



*Rewarding Learning*

**ADVANCED**

General Certificate of Education

2019

Centre Number

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Candidate Number

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## Life and Health Sciences

Assessment Unit A2 2

*assessing*

Organic Chemistry

**MV18**

**[AZ021]**

**TUESDAY 28 MAY, AFTERNOON**

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### **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.

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 at the end of each question 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.

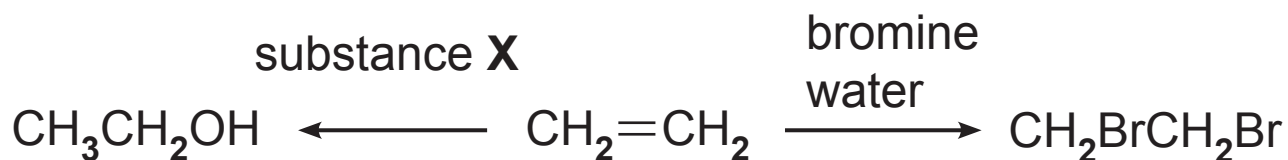
You may use an electronic calculator.

Quality of written communication will be assessed in Question **5(a)**.

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1 Alkanes and alkenes react with halogens. Alkenes also react with hydrogen bromide.

(a) Two reactions of ethene are shown below.



(i) What colour change is observed when ethene reacts with bromine water? [2 marks]

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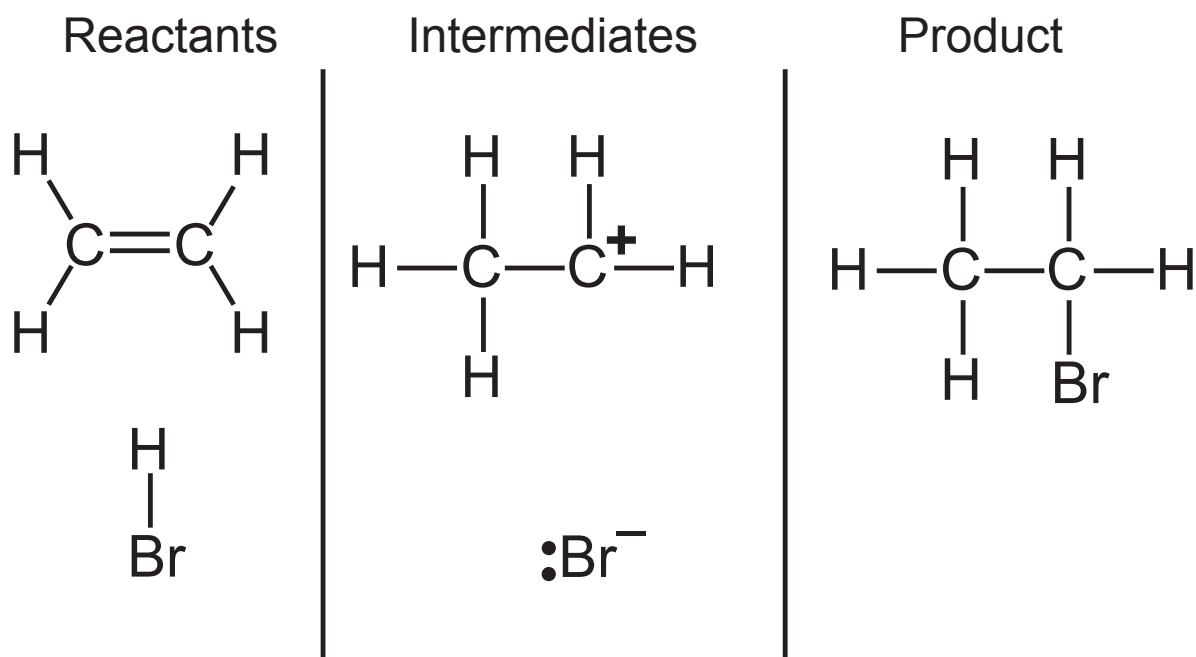
(ii) State the IUPAC name of  $\text{CH}_2\text{BrCH}_2\text{Br}$ . [2 marks]

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(iii) Identify substance X. [1 mark]

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(b) The diagram below shows some details of the mechanism for the reaction of ethene with hydrogen bromide.



(i) In the reactants stage, draw two curly arrows to show the formation of the intermediates. [2 marks]

(ii) What general name is given to the positively charged organic intermediate? [1 mark]

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(iii) In the intermediates stage, draw a curly arrow to show the formation of the product. [1 mark]

(iv) State the IUPAC name of the product. [1 mark]

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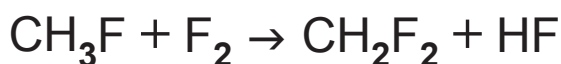
(v) What is the name of this mechanism? [2 marks]

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**(vi)** Write a balanced symbol equation for the reaction of ethene with hydrogen bromide. [1 mark]

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**(c)** Alkanes and halogenoalkanes react with halogens. One reaction which occurs is shown below.



