Write your name here

| Surname | Other names |
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| | |

**Pearson Edexcel**
**International**
**Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Chemistry

## Advanced

## Unit 6: Chemistry Laboratory Skills II

Thursday 26 January 2017 – Afternoon
**Time: 1 hour 15 minutes**

Paper Reference
**WCH06/01**

**Candidates may use a calculator.**

Total Marks

### Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

### Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

### Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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P 4 8 3 6 9 A 0 1 1 6

Pearson

**Answer ALL the questions. Write your answers in the spaces provided.**

**1** The inorganic compound **A** has two cations and one anion. Complete the table.

| | Test | Observation | Inference | |
|---|---|---|---|---|
| (a) | Note the appearance of solid **A**. | Pale green crystals. | One of the elements present in **A** must be found in the part of the Periodic Table called<br>.....<br>..... | (1) |
| (b) | Mix a spatula measure of solid **A**, with 20 $cm^3$ of distilled water. | Solid **A** dissolved easily to form a very pale green solution. | The **formula** of the cation responsible for the pale green colour is likely to be<br>..... | (1) |
| (c) | To about 5 $cm^3$ of the solution of **A**, add 1 $cm^3$ of dilute sodium hydroxide. | A green precipitate formed which turned brown on standing. | The green precipitate is<br>.....<br>The brown solid is<br>..... | (2) |
| (d) | Gently warm the mixture obtained in (c) and test the gas evolved.<br>Test the gas evolved by<br>.....<br>..... | Result of test.<br>..... | The gas evolved is ammonia.<br>Therefore the **formula** of the second cation present in **A** is<br>..... | (3) |
| (e) | To about 5 $cm^3$ of a fresh sample of the solution of **A**, add a few drops of<br>.....<br>.....<br>and then<br>.....<br>..... | .....<br>..... | The anion present is a sulfate. | (3) |

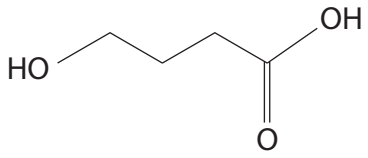
(f) What is the **formula** of compound **A**?

**(1)**

.....

**(Total for Question 1 = 11 marks)**

**2** 4-hydroxybutanoic acid is a naturally occurring substance found in the human central nervous system, as well as in wine, beef and citrus fruits. 4-hydroxybutanoic acid is a sticky solid with a melting temperature of 48–50 °C.
The structure of 4-hydroxybutanoic acid is




(a) About 5 g of 4-hydroxybutanoic acid was placed in a test tube and melted by heating in a hot water bath. A small piece of sodium was added to the molten 4-hydroxybutanoic acid.

(i) Suggest why the flammability of 4-hydroxybutanoic acid would **not** present a significant risk in this experiment, even if a Bunsen burner were used.

**(1)**

(ii) Suggest **one** reason why a water bath was used in this experiment rather than a Bunsen burner.

**(1)**

(iii) Describe the observation that shows a reaction is occurring.

**(1)**

(iv) Give the equation for this reaction. Use a **skeletal** formula for the organic product. State symbols are not required.

**(2)**

(b) A spatula measure of 4-hydroxybutanoic acid was added to a solution of sodium hydrogencarbonate in a test tube. Vigorous effervescence was observed.

(i) Name the gas formed.

**(1)**

.....

(ii) State the test that you would use to confirm the identity of the gas formed. Give the result of the test.

**(2)**

.....

.....

.....

(iii) Draw a diagram of the apparatus you would use to carry out the test that you have given in 2(b)(ii).

**(2)**

(c) Identifying the functional groups present is a vital part of the determination of the structure of an organic compound.

(i) Explain fully whether or not the tests mentioned in 2(a) and 2(b) allow the two functional groups of 4-hydroxybutanoic acid to be identified.

**(2)**

(ii) Use the data in the table to explain how the infrared spectrum of 4-hydroxybutanoic acid could be used to identify its two functional groups. State the relevant wavenumber ranges.

