Rewarding Learning

ADVANCED

General Certificate of Education

2023

Centre Number

Candidate Number

Life and Health Sciences

AZ021

Assessment Unit A2 2

assessing

Organic Chemistry

[AZ021]

WEDNESDAY 14 JUNE, MORNING

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 six** 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 **5(b)**.

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

Examiner Only	
Marks	Remark

1 **(a)** Crude oil is a mixture of hydrocarbons that is transported around the world in ships.

(i) State two negative environmental effects associated with an oil spill that occurs at sea.

1. _____

_____

2. _____

_____ [2]

(ii) Define the term **hydrocarbon**.

_____

_____ [1]

(iii) Explain how fractional distillation can be used to separate the compounds in crude oil into fractions, some of which are used as fuels.

_____

_____

_____

_____

_____

_____ [3]

(iv) Name another process that is used to obtain alkane fuels from the hydrocarbons in crude oil.

_____ [1]

Examiner Only	
Marks	Remark

(b) The saturated hydrocarbon 2,2,4-trimethylpentane (C_8H_{18}) is used as a fuel.

(i) Define the term **saturated**.

_____

_____ [1]

(ii) To which homologous series does 2,2,4-trimethylpentane belong?

_____ [1]

(iii) Write a balanced symbol equation for the complete combustion of 2,2,4-trimethylpentane (C_8H_{18}).

_____ [2]

(c) Combustion of impure hydrocarbon fuels can lead to the formation of products which are considered pollutants.

Name a pollutant from the combustion of impure hydrocarbons that is toxic, and another that causes acid rain.

Pollutant that is toxic: _____

Pollutant that causes acid rain: _____ [2]

(d) Car exhausts are fitted with a device that changes nitrogen dioxide into less harmful products.

(i) Name the device fitted to car exhausts.

_____ [1]

(ii) Write a balanced symbol equation for the reaction which converts nitrogen dioxide into less harmful products.

_____ [2]

(iii) Name the type of reaction described in **(ii)**.

_____ [1]

(e) Alternative fuels made from plants have been developed to have a lower environmental impact than the alkane fuels, petrol or diesel.

Examiner Only	
Marks	Remark

(i) Name two alternative fuels that are made from plants.

1. _____

2. _____ [2]

(ii) Suggest why alternative fuels made from plants may be considered less polluting than alkane fuels.

_____

_____ [1]

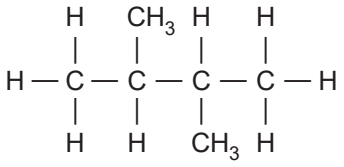
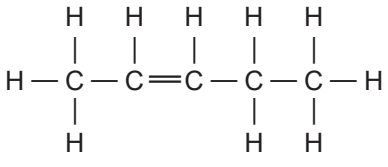
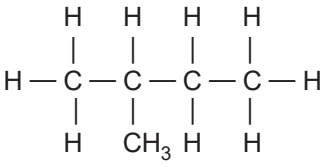
(iii) Suggest why alternative fuels made from plants are less widely used than petrol or diesel.

_____

_____ [1]

Examiner Only	
Marks	Remark

2 **(a)** The structural formula of three organic compounds, **X**, **Y** and **Z** are listed below.

X	**Y**	**Z**
		

(i) Draw the skeletal formula of **X**.

[1]

(ii) State the IUPAC name of **Y**.

_____ [1]

(b) Compounds **Y** and **Z** both exist as colourless liquids at room temperature and pressure.

(i) Name a reagent that could be used to distinguish between them.

_____ [1]

(ii) State the colour change that is observed when the reagent described in **(i)** reacts with compound **Y**.

_____ to _____ [1]

(iii) Explain why the reagent described in **(i) does not react** with compound **Z**.

_____

_____ [1]

Examiner Only	
Marks	Remark

3 Organic compounds react in a range of different ways depending on the functional group that is present.

(a) Ethene readily reacts with hydrogen bromide.

(i) Explain, **with reference to the bonds present in ethene**, why hydrogen bromide is described as an electrophile in this reaction.