**(i)** State the IUPAC name of  $\text{CH}_3\text{F}$  and  $\text{CH}_2\text{F}_2$ . [1 mark]

$\text{CH}_3\text{F}$  \_\_\_\_\_

$\text{CH}_2\text{F}_2$  \_\_\_\_\_

**(ii)** What name is given to this type of reaction? [1 mark]

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**(iii)** Write a balanced symbol equation for the reaction of methane with fluorine forming tetrafluoromethane. [2 marks]

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2 (a) Four different alcohols, all with the same formula  $C_5H_{11}OH$ , were labelled **A**, **B**, **C** and **D**.

(i) Complete the table giving the IUPAC name, structural formula and classification (P = primary, S = secondary, T = tertiary) for each alcohol.  
[6 marks]

Alcohol	IUPAC name	Structural formula	Classification
<b>A</b>		$  \begin{array}{cccccc}  & H & H & H & H & H \\  &   &   &   &   &   \\  H & -C & -C & -C & -C & -C-OH \\  &   &   &   &   &   \\  & H & H & H & H & H  \end{array}  $	P
<b>B</b>	pentan-2-ol		
<b>C</b>		$  \begin{array}{cccccc}  & H & H & CH_3 & H \\  &   &   &   &   \\  H & -C & -C & -C & -C-OH \\  &   &   &   &   \\  & H & H & H & H  \end{array}  $	P
<b>D</b>		$  \begin{array}{cccccc}  & H & CH_3 & H & H \\  &   &   &   &   \\  H & -C & -C & -C & -C-H \\  &   &   &   &   \\  & H & OH & H & H  \end{array}  $	

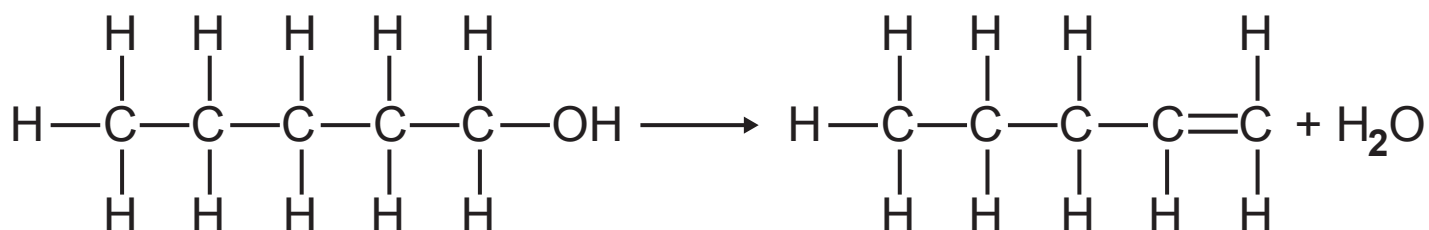
(ii) Which alcohol(s) (**A**, **B**, **C**, **D**) can undergo oxidation to form a ketone? [1 mark]

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- (iii) Draw the structural formula and state the IUPAC name of **another primary alcohol**, apart from alcohols **A** and **C**, which has the formula  $C_5H_{11}OH$ . [2 marks]

IUPAC name: \_\_\_\_\_

- (b) Alcohol **A** from the table in (a)(i) reacts as shown below in the presence of a catalyst.



- (i) Name the type of reaction shown above. [1 mark]

\_\_\_\_\_

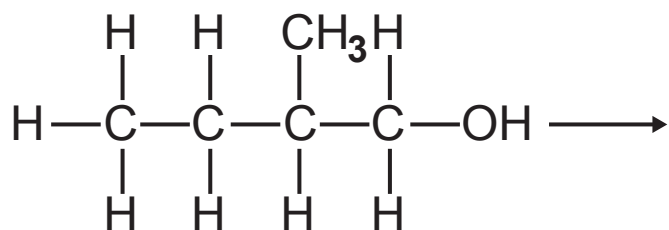
- (ii) State the IUPAC name of the organic product of the reaction. [1 mark]

\_\_\_\_\_

- (iii) Name the catalyst used in this reaction. [2 marks]

\_\_\_\_\_

(iv) Alcohol **C** from the table in (a)(i) on page 6 undergoes the same type of reaction. Complete the equation below for this reaction and state the IUPAC name of the organic product. [2 marks]

