



Rewarding Learning

**ADVANCED**  
**General Certificate of Education**  
**2024**

Centre Number

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Candidate Number

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# Chemistry

Assessment Unit A2 3

*assessing*

Further Practical Chemistry

**Practical Booklet B (Theory)**



**[ACH32]**

\*ACH32\*

**FRIDAY 21 JUNE, MORNING**

## TIME

1 hour 15 minutes.

## 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 outside the boxed area on each page or on blank pages.**

Complete in black ink only. **Do not write with a gel pen or with a pencil.**

Answer **all four** questions.

## INFORMATION FOR CANDIDATES

The total mark for this paper is 60.

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

A Periodic Table of Elements (including some data) is provided.



- 1 Butyl ethanoate is a colourless liquid at room temperature and pressure. It can be prepared by reacting ethanoic acid with butan-1-ol in the presence of concentrated sulfuric acid.

Some information on the two organic reactants is given in the table below:

	Ethanoic acid	Butan-1-ol
Melting point /°C	16	-90
Boiling point /°C	118	118
Density of liquid /g cm <sup>-3</sup>	1.05	0.81
Solubility in water	soluble	soluble

- (a) The following method may be used to prepare butyl ethanoate:

*Mix 15 cm<sup>3</sup> of ethanoic acid with 30 cm<sup>3</sup> of butan-1-ol in a round-bottomed flask. Add concentrated sulfuric acid slowly with swirling. Ensuring no loss of reactants or products, heat the mixture for approximately 30 minutes and then allow the mixture to cool. Pour the contents of the round-bottomed flask into a reagent bottle containing cold water. Stopper the bottle, shake the contents and allow to settle.*

- (i) Explain why the concentrated sulfuric acid is added slowly with swirling.

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[2]



(ii) Explain why the ethanoic acid for this preparation should **not** be stored in a fridge at 4 °C.

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[1]

(iii) Name the technique used to ensure no loss of reactants or products when heating the mixture.

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[1]

(iv) Suggest what should be added to the round-bottomed flask to promote smooth boiling.

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[1]

(v) After allowing to settle, two layers form in the reagent bottle. Giving practical details, describe how the upper organic layer could be separated into a clean, dry beaker.

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[3]

[Turn over



**(b)** The organic layer is the crude product. To remove any remaining traces of acid, it is shaken with sodium carbonate solution. The upper organic layer is then separated from the aqueous layer. The organic product is then dried.

**(i)** What would indicate that all remaining traces of acid have been removed from the crude product?

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[1]

**(ii)** Describe how the organic product is dried.

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[5]

**(iii)** State how you would remove any remaining organic impurities.

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[1]

**(iv)** State the effect of the presence of impurities on the boiling point of an organic liquid.

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[1]



(c) (i) Write an equation for the reaction to produce butyl ethanoate.

[2]

(ii) Calculate the number of moles of ethanoic acid added in this preparation.

Answer \_\_\_\_\_ [2]

(iii) Calculate the number of moles of butan-1-ol added in this preparation.

Answer \_\_\_\_\_ [2]

(iv) Explain, using your answers to (c)(i), (ii) and (iii), why ethanoic acid is the limiting reactant.

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[2]

[Turn over



(v) 12.2 g of butyl ethanoate were obtained. Calculate the percentage yield, giving your answer to the nearest whole number.

Answer \_\_\_\_\_ % [3]





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**(Questions continue overleaf)**

**[Turn over**

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\*16ACH3207\*

**2** Transition metal ions form coloured complexes.

- (a)** A few spatula measures of a cobalt(II) compound were dissolved in approximately 50 cm<sup>3</sup> of deionised water and a series of tests were carried out on portions of the resulting pink solution.

A few drops of aqueous ammonia were added to a portion of the solution and a blue precipitate formed. On addition of excess aqueous ammonia, the blue precipitate disappeared and a yellow solution formed. The yellow solution was shaken, allowed to stand and observed over a period of several minutes.

A few drops of silver nitrate solution were added to a separate portion of the pink solution. A white precipitate formed.