_____

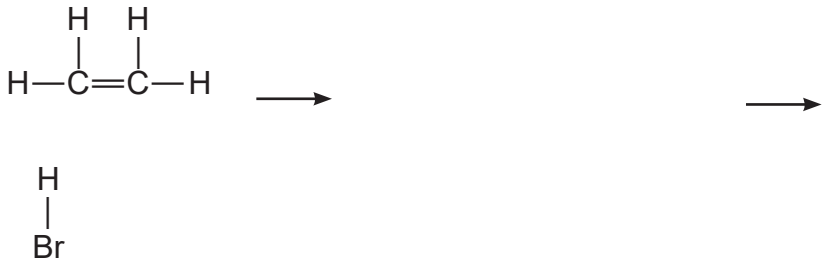
_____

_____

_____ [3]

(ii) Complete the mechanism for the reaction of ethene with hydrogen bromide.

Reactants **Intermediates** **Product**



Examiner Only	
Marks	Remark

[5]

(iii) State the IUPAC name of the **product** formed in **(ii)**.

_____ [1]

(iv) What is the general name for the type of **organic intermediate** formed in **(ii)**?

_____ [1]

(b) Alkenes such as propene will react with hydrogen in an exothermic reaction.

(i) Write a balanced symbol equation for the reaction of propene with hydrogen.

_____ [1]

(ii) Name the catalyst used in this reaction.

_____ [1]

(iii) Name the type of reaction taking place when an alkene, such as propene, reacts with hydrogen.

_____ [1]

(iv) State a practical application for this **type** of reaction.

_____ [1]

(c) Dichloromethane is an important solvent that can be made by reacting methane with chlorine in a photo-catalysed reaction.

(i) Write a balanced symbol equation for the reaction of methane with chlorine forming dichloromethane.

_____ [2]

(ii) Suggest why this is described as a photo-catalysed reaction.

_____

_____ [1]

Examiner Only

Marks	Remark

(d) Butanal can be produced by the oxidation of butan-1-ol.

(i) State the molecular formula of butanal.

_____ [1]

(ii) Name the homologous series to which butanal belongs.

_____ [1]

(iii) Butanal produced by oxidation should be removed from the reaction mixture as soon as it forms.

Name the practical technique used to remove the butanal.

_____ [1]

(iv) Name a reagent that can be used to show that the compound produced is butanal and not butanoic acid.

_____ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

4 **(a)** The alkene hex-3-ene can exist as two geometric isomers.

(i) Draw the structural formula of the two geometric isomers and classify each as E or Z.

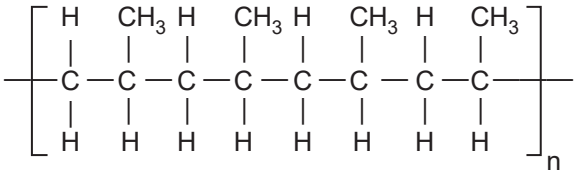
_____ _____ [3]

(ii) Explain why hex-1-ene **does not** exist as geometric isomers.

_____

_____ [1]

(b) A section of the chain of a non-biodegradable polymer is shown below.



(i) Draw the structural formula and state the IUPAC name of the monomer used to make this polymer.

IUPAC name: _____ [2]

(ii) State a major environmental impact associated with the incineration of polymers and explain how it can be reduced.

Environmental impact: _____

How it is reduced: _____

_____ [2]

(c) Polylactic acid (PLA) is a type of biodegradable polymer known as a bioplastic.

Suggest why bioplastics such as polylactic acid (PLA) are biodegradable.

_____

_____ [2]

(d) An unknown hydrocarbon was found to contain 85.7% carbon by mass.

(i) Determine the empirical formula of the hydrocarbon.

Empirical formula: _____ [3]

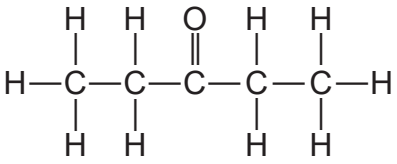
(ii) The relative molecular mass of the hydrocarbon is 126.