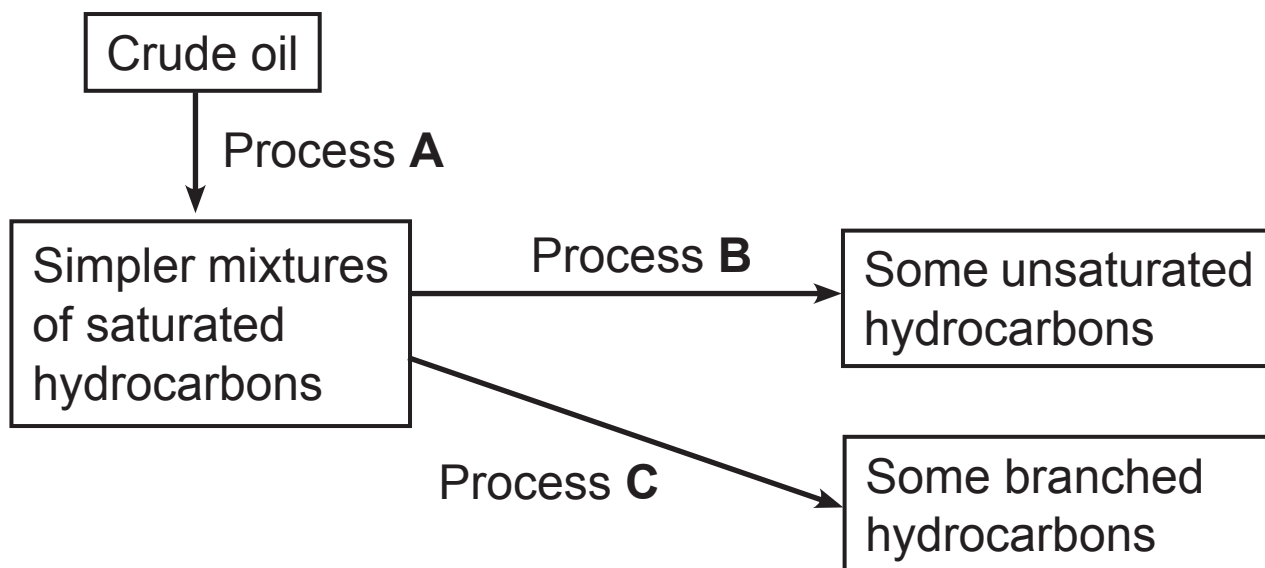


IUPAC name: \_\_\_\_\_

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**(Questions continue overleaf)**

3 Crude oil is a complex mixture of hydrocarbons.

(a) The diagram below shows how crude oil is processed.



(i) Name processes **A**, **B** and **C**. [3 marks]

**A** \_\_\_\_\_

**B** \_\_\_\_\_

**C** \_\_\_\_\_

(ii) What is meant by the term unsaturated? [1 mark]

\_\_\_\_\_

\_\_\_\_\_

(iii) What is meant by the term hydrocarbon? [1 mark]

\_\_\_\_\_

\_\_\_\_\_

**(b)** The IUPAC names of some hydrocarbons are given below.

ethene	octane	hex-2-ene
pentane	propane	but-1-ene

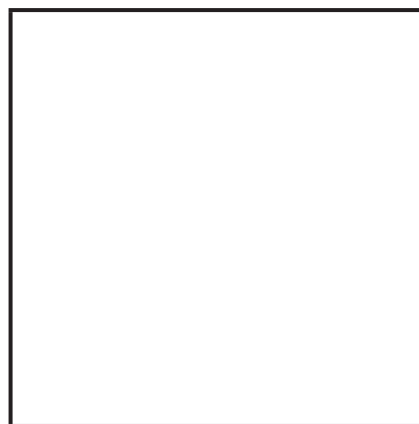
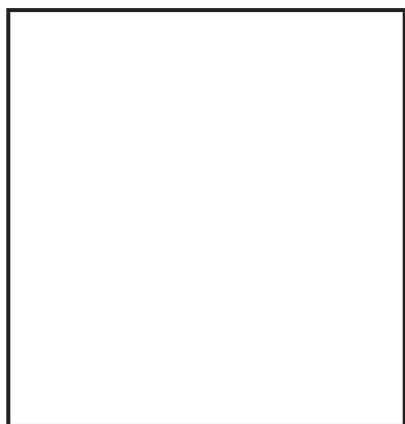
**(i)** Write the names of all the hydrocarbons from the table which are saturated. [1 mark]

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**(ii)** Draw the skeletal formula of hex-2-ene. [1 mark]

**(iii)** Hex-2-ene forms cis-trans isomers. Draw the two isomers in the boxes below and label them appropriately as cis and trans. [3 marks]



\_\_\_\_\_

\_\_\_\_\_

**(iv)** Hex-2-ene reacts with hydrogen. State the catalyst used in this reaction and give the name of the organic product formed. [2 marks]

Catalyst: \_\_\_\_\_

Product: \_\_\_\_\_

**(v)** Draw the structural formula and state the IUPAC name of one branched chain isomer of pentane. [2 marks]

IUPAC name: \_\_\_\_\_

**(vi)** Write a balanced symbol equation for the combustion of pentane in a plentiful supply of air. [2 marks]

\_\_\_\_\_

(c) A sample of 1.16 g of a hydrocarbon contains 0.96 g of carbon. The relative molecular mass of the hydrocarbon is 58. The empirical formula and molecular formula of the hydrocarbon may be determined using the data.

(i) What is meant by the terms empirical formula and molecular formula? [2 marks]

Empirical formula \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Molecular formula \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

- (ii)** Determine the empirical formula of the hydrocarbon.  
[3 marks]

Empirical formula = \_\_\_\_\_

- (iii)** Determine the molecular formula of the hydrocarbon.  
[2 marks]

Molecular formula = \_\_\_\_\_

- (iv)** Name the homologous series to which the hydrocarbon belongs. Explain your answer.  
[2 marks]

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4 Poly(chloroethene) and nylon are polymers.

