Ethanoic anhydride is used in the laboratory preparation of a variety of organic compounds.

(a) The information opposite shows the reaction that occurs in the laboratory preparation of aspirin using ethanoic anhydride.

(i) Name reactant **A** and product **B**. [2 marks]

A _____

B _____

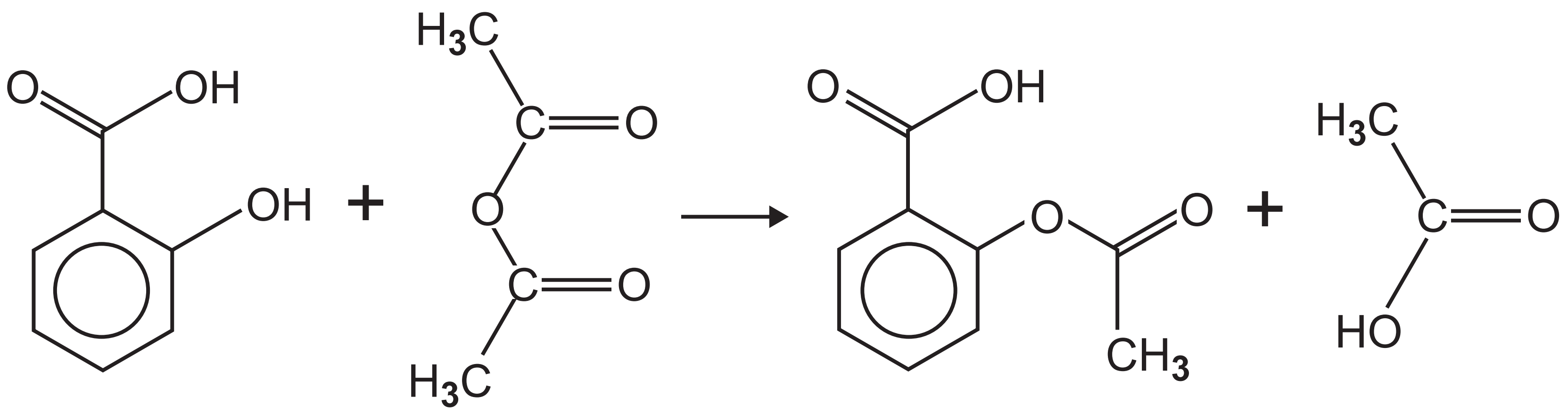
(ii) In a reaction, 6.80 g of **A** was reacted with an excess of ethanoic anhydride.

Calculate the theoretical yield of aspirin in this reaction. [2 marks]

Give your answer to **3 significant figures**.

You are advised to show your working.

Theoretical yield _____ g

Equation				
Compound name	**A**	ethanoic anhydride	aspirin	**B**
Relative Molecular Mass	138	102	180	60

(iii) 5.96 g of aspirin was prepared using a different mass of reactant **A**.

The theoretical yield of aspirin was calculated as 9.60 g.

Show that the percentage yield for this preparation is 62.1**%**. [1 mark]

(iv) Suggest two possible reasons why the percentage yield was not 100**%**. [2 marks]

1. _____

_____

2. _____

_____

(b) Aspirin prepared in the laboratory needs to be purified.

(i) Name the process used to purify aspirin that has been prepared in the laboratory. [1 mark]

_____

(ii) Initially, in the purification process, the impure sample of aspirin must be dissolved.

What is done to ensure that all the aspirin has dissolved and it can be easily crystallised again? [2 marks]

_____

_____

(iii) The mixture is then gravity filtered hot to remove insoluble impurities.
The filtrate is then cooled using crushed ice.

Explain why the filtrate is cooled. [1 mark]

_____

(iv) Describe how **all** the **soluble** impurities are then quickly removed. [2 marks]

_____

_____

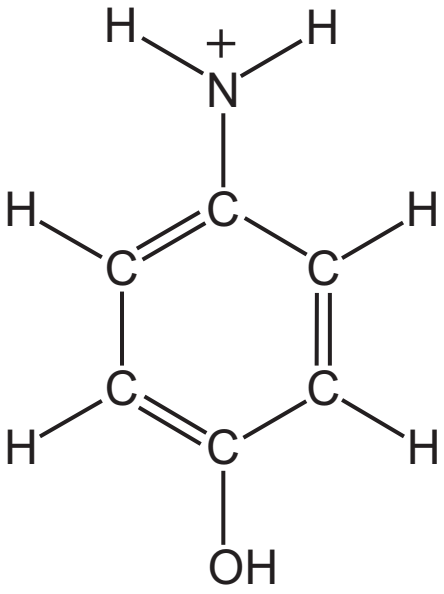
_____

(v) What can be determined to show that the sample of aspirin is pure? [1 mark]

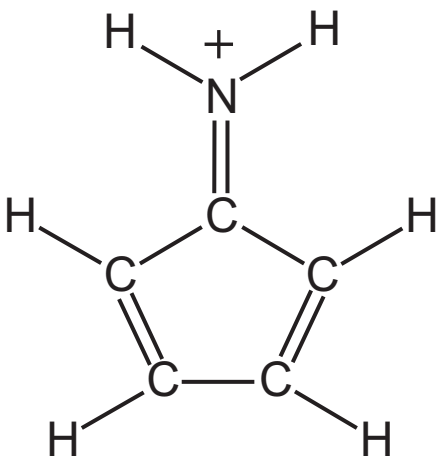
_____

(c) Paracetamol can also be made in a laboratory using ethanoic anhydride.