- (i)** Write an ionic equation for the formation of the blue precipitate.

\_\_\_\_\_ [1]

- (ii)** Give the formula of the complex present in the yellow solution.

\_\_\_\_\_ [1]

- (iii)** What will be observed when the yellow solution is allowed to stand?

\_\_\_\_\_ [1]

- (iv)** Name the cobalt(II) compound.

\_\_\_\_\_ [1]

- (b)** A few cm<sup>3</sup> of concentrated hydrochloric acid were added to a portion of the original pink solution from **(a)** in a boiling tube. A ligand replacement reaction occurred and the colour of the solution changed to blue. When water was added to the boiling tube, the solution changed back to pink.

- (i)** Based on these observations, what can you deduce about the reaction?

\_\_\_\_\_ [1]





- (ii) Write an ionic equation for the reaction which occurred when the concentrated hydrochloric acid was added.

\_\_\_\_\_ [2]

- (iii) State the change in co-ordination number and the change in shape of the complexes in the ligand replacement reaction when concentrated hydrochloric acid was added.

Change in co-ordination number: \_\_\_\_\_

Change in shape: \_\_\_\_\_

\_\_\_\_\_ [2]

- (c) Nickel(II) ions form a variety of complexes with different ligands.

- (i) State the colour change observed when an excess of aqueous ammonia is added to an aqueous solution of nickel(II) sulfate.

\_\_\_\_\_ [1]

- (ii) When excess 1,2-diaminoethane is added to an aqueous solution of nickel(II) sulfate, a ligand replacement reaction occurs and a purple complex forms. Write the formula of the purple complex.

\_\_\_\_\_ [1]

- (iii) Addition of a solution containing the  $\text{edta}^{4-}$  ligand to the purple solution formed in (c)(ii) results in a purple to blue colour change. Write an ionic equation for the reaction which occurs.

\_\_\_\_\_ [2]

[Turn over



**3** A student investigated the chemistry of ethanamide and ethylamine by carrying out the following procedures.

**(a)** Dissolve 0.5g of ethanamide in 3 cm<sup>3</sup> of deionised water. Add drops of the resulting solution onto both red and blue litmus paper.

**(i)** On carrying out this procedure, it was found that the aqueous solution of ethanamide had no effect on red or blue litmus paper. What can be concluded about the aqueous solution?

\_\_\_\_\_ [1]

**(ii)** What would you expect to observe if a solution of ethylamine was used in place of ethanamide with red and blue litmus paper?

red litmus paper: \_\_\_\_\_

blue litmus paper: \_\_\_\_\_ [1]

**(b)** To 1 cm<sup>3</sup> of a solution of ethylamine, add a spatula measure of sodium nitrite and 1 cm<sup>3</sup> of hydrochloric acid.

On carrying out this procedure, bubbles of gas were formed. Identify the gas and name the organic product.

\_\_\_\_\_  
\_\_\_\_\_ [2]



(c) Add half a spatula measure of ethanamide to about 5 cm<sup>3</sup> of dilute sodium hydroxide in a boiling tube. Warm the boiling tube gently.

On carrying out this procedure, a gas with a characteristic smell was produced. Identify the gas and name the other product.

\_\_\_\_\_ [2]

(d) Add a spatula measure of ethanamide to about 5 cm<sup>3</sup> of dilute hydrochloric acid in a boiling tube. Boil the contents of the boiling tube.

Name the two products of this reaction.

\_\_\_\_\_ [2]

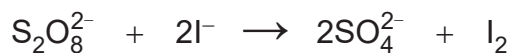
[Turn over

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- 4 Iodide ions in aqueous solution can be oxidised to iodine using a solution containing peroxodisulfate ions ( $\text{S}_2\text{O}_8^{2-}$ ).



- (a) At room temperature, the reaction is relatively slow. It is much faster in the presence of iron(II) ions.

- (i) Based on the equation above, suggest why the reaction is relatively slow.

\_\_\_\_\_ [1]  
\_\_\_\_\_

- (ii) Suggest the role played by the iron(II) ions in this reaction.