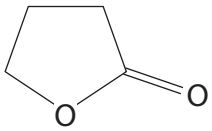
**(2)**

| Group & vibration type | Type of compound | Wavenumber range / $cm^{-1}$ |
|---|---|---|
| O—H stretching | Alcohols and phenols | 3750–3200 |
| | Carboxylic acids | 3300–2500 |
| C—O stretching | Esters: methanoates | 1200–1180 |
| | ethanoates | 1250–1230 |
| | propanoates | 1200–1150 |
| | benzoates | 1310–1250 and 1150–1100 |
| C═O stretching | Aldehydes | 1740–1720 |
| | Ketones | 1700–1680 |
| | Carboxylic acids: alkyl<br>aryl | 1725–1700<br>1700–1680 |
| | Esters | 1750–1735 |

(iii) Explain whether or not infrared spectra could be used to distinguish 4-hydroxybutanoic acid from its isomer, 3-hydroxybutanoic acid.

**(1)**

(d) 4-hydroxybutanoic acid reacts on heating in the presence of a catalyst to form 4-butyrolactone which is used in food flavouring, and as a superglue remover. The structure of 4-butyrolactone is




(i) By considering the functional group present in 4-butyrolactone, name the type of reaction which occurs when 4-hydroxybutanoic acid forms 4-butyrolactone.

**(1)**

(ii) Identify a suitable catalyst for this reaction.

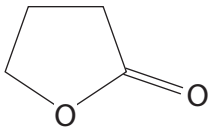
**(1)**

(iii) There are three proton environments in 4-butyrolactone.

Circle each of these proton environments on the structure below and label them X, Y and Z.

Complete the table to give the relative areas under the three peaks and the splitting pattern expected for each peak in the high resolution proton nmr spectrum of this compound.

**(3)**




| Proton environment | Relative peak height | Splitting pattern |
|---|---|---|
| X | | |
| Y | | |
| Z | | |

**(Total for Question 2 = 20 marks)**

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**3** The first stage in a preparation of an azo dye is the formation of benzenediazonium chloride by the reaction of phenylamine (aniline) with nitrous acid at about 5 °C. The equation for the reaction is

$$C_6H_5NH_2 + HNO_2 + H^+ + Cl^- \rightarrow C_6H_5N_2^+ + Cl^- + 2H_2O$$

(a) (i) Nitrous acid is unstable at room temperature, so it is prepared only when it is needed. Identify the **two** reagents required to prepare nitrous acid for this reaction.

**(2)**

.....

.....

(ii) State how a temperature of 'about 5 °C' would be maintained for this preparation.

**(1)**

.....

.....

(b) If the benzenediazonium chloride is allowed to warm up, it decomposes:

$$C_6H_5N_2^+Cl^- + H_2O \rightarrow C_6H_5OH + N_2 + H^+ + Cl^-$$

One way of following the progress of this reaction in a rates experiment is to use a continuous monitoring method, such as measuring the volume of nitrogen produced.

(i) Suggest an advantage of using a continuous monitoring method rather than a sampling method.

**(1)**

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.....

.....

(ii) Draw a diagram of an apparatus suitable for measuring the volume of nitrogen produced at various times during the decomposition of benzenediazonium chloride at 45 °C.

**(3)**

(c) Data from the experiment described in 3(b)(ii) are given in the table. The initial concentration of the benzenediazonium chloride was 0.071 mol $dm^{-3}$ and the concentrations of the benzenediazonium chloride as the reaction proceeded were calculated from the volumes of nitrogen collected.

| Time / min | Volume nitrogen / $cm^3$ | $1000 \times [C_6H_5N_2Cl]$ / mol $dm^{-3}$ |
|---|---|---|
| 0 | 0 | 71.0 |
| 3 | 10.8 | 57.8 |
| 6 | 19.3 | |
| 9 | 26.3 | 39.0 |
| 12 | 32.4 | 31.5 |
| 18 | 41.3 | 20.7 |
| 24 | 46.5 | 14.4 |
| 30 | 50.4 | 9.6 |
| ∞ | 58.3 | 0 |

∞ = time when reaction is complete.