(i) The mass spectrum of paracetamol and the structural formula of two of the fragments labelled **X** and **Y** are given below and opposite.



X

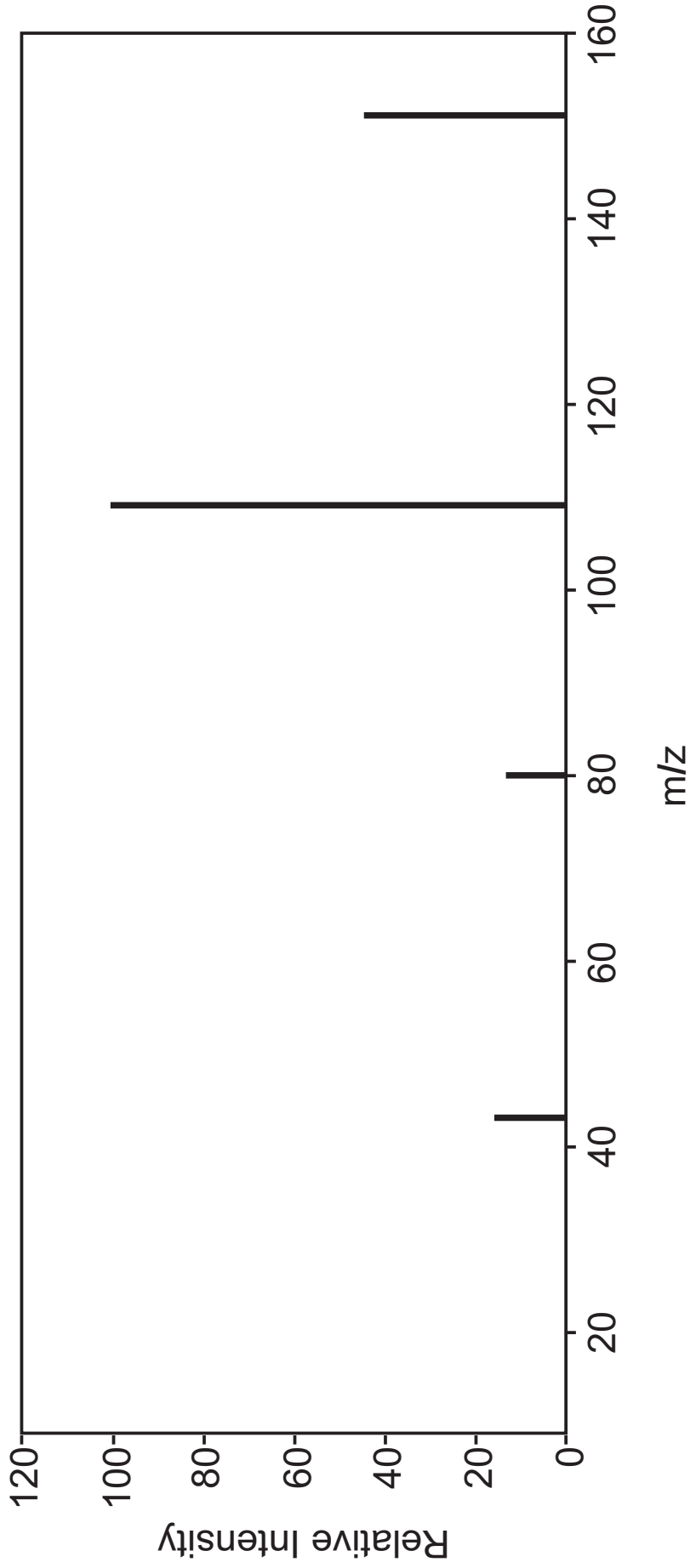


Y

Identify the m/z value of the peak which relates to each fragment. [2 marks]

Fragment **X** _____

Fragment **Y** _____


Relative Intensity
0
20
40
60
80
100
120
m/z
20
40
60
80
100
120
140
160

(ii) The empirical formula of paracetamol is also its molecular formula.

Determine the **molecular formula** of paracetamol using the following percentage composition by mass. [5 marks]

Element	**% of element by mass**
C	63.58
H	5.96
N	9.27
O	21.19

You are advised to show your working.

Molecular formula _____

This is the end of the question paper

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
Total Marks	

Examiner Number

Rewarding Learning

AS 3 and A2 2

Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gce a/as examinations

life & health sciences

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29 Clarendon Road, Clarendon Dock, Belfast BT1 3BG
Tel: +44 (0)28 9026 1200 Fax: +44 (0)28 9026 1234
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Rewarding Learning

11409.02

Subject Code: 0008

THE PERIODIC TABLE OF ELEMENTS

I	II											III	IV	V	VI	VII	0
Group																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 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
133 Cs Caesium 55	137 Ba Barium 56	139 La* Lanthanum 57	178 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
223 Fr Francium 87	226 Ra Radium 88	227 Ac† Actinium 89	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
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

* 58–71 Lanthanum series

† 90–103 Actinium series

a
b x

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

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