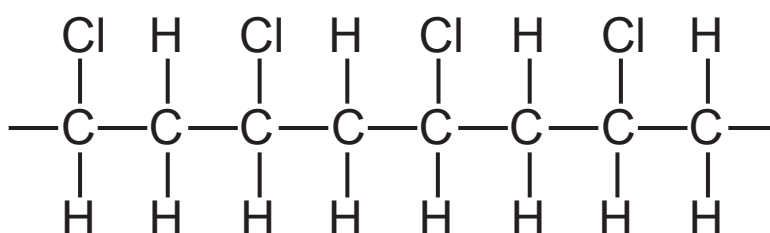
(a) What is meant by the term polymer? [2 marks]

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(b) Part of the structure of poly(chloroethene) is shown below.



(i) Draw the structure of the monomer from which poly(chloroethene) is formed. [1 mark]

(ii) State the type of polymerisation which occurs in forming poly(chloroethene). [1 mark]

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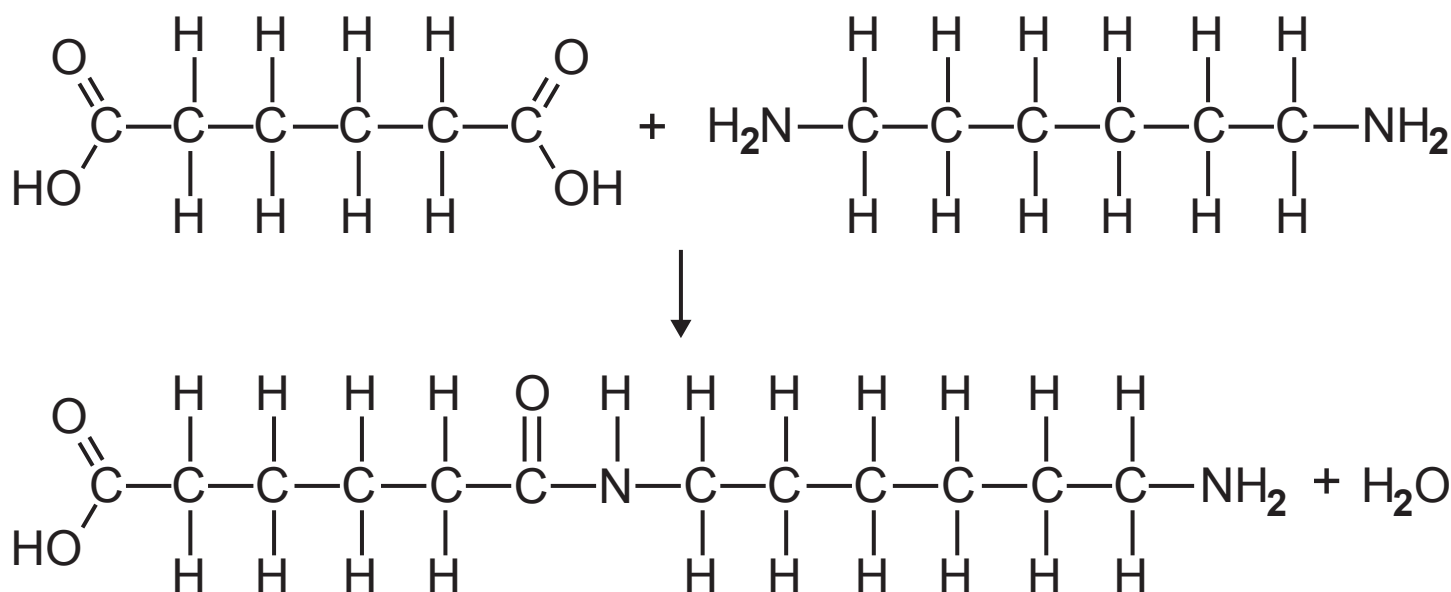
(iii) State one way in which polymer waste is disposed of and explain one advantage of this method of disposal. [2 marks]

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(c) The diagram below shows the reaction between hexanedioic acid and hexane-1,6-diamine. Continued reaction would produce the polymer nylon-6,6.



(i) State the type of polymerisation which occurs to form nylon-6,6. [1 mark]

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(ii) Suggest why the polymer is known as nylon-6,6. [2 marks]

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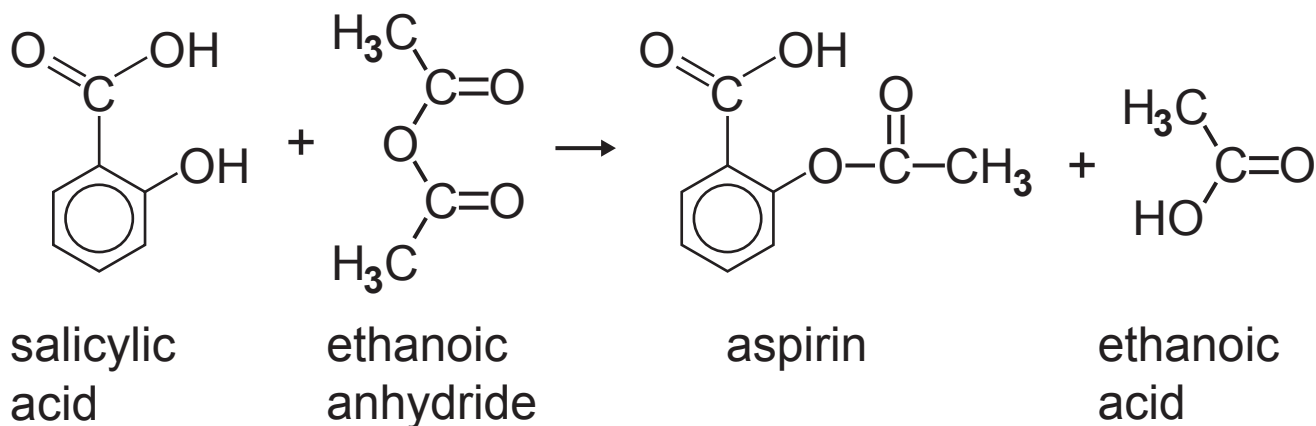
(iii) This type of polymerisation may be reversed when the polymer reacts with water. Suggest the name of this type of reaction. [1 mark]