(i) How would you know when the reaction was complete?

**(1)**

.....

.....

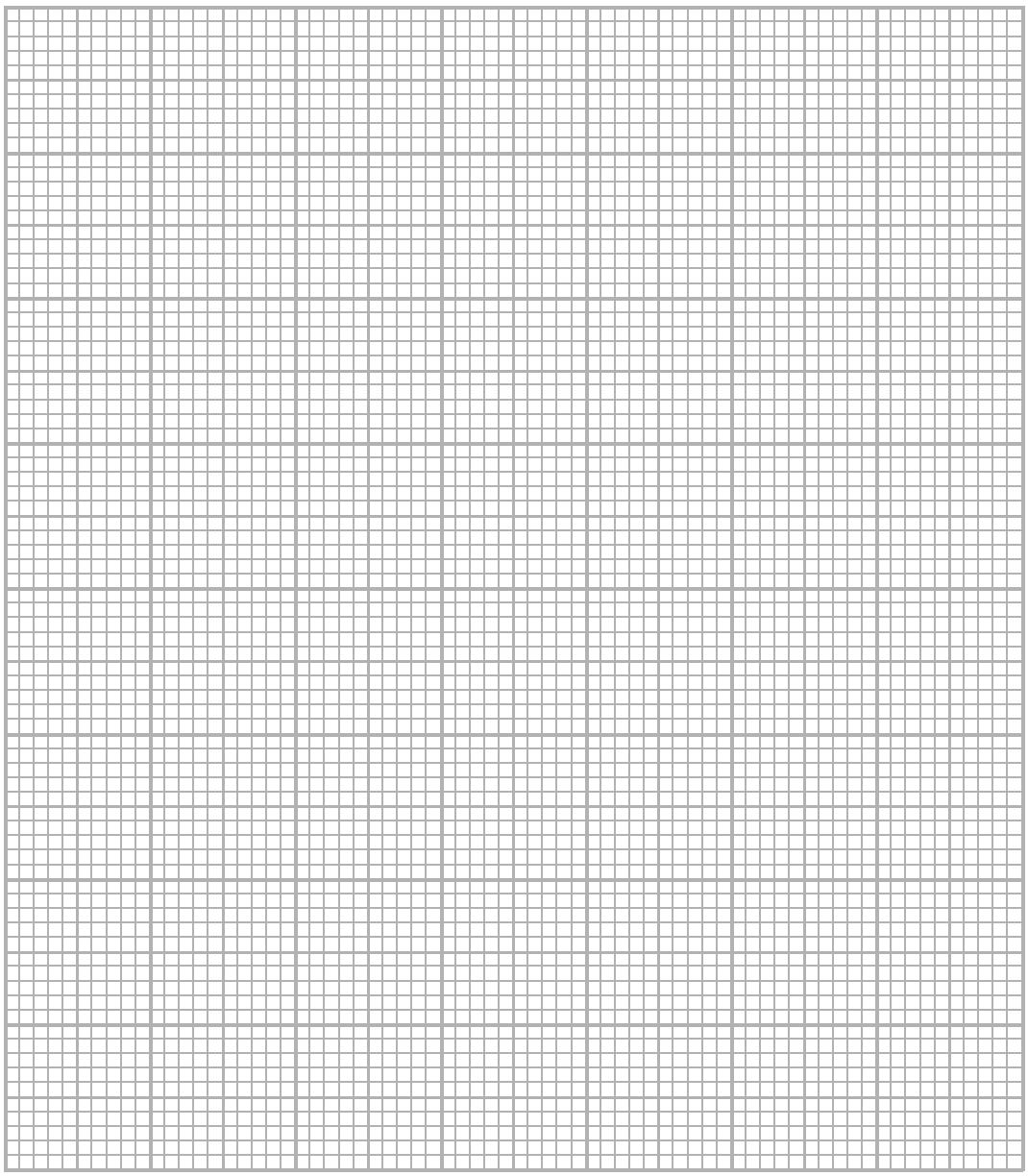
(ii) After a given time, the fraction of nitrogen produced is equal to the fraction of the benzenediazonium chloride that is used up. For example, when ¼ of the nitrogen is produced, ¾ of the benzenediazonium chloride is left. This is used to calculate the concentrations of the benzenediazonium chloride in the table. Calculate the concentration of benzenediazonium chloride at 6 min. You must show your working.