\_\_\_\_\_ [1]  
\_\_\_\_\_



**(b)** When a colourless solution of potassium peroxodisulfate is added to a colourless solution of potassium iodide, a slow and gradual colour change is observed.

**(i)** State the colour change observed.

\_\_\_\_\_ [1]

**(ii)** In the presence of a small amount of sodium thiosulfate, the colour change in **(b)(i)** is delayed. Explain, using an ionic equation, why the presence of a small amount of sodium thiosulfate delays the colour change.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

**(iii)** In the presence of a small amount of sodium thiosulfate and starch, a different, more immediate, colour change is observed. State the colour change.

\_\_\_\_\_ [1]

[Turn over



(c) 250 cm<sup>3</sup> of a 0.02 mol dm<sup>-3</sup> solution of sodium thiosulfate were prepared from hydrated sodium thiosulfate, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5H<sub>2</sub>O.

(i) Calculate the mass of hydrated sodium thiosulfate required to prepare 250 cm<sup>3</sup> of this solution.

Answer \_\_\_\_\_ [2]

(ii) Describe how the solution of sodium thiosulfate was prepared using the mass calculated in (c)(i).

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[4]





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**THIS IS THE END OF THE QUESTION PAPER**

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Question Number	Examiner Mark	Remark
1		
2		
3		
4		
<b>Total Marks</b>		

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## General Information

1 tonne =  $10^6$  g

1 metre =  $10^9$  nm

One mole of any gas at 293 K and a pressure of 1 atmosphere ( $10^5$  Pa) occupies a volume of 24 dm<sup>3</sup>

Avogadro Constant =  $6.02 \times 10^{23}$  mol<sup>-1</sup>

Planck Constant =  $6.63 \times 10^{-34}$  Js

Specific Heat Capacity of water =  $4.2$  J g<sup>-1</sup> K<sup>-1</sup>

Speed of Light =  $3 \times 10^8$  ms<sup>-1</sup>



## Characteristic absorptions in IR spectroscopy

Wavenumber/cm <sup>-1</sup>	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

## Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C <sub>6</sub> H <sub>5</sub> –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C <sub>6</sub> H <sub>5</sub>	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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# Data Leaflet

