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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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)

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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)

.....

(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)

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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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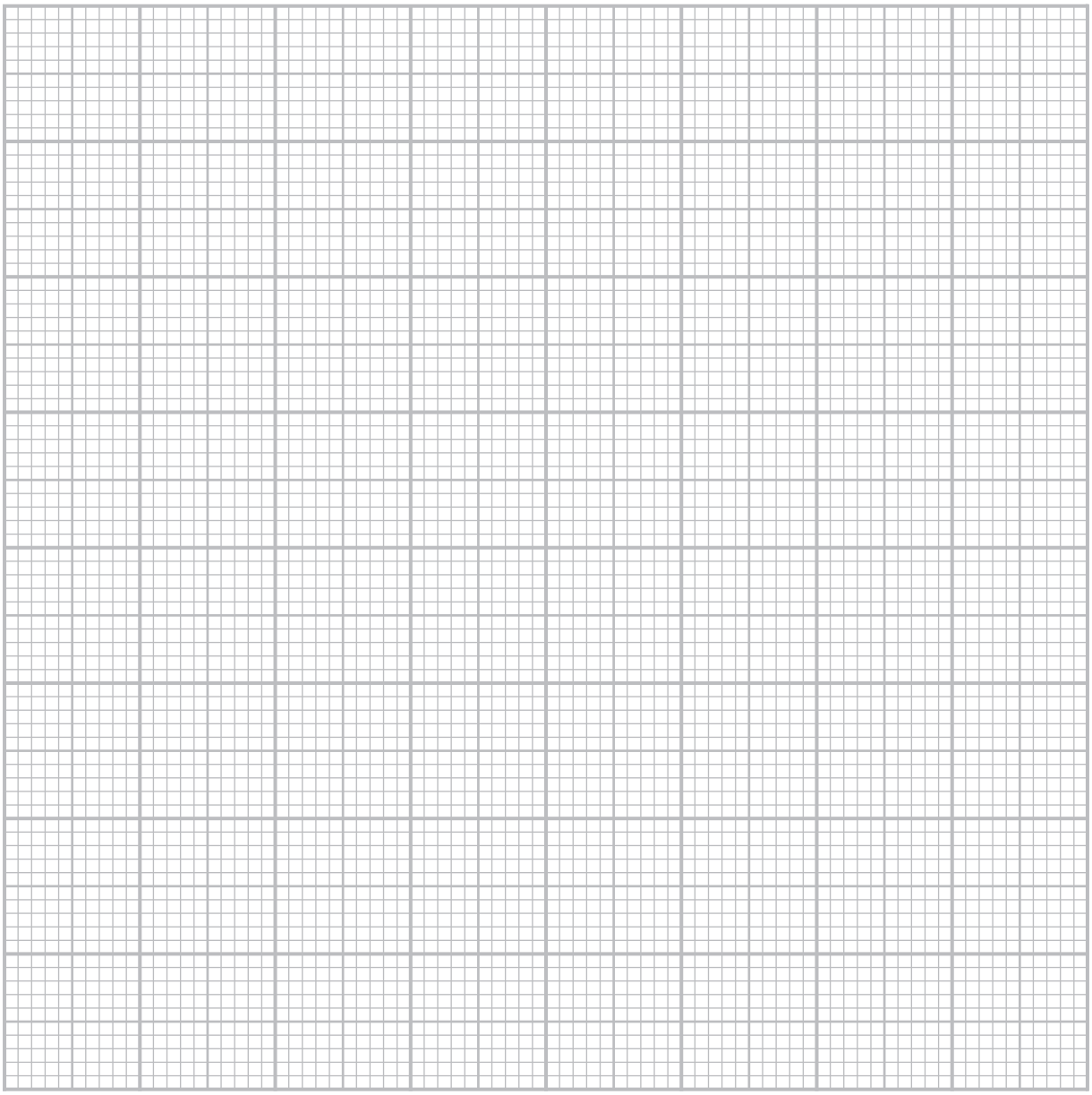
(b) A student's results are shown.

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)



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(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)

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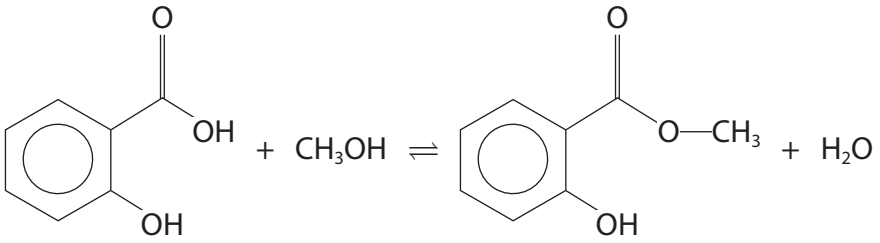
4 This question is about the laboratory preparation of the ester methyl salicylate (oil of wintergreen).

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)

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(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)

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(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)

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5 The label has come off a bottle known to contain an ammonium salt, NH_4**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**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)

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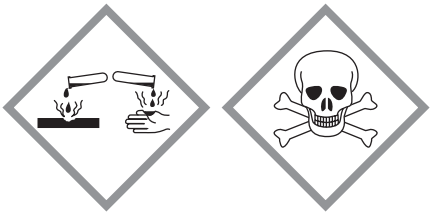
(ii) Containers of ammonia gas have the following hazard warning signs.



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)

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(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)

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(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)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(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							

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

* Lanthanide series

* Actinide 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
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

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