**(1)**

$[C_6H_5N_2Cl]$ at 6 min = ..... mol $dm^{-3}$

(iii) Plot a graph of $1000 \times [C_6H_5N_2Cl]$ (on the vertical axis) against time.
Use appropriate scales, and label the axes of the graph.

**(3)**



(iv) From the graph, estimate **two** half lives of this reaction. Show your working on the graph.

**(1)**

(v) Use the half lives that you have estimated to deduce the order of the reaction. Justify your answer.

**(1)**

(d) Benzenediazonium chloride can be converted into an azo dye by mixing it with phenol in an alkaline solution. Pure crystals of the dye may be obtained by recrystallisation of the impure solid using ethanoic acid as the solvent.

(i) Phenol is an extremely caustic compound. Suggest **one** safety precaution, apart from eye protection and wearing a laboratory coat, that would reduce the risk of using phenol.

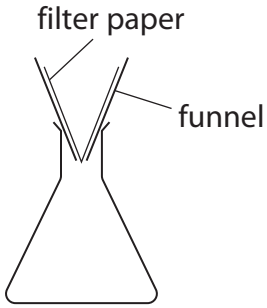
**(1)**

(ii) In the first stage of recrystallisation, the impure solid is dissolved in the minimum volume of hot solvent. Explain why it is important to use the **minimum** volume.

**(1)**

(iii) In the second stage of recrystallisation, the hot solution is filtered using simple (or gravity) filtration. A filter funnel without a stem is often used (see diagram). Explain the advantage of using a funnel like this.

**(1)**

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(iv) When crystallisation is complete, the mixture is filtered under reduced pressure (vacuum filtration). State the type of impurities which are removed at this stage and explain why this method of filtration is preferred to gravity filtration.

**(2)**

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**(Total for Question 3 = 19 marks)**

**TOTAL FOR PAPER = 50 MARKS**

# The Periodic Table of Elements

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) (18) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | 4.0 He helium 2 |
| (1) | (2) | | Key | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | relative atomic mass<br>atomic symbol<br>name<br>atomic (proton) number | | | | | | | | | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 20.2 Ne neon 10 |
| 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 |
| 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.7 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 |
| 85.5 Rb rubidium 37 | 87.6 Sr strontium 38 | 88.9 Y yttrium 39 | 91.2 Zr zirconium 40 | 92.9 Nb niobium 41 | 95.9 Mo molybdenum 42 | [98] Tc technetium 43 | 101.1 Ru ruthenium 44 | 102.9 Rh rhodium 45 | 106.4 Pd palladium 46 | 107.9 Ag silver 47 | 112.4 Cd cadmium 48 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 |
| 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La* lanthanum 57 | 178.5 Hf hafnium 72 | 180.9 Ta tantalum 73 | 183.8 W tungsten 74 | 186.2 Re rhenium 75 | 190.2 Os osmium 76 | 192.2 Ir iridium 77 | 195.1 Pt platinum 78 | 197.0 Au gold 79 | 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 209.0 Bi bismuth 83 | [209] 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 | | | | | | | |

Elements with atomic numbers 112-116 have been reported but not fully authenticated

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 Ce cerium 58 | 141 Pr praseodymium 59 | 144 Nd neodymium 60 | [147] Pm promethium 61 | 150 Sm samarium 62 | 152 Eu europium 63 | 157 Gd gadolinium 64 | 159 Tb terbium 65 | 163 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 |

* Lanthanide series

* Actinide series