## Including the 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

# chemistry

# 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
<b>1</b> <b>H</b> <small>Hydrogen</small> <b>1</b>												<b>4</b> <b>He</b> <small>Helium</small> <b>2</b>					
<b>7</b> <b>Li</b> <small>Lithium</small> <b>3</b>	<b>9</b> <b>Be</b> <small>Beryllium</small> <b>4</b>											<b>11</b> <b>B</b> <small>Boron</small> <b>5</b>	<b>12</b> <b>C</b> <small>Carbon</small> <b>6</b>	<b>14</b> <b>N</b> <small>Nitrogen</small> <b>7</b>	<b>16</b> <b>O</b> <small>Oxygen</small> <b>8</b>	<b>19</b> <b>F</b> <small>Fluorine</small> <b>9</b>	<b>20</b> <b>Ne</b> <small>Neon</small> <b>10</b>
<b>23</b> <b>Na</b> <small>Sodium</small> <b>11</b>	<b>24</b> <b>Mg</b> <small>Magnesium</small> <b>12</b>											<b>27</b> <b>Al</b> <small>Aluminium</small> <b>13</b>	<b>28</b> <b>Si</b> <small>Silicon</small> <b>14</b>	<b>31</b> <b>P</b> <small>Phosphorus</small> <b>15</b>	<b>32</b> <b>S</b> <small>Sulfur</small> <b>16</b>	<b>35.5</b> <b>Cl</b> <small>Chlorine</small> <b>17</b>	<b>40</b> <b>Ar</b> <small>Argon</small> <b>18</b>
<b>39</b> <b>K</b> <small>Potassium</small> <b>19</b>	<b>40</b> <b>Ca</b> <small>Calcium</small> <b>20</b>	<b>45</b> <b>Sc</b> <small>Scandium</small> <b>21</b>	<b>48</b> <b>Ti</b> <small>Titanium</small> <b>22</b>	<b>51</b> <b>V</b> <small>Vanadium</small> <b>23</b>	<b>52</b> <b>Cr</b> <small>Chromium</small> <b>24</b>	<b>55</b> <b>Mn</b> <small>Manganese</small> <b>25</b>	<b>56</b> <b>Fe</b> <small>Iron</small> <b>26</b>	<b>59</b> <b>Co</b> <small>Cobalt</small> <b>27</b>	<b>59</b> <b>Ni</b> <small>Nickel</small> <b>28</b>	<b>64</b> <b>Cu</b> <small>Copper</small> <b>29</b>	<b>65</b> <b>Zn</b> <small>Zinc</small> <b>30</b>	<b>70</b> <b>Ga</b> <small>Gallium</small> <b>31</b>	<b>73</b> <b>Ge</b> <small>Germanium</small> <b>32</b>	<b>75</b> <b>As</b> <small>Arsenic</small> <b>33</b>	<b>79</b> <b>Se</b> <small>Selenium</small> <b>34</b>	<b>80</b> <b>Br</b> <small>Bromine</small> <b>35</b>	<b>84</b> <b>Kr</b> <small>Krypton</small> <b>36</b>
<b>85</b> <b>Rb</b> <small>Rubidium</small> <b>37</b>	<b>88</b> <b>Sr</b> <small>Strontium</small> <b>38</b>	<b>89</b> <b>Y</b> <small>Yttrium</small> <b>39</b>	<b>91</b> <b>Zr</b> <small>Zirconium</small> <b>40</b>	<b>93</b> <b>Nb</b> <small>Niobium</small> <b>41</b>	<b>96</b> <b>Mo</b> <small>Molybdenum</small> <b>42</b>	<b>98</b> <b>Tc</b> <small>Technetium</small> <b>43</b>	<b>101</b> <b>Ru</b> <small>Ruthenium</small> <b>44</b>	<b>103</b> <b>Rh</b> <small>Rhodium</small> <b>45</b>	<b>106</b> <b>Pd</b> <small>Palladium</small> <b>46</b>	<b>108</b> <b>Ag</b> <small>Silver</small> <b>47</b>	<b>112</b> <b>Cd</b> <small>Cadmium</small> <b>48</b>	<b>115</b> <b>In</b> <small>Indium</small> <b>49</b>	<b>119</b> <b>Sn</b> <small>Tin</small> <b>50</b>	<b>122</b> <b>Sb</b> <small>Antimony</small> <b>51</b>	<b>128</b> <b>Te</b> <small>Tellurium</small> <b>52</b>	<b>127</b> <b>I</b> <small>Iodine</small> <b>53</b>	<b>131</b> <b>Xe</b> <small>Xenon</small> <b>54</b>
<b>133</b> <b>Cs</b> <small>Caesium</small> <b>55</b>	<b>137</b> <b>Ba</b> <small>Barium</small> <b>56</b>	<b>139</b> <b>La</b> <sup>*</sup> <small>Lanthanum</small> <b>57</b>	<b>178</b> <b>Hf</b> <small>Hafnium</small> <b>72</b>	<b>181</b> <b>Ta</b> <small>Tantalum</small> <b>73</b>	<b>184</b> <b>W</b> <small>Tungsten</small> <b>74</b>	<b>186</b> <b>Re</b> <small>Rhenium</small> <b>75</b>	<b>190</b> <b>Os</b> <small>Osmium</small> <b>76</b>	<b>192</b> <b>Ir</b> <small>Iridium</small> <b>77</b>	<b>195</b> <b>Pt</b> <small>Platinum</small> <b>78</b>	<b>197</b> <b>Au</b> <small>Gold</small> <b>79</b>	<b>201</b> <b>Hg</b> <small>Mercury</small> <b>80</b>	<b>204</b> <b>Tl</b> <small>Thallium</small> <b>81</b>	<b>207</b> <b>Pb</b> <small>Lead</small> <b>82</b>	<b>209</b> <b>Bi</b> <small>Bismuth</small> <b>83</b>	<b>210</b> <b>Po</b> <small>Polonium</small> <b>84</b>	<b>210</b> <b>At</b> <small>Astatine</small> <b>85</b>	<b>222</b> <b>Rn</b> <small>Radon</small> <b>86</b>
<b>223</b> <b>Fr</b> <small>Francium</small> <b>87</b>	<b>226</b> <b>Ra</b> <small>Radium</small> <b>88</b>	<b>227</b> <b>Ac</b> <sup>†</sup> <small>Actinium</small> <b>89</b>	<b>261</b> <b>Rf</b> <small>Rutherfordium</small> <b>104</b>	<b>262</b> <b>Db</b> <small>Dubnium</small> <b>105</b>	<b>266</b> <b>Sg</b> <small>Seaborgium</small> <b>106</b>	<b>264</b> <b>Bh</b> <small>Bohrium</small> <b>107</b>	<b>277</b> <b>Hs</b> <small>Hassium</small> <b>108</b>	<b>268</b> <b>Mt</b> <small>Meitnerium</small> <b>109</b>	<b>271</b> <b>Ds</b> <small>Darmstadtium</small> <b>110</b>	<b>272</b> <b>Rg</b> <small>Roentgenium</small> <b>111</b>	<b>285</b> <b>Cn</b> <small>Copernicium</small> <b>112</b>						

