Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|

Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

## Friday 14 June 2024

Morning (Time: 1 hour 20 minutes)

Paper reference **WCH16/01**

# Chemistry

## International Advanced Level

## UNIT 6: Practical Skills in Chemistry II

**You must have:**
Scientific calculator, ruler

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs, it must be dark (HB or B)
- **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.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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F:1/1/1/1/1/

P 7 5 7 8 3 R A 0 1 1 6

Pearson

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

**1** An organic compound **A** is a liquid. It contains two functional groups.
Tests are carried out to identify **A**.

(a) Test **1** A small amount of phosphorus(V) chloride, $PCl_5$, is added to 2 $cm^3$ of **A**.

| Observation |
|---|
| misty fumes given off |

Test **2** Aqueous sodium hydrogencarbonate, $NaHCO_3(aq)$, is added to 2 $cm^3$ of **A**.

| Observation |
|---|
| no visible reaction |

Identify, by name or formula, the functional group identified by these tests.
Justify your answer.

**(2)**

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(b) Test **3** A few drops of **A** are added to 2 $cm^3$ of Tollens' reagent (ammoniacal silver nitrate solution).

The mixture is placed in a warm water bath.

| Observation |
|---|
| silver mirror |

Identify, by name or formula, the functional group identified by this test.

**(1)**

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(c) Compound **A** is non-cyclic and its mass spectrum has a molecular ion peak with *m/z* value of 74.

(i) Draw the **displayed** formula of the **two** structural isomers of **A**, using this information and your answers from (a) and (b).

**(2)**

(ii) A low resolution proton NMR spectrum of **A** shows four peaks with relative areas of 1:2:2:1.

Deduce which of the structures in (c)(i) is correct, by identifying the relative peak areas on your formula.

**(1)**

**(Total for Question 1 = 6 marks)**

**2** A series of experiments is carried out on an aqueous solution of a chromium(III) salt, **B**.

(a) Experiment **1**
To a sample of solution **B**, aqueous sodium hydroxide is added drop by drop until in **excess**.

(i) Complete the table giving the observations you would see.

**(2)**

| Observation on adding a few drops of sodium hydroxide | Observation on adding an excess of sodium hydroxide |
|---|---|
| | |

(ii) State what you can deduce about the nature of chromium(III) hydroxide from the results of Experiment **1**.

**(1)**

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(b) Experiment **2**
5 $cm^3$ of hydrogen peroxide solution is added to the final mixture formed in (a) (i) and heated gently.
A yellow solution containing chromate(VI) ions, $CrO_4^{2-}$, is produced.

Explain the role of the hydrogen peroxide in this reaction.
Justify your answer.

**(2)**

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(c) Experiment **3**
Dilute sulfuric acid is added to the yellow solution formed in Experiment **2**.
The solution turns orange.

Complete and balance the equation for this reaction.

State symbols are not required.

**(1)**

$$\ldots . \, CrO_4^{2-} \; + \; \ldots . \, H^+ \rightleftharpoons$$

**(Total for Question 2 = 6 marks)**

**3** A group of students carried out an experiment to investigate the reaction between potassium manganate(VII) and ethanedioate ions in acid conditions.

The equation for the reaction is shown.

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$$

**Procedure**

Step **1** Measure 10.0 $cm^3$ of potassium iodide solution into each of eight conical flasks.

Step **2** Measure 100.0 $cm^3$ of ethanedioic acid solution into a 250 $cm^3$ beaker. Add 25.0 $cm^3$ of potassium manganate(VII) solution and 5.0 $cm^3$ sulfuric acid to the beaker. Mix the contents of the beaker and start a timer.

Step **3** Immediately withdraw 10.0 $cm^3$ of reaction mixture and add it to the first conical flask containing (excess) potassium iodide solution.

Step **4** Continue removing 10.0 $cm^3$ of reaction mixture every minute for seven minutes. Each time, add the reaction mixture to a new conical flask containing the potassium iodide solution.

Step **5** Using starch as an indicator, titrate the iodine formed in the conical flasks with sodium thiosulfate solution.

The equation for the reaction in Step **3** is shown.

$$2MnO_4^-(aq) + 16H^+(aq) + 10I^-(aq) \rightarrow 2Mn^{2+}(aq) + 5I_2(aq) + 8H_2O(l)$$

The equation for the titration in Step **5** is shown.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

(a) (i) Explain why Step **3** effectively stops the reaction between potassium manganate(VII) and ethanedioate ions.

**(2)**

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(ii) State when the starch indicator should be added during the titrations in Step **5**.

**(1)**

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(b) A student's results are shown.

| Time (t) / min | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Volume of sodium thiosulfate / $cm^3$ | 30.00 | 29.80 | 28.60 | 27.50 | 19.00 | 7.50 | 2.50 | 1.50 |

(i) Plot a graph of volume of sodium thiosulfate against time.

**(3)**

(ii) Describe how the rate of reaction changes during the reaction.

