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ADVANCED

General Certificate of Education

2022

Centre Number

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Candidate Number

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Life and Health Sciences

Assessment Unit A2 2

assessing

Organic Chemistry



AZ021

[AZ021]

MONDAY 13 JUNE, AFTERNOON

TIME

1 hour 45 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all five** questions.

Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

Your attention is drawn to the Data leaflet which is used with the question paper.

You may use an electronic calculator.

Quality of written communication will be assessed in Question **3(e)(ii)**.

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

Total Marks	
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1 Many organic chemicals such as saturated hydrocarbons are obtained from crude oil. Crude oil is separated into simpler mixtures of hydrocarbons using fractional distillation.

(a) What is meant by the term saturated hydrocarbons?

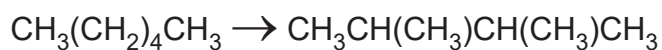
_____ [2]

(b) Explain how fractional distillation is used to separate crude oil.

_____ [2]

(c) Once separated, hydrocarbons may be further processed.

One processing reaction is shown below.



(i) Name the process occurring in this reaction.

_____ [1]

(ii) State the IUPAC name of the reactant and the product.

$\text{CH}_3(\text{CH}_2)_4\text{CH}_3$ _____

$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{CH}_3$ _____ [2]

Examiner Only

Marks

Remark

2 The equations below show some organic reactions.

The letters **W**, **X**, **Y** and **Z** represent organic compounds.

Reaction	Equation
1	trichloromethane + chlorine \rightarrow W + hydrogen chloride
2	$C_{10}H_{22} \rightarrow 2C_4H_8 + X$
3	$CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$
4	hex-2-ene + hydrogen \rightarrow Y
5	$CH_3CH_2CH_2CH_2OH \rightarrow Z + H_2O$

(a) Write the molecular formula for **W** in Reaction 1 and state its IUPAC name.

molecular formula _____

IUPAC name _____ [2]

(b) Name the type of reaction which is occurring in Reaction 1.

_____ [1]

(c) Write the molecular formula of **X** in Reaction 2 and state its IUPAC name.

molecular formula _____

IUPAC name _____ [2]

(d) Name the type of reaction occurring in Reaction 2.

_____ [1]

(e) State the IUPAC name of CH_3CH_2CHO in Reaction 3.

_____ [1]

Examiner Only

Marks Remark

- (f) Name a suitable reagent to carry out Reaction 3 and state the type of reaction occurring.

Reagent: _____

Type of reaction: _____ [3]

- (g) Suggest the name of the mechanism for Reaction 4.

_____ [2]

- (h) Identify Y in Reaction 4.

_____ [1]

- (i) Write a balanced symbol equation for Reaction 4.

_____ [1]

- (j) Name a suitable catalyst for Reaction 4.

_____ [1]

- (k) Name the type of reaction occurring in Reaction 5.

_____ [1]

- (l) Name a suitable catalyst for Reaction 5.

_____ [1]

- (m) Draw the structural formula of Z in Reaction 5 and state its IUPAC name.

structural formula

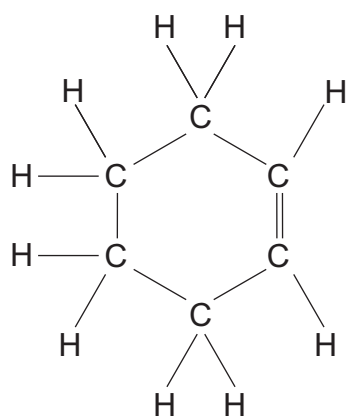
IUPAC name _____ [2]

Examiner Only

Marks Remark

(d) The compound below is also unsaturated.

It is a liquid at room temperature.



(i) What is the IUPAC name for this molecule?

_____ [1]

(ii) Write the molecular formula for this compound.

_____ [1]

(iii) Describe how you would test this liquid compound for unsaturation and state all the observations which would be made.

_____ [3]

Examiner Only

Marks Remark

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(Questions continue overleaf)

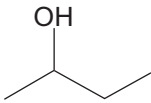
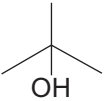
4 Alcohols may be classified as primary, secondary or tertiary.

(a) (i) State the difference between a primary and secondary alcohol.

_____ [1]

There are four alcohols with the molecular formula C_4H_9OH .

(ii) Complete the table below for these alcohols.