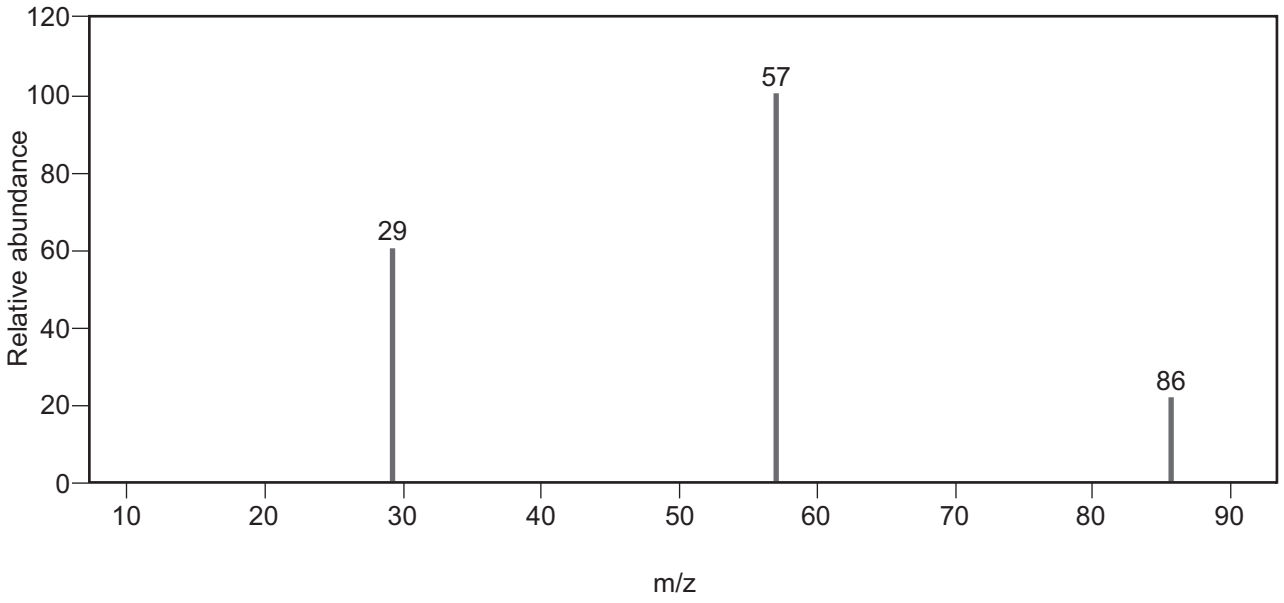
Determine the molecular formula of the hydrocarbon.

Molecular formula: _____ [1]

Examiner Only	
Marks	Remark

(e) The structural formula and mass spectrum of pentan-3-one are shown below.





Source: Principal Examiner

Examiner Only	
Marks	Remark

(i) On the mass spectrum for pentan-3-one circle the **base peak**. [1]

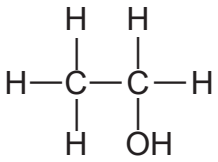
(ii) Draw the structural formulae of the fragment ions that cause the peaks at m/z values of 29 and 57.

m/z = 29	m/z = 57

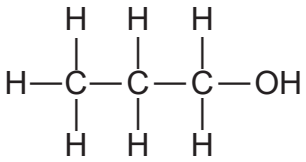
[2]

5 This question is about the homologous series of alcohols.

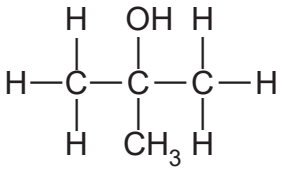
(a) The structural formula of four alcohols labelled **A** to **D** are drawn below.



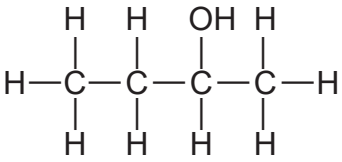
A



B



C



D

Examiner Only	
Marks	Remark

(i) What is the general formula for an alcohol?