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

$\begin{matrix} a \\ X \\ b \end{matrix}$	<b>a</b> = relative atomic mass (approx) <b>x</b> = atomic symbol <b>b</b> = atomic number
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<b>140</b> <b>Ce</b> <small>Cerium</small> <b>58</b>	<b>141</b> <b>Pr</b> <small>Praseodymium</small> <b>59</b>	<b>144</b> <b>Nd</b> <small>Neodymium</small> <b>60</b>	<b>145</b> <b>Pm</b> <small>Promethium</small> <b>61</b>	<b>150</b> <b>Sm</b> <small>Samarium</small> <b>62</b>	<b>152</b> <b>Eu</b> <small>Europium</small> <b>63</b>	<b>157</b> <b>Gd</b> <small>Gadolinium</small> <b>64</b>	<b>159</b> <b>Tb</b> <small>Terbium</small> <b>65</b>	<b>162</b> <b>Dy</b> <small>Dysprosium</small> <b>66</b>	<b>165</b> <b>Ho</b> <small>Holmium</small> <b>67</b>	<b>167</b> <b>Er</b> <small>Erbium</small> <b>68</b>	<b>169</b> <b>Tm</b> <small>Thulium</small> <b>69</b>	<b>173</b> <b>Yb</b> <small>Ytterbium</small> <b>70</b>	<b>175</b> <b>Lu</b> <small>Lutetium</small> <b>71</b>
<b>232</b> <b>Th</b> <small>Thorium</small> <b>90</b>	<b>231</b> <b>Pa</b> <small>Protactinium</small> <b>91</b>	<b>238</b> <b>U</b> <small>Uranium</small> <b>92</b>	<b>237</b> <b>Np</b> <small>Neptunium</small> <b>93</b>	<b>242</b> <b>Pu</b> <small>Plutonium</small> <b>94</b>	<b>243</b> <b>Am</b> <small>Americium</small> <b>95</b>	<b>247</b> <b>Cm</b> <small>Curium</small> <b>96</b>	<b>245</b> <b>Bk</b> <small>Berkelium</small> <b>97</b>	<b>251</b> <b>Cf</b> <small>Californium</small> <b>98</b>	<b>254</b> <b>Es</b> <small>Einsteinium</small> <b>99</b>	<b>253</b> <b>Fm</b> <small>Fermium</small> <b>100</b>	<b>256</b> <b>Md</b> <small>Mendelevium</small> <b>101</b>	<b>254</b> <b>No</b> <small>Nobelium</small> <b>102</b>	<b>257</b> <b>Lr</b> <small>Lawrencium</small> <b>103</b>