**(1)**

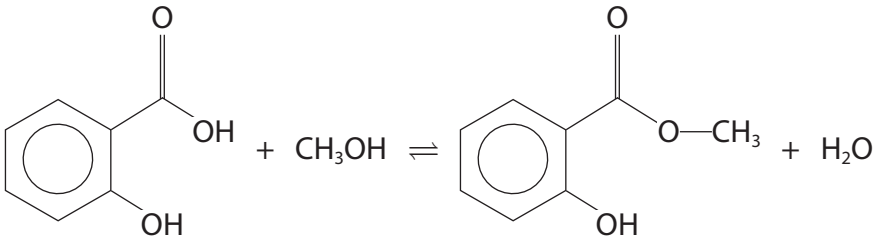
(iii) Explain why the rate of reaction changes in this way.

**(3)**

**(Total for Question 3 = 10 marks)**

**4** This question is about the laboratory preparation of the ester methyl salicylate (oil of wintergreen).

The equation for this reaction is shown.




salicylic acid methanol methyl salicylate water

**Procedure**

Step **1** 20.0 g of salicylic acid and 100 $cm^3$ of methanol are placed into a round-bottomed flask.

Step **2** 15.0 $cm^3$ of concentrated sulfuric acid is added slowly, whilst swirling the flask.

Step **3** The mixture is heated gently under reflux for 45 minutes.

Step **4** After cooling, the mixture is poured into a separating funnel and about 50 $cm^3$ of iced water is added. The funnel is stoppered, shaken and allowed to settle. The aqueous layer is discarded.

Step **5** The organic layer is returned to the separating funnel and washed with 50 $cm^3$ of sodium carbonate solution.

Step **6** The aqueous layer is discarded leaving the crude methyl salicylate.

Step **7** The crude methyl salicylate is distilled and the fraction with the boiling temperature range 220–224°C is collected.

Step **8** The pure methyl salicylate is transferred to a bottle and weighed.

(a) Show, by calculation, that the methanol is in excess in this preparation.

[$M_r$ values: salicylic acid = 138.0 methanol = 32.0,
Density of methanol = 0.791 g $cm^{-3}$]

**(3)**

(b) State the purpose of the sulfuric acid.

**(1)**

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(c) Draw a diagram of the apparatus used in Step **3** when the mixture is heated under reflux.

**(3)**

(d) Describe how to wash the organic layer with sodium carbonate solution in Step **5**.

**(2)**

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(e) The mass of pure methyl salicylate obtained was 14.1 g.

Calculate the percentage yield, giving your answer to an appropriate number of significant figures.

**(3)**

**(Total for Question 4 = 12 marks)**

**5** The label has come off a bottle known to contain an ammonium salt, $NH_4\mathbf{X}$, where **X** is known to be a halide ion.

A student carried out an experiment to determine the identity of the halide, **X**.

**Procedure**

Step **1** 2.27 g of $NH_4\mathbf{X}$ was placed in a conical flask.

Step **2** 50.0 $cm^3$ of 1.00 mol $dm^{-3}$ aqueous sodium hydroxide was added to the conical flask.

Step **3** The solution in the conical flask was boiled gently.

The equation for the reaction in Step **3** is shown.

$$NaOH(aq) + NH_4\mathbf{X}(aq) \rightarrow NaX(aq) + H_2O(l) + NH_3(g)$$

Step **4** The gas coming from the conical flask was tested regularly until all the ammonia had been evolved.

Step **5** The flask was removed from the heat and allowed to cool.

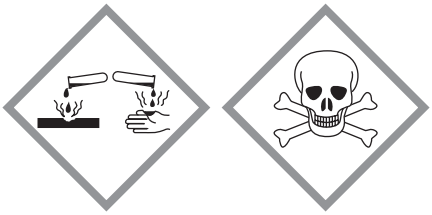
Step **6** The entire contents of the flask, containing the excess sodium hydroxide solution, were titrated with a solution of 1.00 mol $dm^{-3}$ hydrochloric acid.

(a) (i) Describe how to carry out Step **4**.

You should identify **both** how to perform the test **and** how you would know all the ammonia had been evolved.

**(2)**

(ii) Containers of ammonia gas have the following hazard warning signs.



State these two hazards associated with ammonia.

**(1)**

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(iii) Give a precaution to reduce the risk when carrying out Steps **3** and **4**.
It is assumed that safety goggles and a laboratory coat are used.

**(1)**

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(b) The titre in Step **6** is 26.80 $cm^3$ of 1.00 mol $dm^{-3}$ hydrochloric acid.

(i) Calculate the molar mass of $NH_4$**X**.

Use the data from Steps **1** and **2**.

**(4)**

(ii) Identify the halide **X**, present in $NH_4$**X**, using your answer to (b)(i).

**(2)**

(iii) Give a chemical test, with the expected result, to confirm the identity of the halide ion in a sample of $NH_4$**X**.

**(2)**

(c) Another student carried out the experiment but did not titrate all the contents of the conical flask in Step **6**.
Instead they transferred the contents of the conical flask to a 100.0 $cm^3$ volumetric flask. The solution was made up to the mark with distilled water and mixed thoroughly.

25.0 $cm^3$ portions of this solution were placed in a conical flask and titrated with 1.00 mol $dm^{-3}$ hydrochloric acid.

Identify **one** advantage and **one** disadvantage of this alternative to Step **6**.

Justify your answers.

**(4)**

Advantage .....

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Disadvantage .....

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**(Total for Question 5 = 16 marks)**

**TOTAL FOR PAPER = 50 MARKS**

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# 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) | | | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | | | | | | | | | | 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 | | | | | | | |

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * Lanthanide series | 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 |
| * Actinide series | 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 |