_____ [1]

(ii) Explain why alcohol **D** is a secondary alcohol.

_____

_____ [1]

(iii) State the IUPAC name of alcohol **B**.

_____ [1]

(iv) Draw the structural formula of a straight chain isomer of alcohol **D**.

[1]

(v) State and explain which of the alcohols **A** to **D** could not be oxidised by refluxing it with acidified potassium dichromate(VI).

Alcohol: _____

Explanation: _____ [2]

(vi) The molecular formula for alcohol **D** is $C_4H_{10}O$.
Explain why this is also its empirical formula.

_____

_____ [1]

(vii) Alcohols can undergo an elimination reaction called dehydration.
Name the catalyst used in this reaction.

_____ [1]

(viii) Write a balanced symbol equation for the dehydration of alcohol **A**.

_____ [1]

(ix) State the IUPAC name of the organic product in **(viii)**.

IUPAC name: _____ [1]

Examiner Only	
Marks	Remark

(b) Ethanol can be produced industrially by the hydration of ethene using steam or the fermentation of sugars in solution.

- Describe the conditions used in the hydration of ethene using steam.
- Describe the conditions used in the fermentation of sugars in solution.
- Compare the methods. You may wish to refer to yield, purity and speed.

Quality of written communication will be assessed in this question.

Description of the hydration of ethene using steam.

Description of the fermentation of sugars in solution.

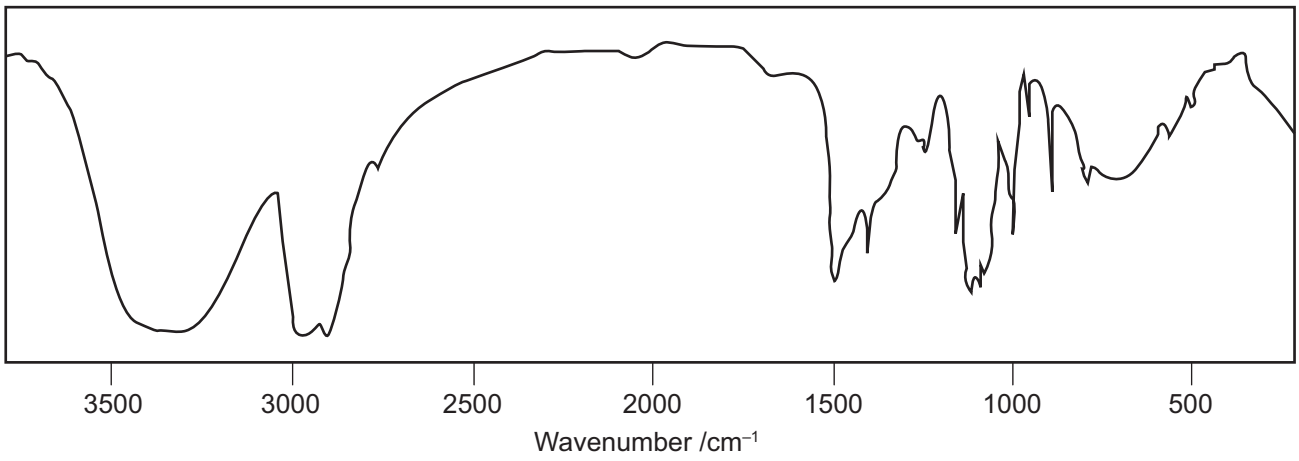
Comparison of methods of production.

[6]

Examiner Only

Marks	Remark

(c) The infrared (IR) spectrum of a compound is shown below.



Source: Principal Examiner

(i) What label should go on the ***y*-axis** of the infrared (IR) spectrum above?

_____ [1]

Wavenumber /cm^{-1}	Bond
750 – 1100	C-C (alkanes, alkyl groups)
1000 – 1300	C-O (alcohols, carboxylic acids)
1650 – 1800	C=O (carboxylic acids, aldehydes, ketones)
2500 – 3200	O-H (carboxylic acid)
2750 – 2850	C-H (aldehydes)
2850 – 3000	C-H (alkanes, alkyl groups, alkenes)
3200 – 3600	O-H (alcohols)

(ii) Using the table above, explain **fully** why the infrared (IR) spectrum could be that of butan-1-ol but not butanoic acid.