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**(b)** The reaction below shows the production of aspirin from salicylic acid and ethanoic anhydride. The molecular formula of salicylic acid is  $C_7H_6O_3$  and its relative formula mass is 138.



**(i)** Write the molecular formula of aspirin. [1 mark]

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**(ii)** Calculate the relative formula mass of aspirin. [1 mark]

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**(iii)** In a laboratory experiment 2.25 g of aspirin was obtained. Calculate the number of moles of aspirin obtained. [1 mark]

Moles of aspirin = \_\_\_\_\_

- (iv) State the number of moles of ethanoic anhydride required to produce this number of moles of aspirin.  
[1 mark]

Moles of ethanoic anhydride = \_\_\_\_\_

- (v) During this reaction 0.024 moles of ethanoic anhydride were used. Using your answer to (b)(iv), calculate the percentage of ethanoic anhydride which reacted. Give your answer to 1 decimal place.  
[2 marks]

Percentage of ethanoic anhydride = \_\_\_\_\_ %

- (vi) Suggest **one** reason why not all the ethanoic anhydride reacted. [1 mark]

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- (c) An impure sample of aspirin is purified using the following method.

**Dissolve the sample of aspirin in a minimum volume of hot solvent to increase yield. Filter the mixture through filter paper. Allow the filtrate to cool and crystallise. Filter off the crystals using suction filtration. Dry the crystals and determine their melting point. A pure laboratory sample of aspirin will melt at 139 °C.**

- (i) State a reason why dissolving the sample of aspirin in a minimum volume of hot solvent increases yield. [1 mark]

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- (ii) Draw a labelled diagram of the assembled apparatus used for suction filtration. [4 marks]

**(iii)** State **two** reasons why suction filtration is used rather than gravity filtration for the second filtration. [2 marks]

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

**(iv)** Suggest **two** ways the melting point would be different if there were impurities in the sample of aspirin. [2 marks]

1. \_\_\_\_\_

\_\_\_\_\_

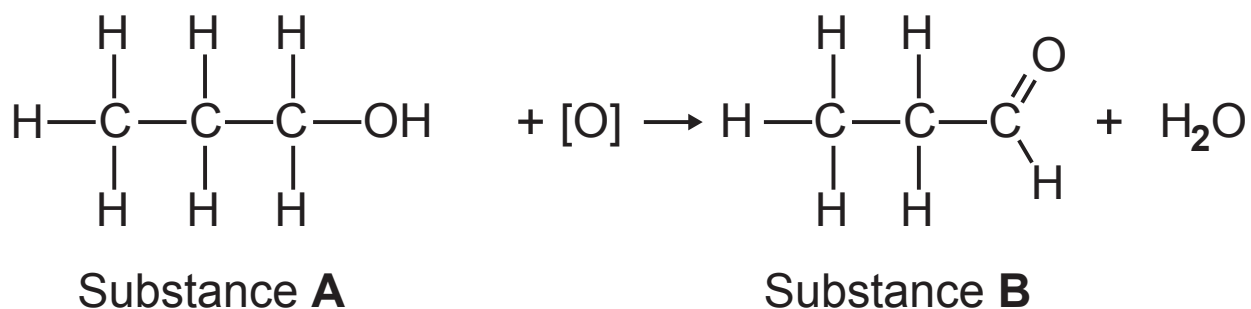
2. \_\_\_\_\_

\_\_\_\_\_

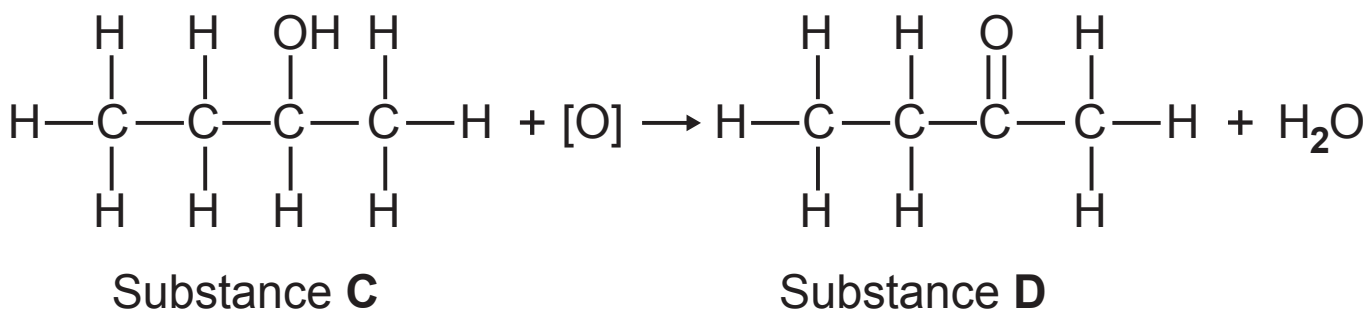
**6** Alcohols can be oxidised to aldehydes, ketones and carboxylic acids depending on the alcohol and the conditions used.