Name	Skeletal formula	Classification
butan-1-ol		Primary
		
2-methylpropan-1-ol		Primary
		

[6]

(b) Propan-2-ol (boiling point 83°C) may be prepared by heating a mixture of 2-bromopropane (boiling point 59°C) and sodium hydroxide solution under reflux.

Anti-bumping granules are also added to the mixture.

(i) Write a symbol equation for the preparation of propan-2-ol from 2-bromopropane.

_____ [2]

Examiner Only

Marks Remark

- (ii) Draw a labelled diagram of the assembled apparatus used for heating under reflux.

Examiner Only

Marks Remark

[4]

- (iii) What is meant by heating under reflux?

_____ [1]

- (iv) What is the purpose of the anti-bumping granules?

_____ [1]

- (v) How could propan-2-ol be separated from the reaction mixture after heating under reflux?

_____ [1]

- (vi) State one impurity which may be present in the alcohol collected.

_____ [1]

(c) The molecular formula of an alcohol, **R**, is the same as its empirical formula.

(i) Determine the empirical formula of alcohol **R** using the following percentage composition by mass.

element	percentage composition by mass /%
carbon	68.18
hydrogen	13.64
oxygen	18.18

empirical formula = _____ [4]

(ii) Explain how the empirical formula of alcohol **R** shows that the molecular formula is the same as the empirical formula.

_____ [1]

Examiner Only	
Marks	Remark

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(Questions continue overleaf)

5 Aspirin may be prepared from salicylic acid and ethanoic anhydride.

The equation below shows the reaction along with the relative formula masses (RFM) of the reactants and aspirin.



salicylic acid
RFM = 138

ethanoic anhydride
RFM = 102

aspirin
RFM = 180

(a) State the IUPAC name of the product with formula CH_3COOH .

_____ [1]

(b) The procedure below describes the main steps in the preparation of an impure sample of aspirin.

Place 20.0 g of salicylic acid in a dry pear-shaped flask and add 40.0 cm³ of ethanoic anhydride.

Add 5 cm³ of concentrated phosphoric acid slowly. Heat the mixture under reflux for 20–30 minutes.

Add water and pour the mixture onto crushed ice.

Remove the impure aspirin by suction filtration.

(i) What is the role of the concentrated phosphoric acid?

_____ [1]

(ii) Why is the concentrated phosphoric acid added slowly?

_____ [2]

(iii) Why is water added after heating under reflux?

_____ [1]

(iv) Why is suction filtration used instead of gravity filtration?

_____ [1]

Examiner Only

Marks Remark

(c) Describe how you would test the impure aspirin sample for the presence of salicylic acid impurities. Include the colour change observed.

[3]

(d) Describe how the impure aspirin may be recrystallised using the solvent ethanol.

[4]

Examiner Only

Marks	Remark

(e) 20.0 g of aspirin was obtained when 20.0 g of salicylic acid was reacted with excess ethanoic anhydride.

(i) Calculate the theoretical yield.

theoretical yield = _____ g [2]

(ii) Calculate the percentage yield.

percentage yield = _____ % [1]

Examiner Only

Marks Remark

- (g) The table below shows the characteristic absorptions in infrared (IR) spectroscopy.

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, esters, carboxylic acids
1600 – 1700	C=C	Alkenes
1650 – 1800	C=O	Carboxylic acid, esters, aldehydes, ketones, acid anhydrides
2500 – 3200	O—H	Carboxylic acids
2750 – 2850	C—H	Aldehydes
2850 – 3000	C—H	Alkanes, alkyl groups, alkenes, benzene compounds
3200 – 3600	O—H	Alcohols

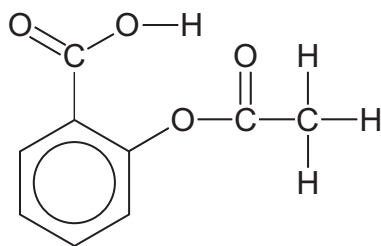
IR Spectrum for Aspirin

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Examiner Only

Marks Remark

The structure of aspirin is shown below. Identify the bonds responsible for the peaks in the IR spectrum for aspirin labelled **A**, **B** and **C**.



Peak **A** _____

Peak **B** _____

Peak **C** _____

[3]

THIS IS THE END OF THE QUESTION PAPER

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Marks

Remark

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AS 3 and A2 2
Periodic Table of the Elements

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

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kind. No other type of data booklet or information
sheet is authorised for use in the examinations**

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THE PERIODIC TABLE OF ELEMENTS

Group

I	II											III	IV	V	VI	VII	0
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	x
b	

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number