_____

_____

_____

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

6 Nylon and aspirin are compounds that can be produced on a small scale in a laboratory.

(a) Nylon is an important polymer that can be prepared from 1,6-diaminohexane and hexanedioyl dichloride.

A section of the practical method is given below.

- *2.2 g of 1,6-diaminohexane was dissolved in distilled water.*
- *1.5 g of hexanedioyl dichloride was dissolved in cyclohexane.*
- *5 cm^3 of the aqueous solution was poured into a 25 cm^3 beaker.*
- *5 cm^3 of the cyclohexane solution was carefully poured on top.*

(i) Name the type of polymerisation reaction used to produce nylon.

_____ [1]

(ii) Draw the structural formula for cyclohexane.

[1]

(iii) Explain why the cyclohexane solution was carefully poured on top of the aqueous solution.

_____

_____ [1]

(iv) State where the greyish film of nylon forms and describe how it can be collected.

_____

_____

_____ [2]

(b) Aspirin can be prepared and purified in the laboratory from salicylic acid and ethanoic anhydride.

(i) Describe how the melting point of aspirin prepared in a laboratory can be determined.

_____

_____

_____

_____

_____ [3]

(ii) The melting point of pure aspirin is 135ºC. If the sample of aspirin produced contained impurities, how would this affect the melting point?

_____

_____ [1]

(c) After recrystalising their aspirin, a student wanted to check if their sample contained any remaining unreacted salicylic acid impurities.

(i) Name the chemical that can be used to check for salicylic acid impurities.

_____ [1]

(ii) State the colour change observed if a sample containing salicylic acid impurities was tested with the reagent in **(i)**.

_____ to _____ [1]

(iii) The student's method required them to:

"*Wash crystals with a small volume of distilled water to remove soluble impurities.*"

At this point some of the aspirin dissolved and was lost.

Suggest an improvement that could be made to this step that would minimise the amount of aspirin that is lost through dissolving.

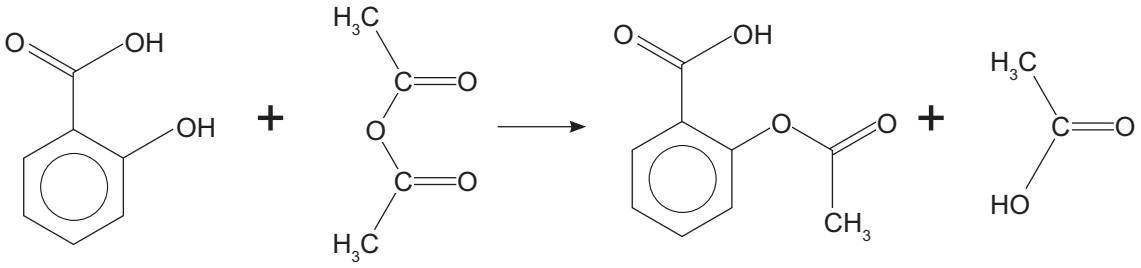
_____

_____ [1]

Examiner Only	
Marks	Remark

(d) 4.05 g of purified aspirin was made by reacting salicylic acid with an excess of ethanoic anhydride.
The percentage yield for the reaction was 68%.

The equation for the reaction is:



Compound name	salicylic acid	ethanoic anhydride	aspirin	ethanoic acid
Relative Molecular Mass	138	102	180	60

(i) Calculate the student's theoretical yield.

Give your answer to 2 decimal places.

Theoretical yield: _____ g [1]

(ii) Using the equation and relative molecular masses given, calculate the mass of salicylic acid used to produce 4.05g of aspirin.

Give your answer to 2 decimal places.

Mass of salicylic acid: _____ g [3]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

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

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life & health sciences

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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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