**(a)** Some oxidation reactions of alcohols are shown below where [O] represents a suitable oxidising agent.

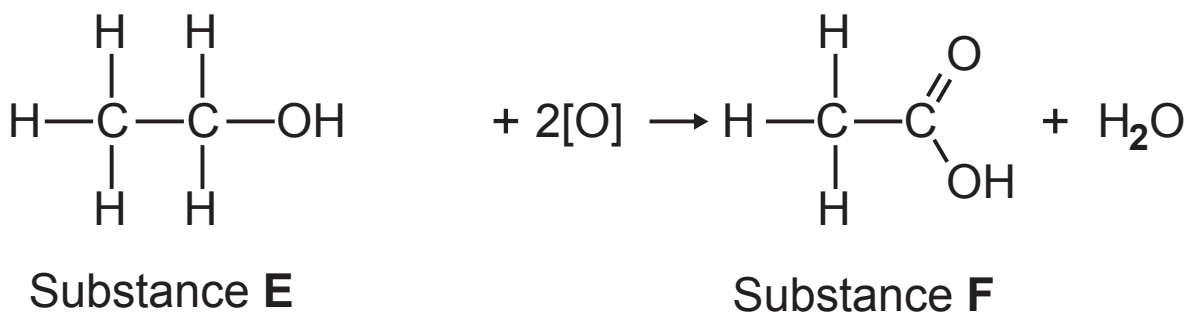
Reaction 1:



Reaction 2:



Reaction 3:



(i) Name a suitable oxidising agent to carry out the oxidation reactions of alcohols. State the colour change observed when the reaction occurs.

[3 marks]

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(ii) State the IUPAC names of substances **B**, **D** and **F**.

[3 marks]

**B** \_\_\_\_\_

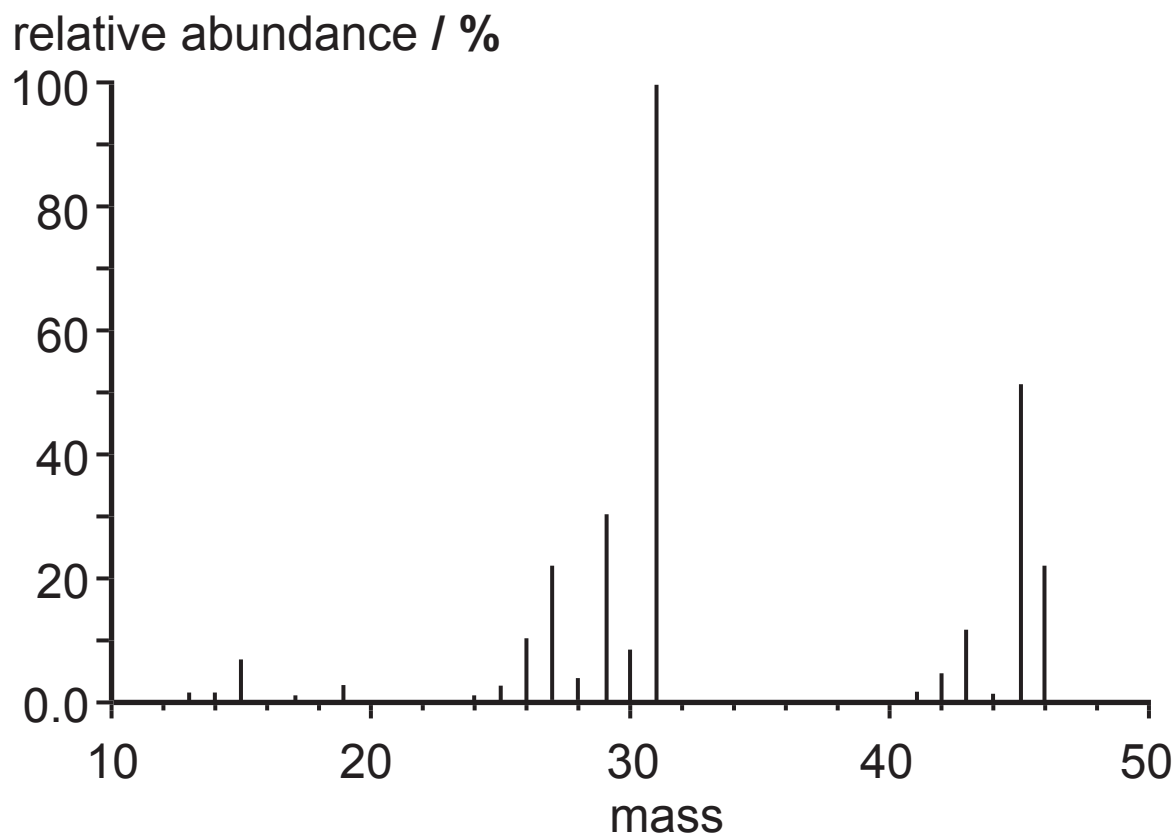
**D** \_\_\_\_\_

**F** \_\_\_\_\_

(iii) Draw the skeletal formula for substance **D**.

