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

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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)

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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)

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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)

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

(3)

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(Total for Question 3 = 10 marks)

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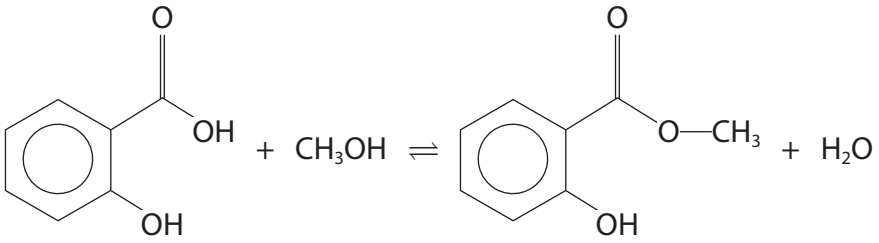
4 This question is about the laboratory preparation of the ester methyl salicylate (oil of wintergreen).

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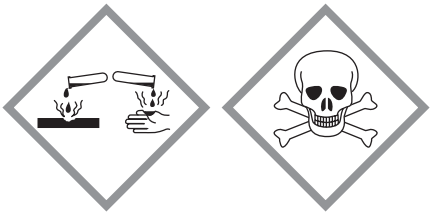
(ii) Containers of ammonia gas have the following hazard warning signs.



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

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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							

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

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