[1 mark]

(b) The mass spectrum shown below was obtained for one of the substances **A**, **C** or **E**. The peaks occur at mass values which show the relative formula mass of the molecule and its fragments.



Identify which substance **A**, **C** or **E** would produce this spectrum and explain your answer. [2 marks]

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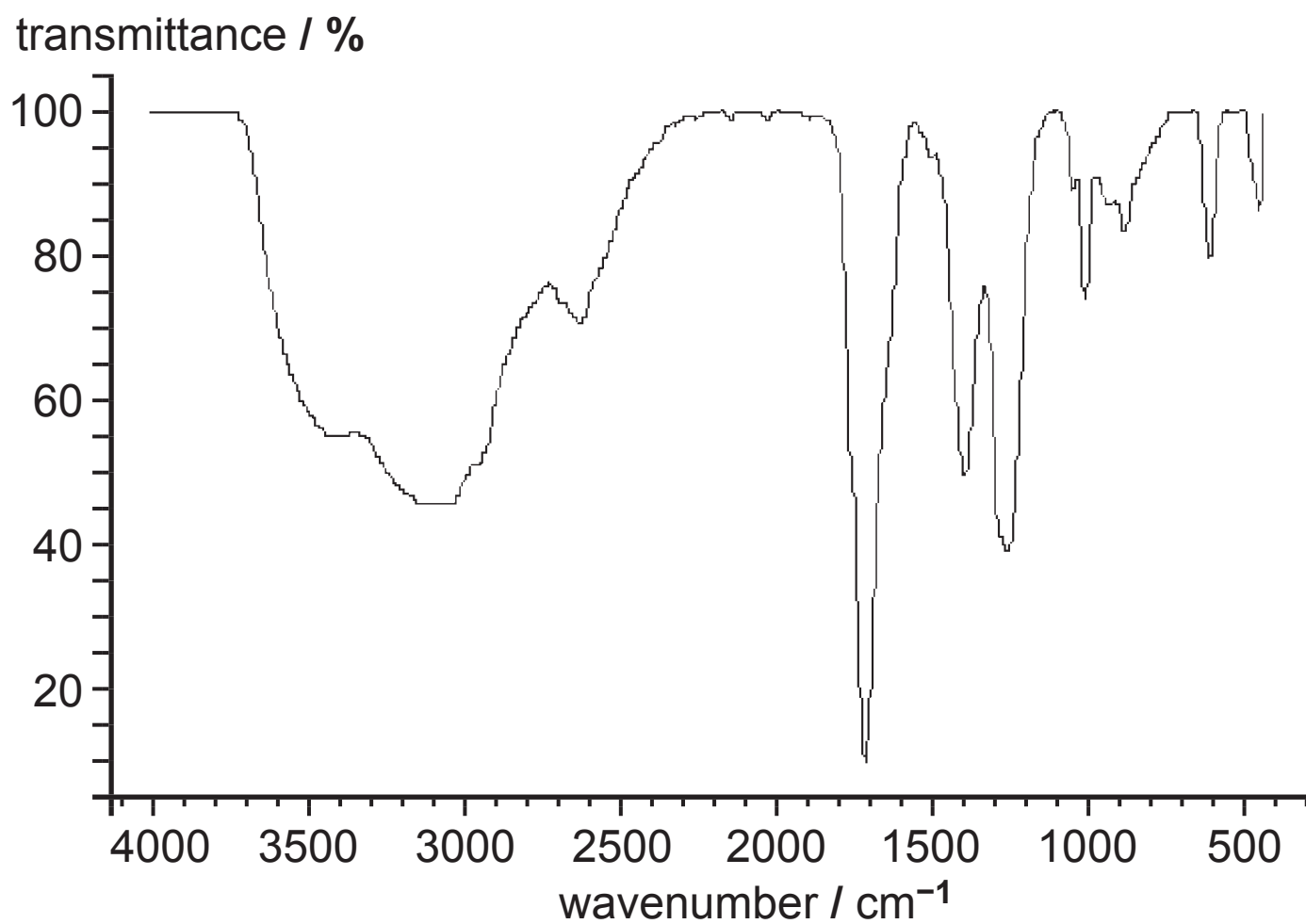
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**(Questions continue overleaf)**

(c) The following infrared (IR) spectrum was obtained from one of the substances **A**, **B**, **C**, **D**, **E** or **F**.



Using the table below identify which substance (A, B, C, D, E or F) would produce this spectrum and explain your answer. [2 marks]

Wavenumber (cm <sup>-1</sup> )	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 acids)
2750 – 2850	C—H (aldehydes)
2850 – 3000	C—H (alkanes, alkyl groups, alkenes)
3200 – 3600	O—H (alcohols)

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**This is the end of the question paper**

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## Sources

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Q6(c)...Graph – Spectrum 1 from © Inspirational chemistry – resources for modern curricula by Vicky Wong. Chapter 7, Analysis, 7.5  
Spectroscopy, page 185. Published by the Royal Society of Chemistry, 2006. <https://pubs.rsc.org/en/content/ebook/978-0-85404-399-6>

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
<b>Total Marks</b>	

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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

**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**

For first teaching from September 2016  
For first award of AS Level in Summer 2017  
For first award of A Level in Summer 2018  
Subject Code: 0008

# THE PERIODIC TABLE OF ELEMENTS

Group

1    2    3    4    5    6    7    8    9    10    11    12    13    14    15    16    17    18

1	<b>H</b> Hydrogen 1															4	<b>He</b> Helium 2																			
7	<b>Li</b> Lithium 3	9	<b>Be</b> Beryllium 4															20	<b>Ne</b> Neon 10																	
23	<b>Na</b> Sodium 11	24	<b>Mg</b> Magnesium 12															40	<b>Ar</b> Argon 18																	
39	<b>K</b> Potassium 19	40	<b>Ca</b> Calcium 20	45	<b>Sc</b> Scandium 21	48	<b>Ti</b> Titanium 22	51	<b>V</b> Vanadium 23	52	<b>Cr</b> Chromium 24	55	<b>Mn</b> Manganese 25	56	<b>Fe</b> Iron 26	59	<b>Co</b> Cobalt 27	59	<b>Ni</b> Nickel 28	64	<b>Cu</b> Copper 29	65	<b>Zn</b> Zinc 30	70	<b>Ga</b> Gallium 31	73	<b>Ge</b> Germanium 32	75	<b>As</b> Arsenic 33	79	<b>Se</b> Selenium 34	80	<b>Br</b> Bromine 35	84	<b>Kr</b> Krypton 36	
85	<b>Rb</b> Rubidium 37	88	<b>Sr</b> Strontium 38	89	<b>Y</b> Yttrium 39	91	<b>Zr</b> Zirconium 40	93	<b>Nb</b> Niobium 41	96	<b>Mo</b> Molybdenum 42	98	<b>Tc</b> Technetium 43	101	<b>Ru</b> Ruthenium 44	103	<b>Rh</b> Rhodium 45	106	<b>Pd</b> Palladium 46	108	<b>Ag</b> Silver 47	112	<b>Cd</b> Cadmium 48	115	<b>In</b> Indium 49	119	<b>Sn</b> Tin 50	122	<b>Sb</b> Antimony 51	127	<b>I</b> Iodine 53	131	<b>Xe</b> Xenon 54			
133	<b>Cs</b> Caesium 55	137	<b>Ba</b> Barium 56	139	<b>La</b> Lanthanum 57	178	<b>Hf</b> Hafnium 72	181	<b>Ta</b> Tantalum 73	184	<b>W</b> Tungsten 74	186	<b>Re</b> Rhenium 75	190	<b>Os</b> Osmium 76	192	<b>Ir</b> Iridium 77	195	<b>Pt</b> Platinum 78	197	<b>Au</b> Gold 79	201	<b>Hg</b> Mercury 80	204	<b>Tl</b> Thallium 81	207	<b>Pb</b> Lead 82	209	<b>Bi</b> Bismuth 83	210	<b>Po</b> Polonium 84	222	<b>Rn</b> Radon 86			
223	<b>Fr</b> Francium 87	226	<b>Ra</b> Radium 88	227	<b>Ac</b> Actinium 89	261	<b>Rf</b> Rutherfordium 104	262	<b>Db</b> Dubnium 105	266	<b>Sg</b> Seaborgium 106	264	<b>Bh</b> Bohrium 107	277	<b>Hs</b> Hassium 108	268	<b>Mt</b> Meitnerium 109	271	<b>Ds</b> Darmstadtium 110	272	<b>Rg</b> Roentgenium 111	285	<b>Cn</b> Copernicium 112													
				* 58–71 Lanthanum series				140		<b>Ce</b> Cerium 58	141	<b>Pr</b> Praseodymium 59	144	<b>Nd</b> Neodymium 60	145	<b>Pm</b> Promethium 61	150	<b>Sm</b> Samarium 62	152	<b>Eu</b> Europium 63	157	<b>Gd</b> Gadolinium 64	159	<b>Tb</b> Terbium 65	162	<b>Dy</b> Dysprosium 66	165	<b>Ho</b> Holmium 67	167	<b>Er</b> Erbium 68	169	<b>Tm</b> Thulium 69	173	<b>Yb</b> Ytterbium 70	175	<b>Lu</b> Lutetium 71
				† 90–103 Actinium series				232		<b>Th</b> Thorium 90	231	<b>Pa</b> Protactinium 91	238	<b>U</b> Uranium 92	237	<b>Np</b> Neptunium 93	242	<b>Pu</b> Plutonium 94	243	<b>Am</b> Americium 95	247	<b>Cm</b> Curium 96	245	<b>Bk</b> Berkelium 97	251	<b>Cf</b> Californium 98	254	<b>Es</b> Einsteinium 99	253	<b>Fm</b> Fermium 100	256	<b>Md</b> Mendelevium 101	254	<b>No</b> Nobelium 102	257	<b>Lr</b> Lawrencium 103

\* 58–71 Lanthanum series  
† 90–103 Actinium series

$\begin{matrix} a & x \\ & b \end{matrix}$

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