Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number ☐☐☐☐☐ Candidate Number ☐☐☐☐

Pearson Edexcel International Advanced Level

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.
- **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 ▶

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

1 (a) Compound **X** is a solid that contains a cobalt cation and one type of anion. A small amount of **X** is added to deionised water and the mixture stirred until the solid dissolves.

Tests are carried out on separate samples of the solution of **X**.

Complete the table.

	Test	Observation	Inference	
(i)	Note the appearance	A pink solution	The **formula** of the complex ion formed is	(1)
(ii)	Add acidified barium chloride solution	A white precipitate forms	The **formula** of the anion in **X** is	(1)
(iii)	Add concentrated hydrochloric acid	....	The formula of the complex ion formed is $[CoCl_4]^{2-}$	(1)
(iv)	Add a small amount of dilute aqueous ammonia	A blue precipitate forms	The type of reaction that takes place with the complex ion during this precipitation is	(1)
(v)	Add **excess** dilute aqueous ammonia to the precipitate formed in (iv), until no further change is seen	....	The **formula** of the complex ion formed is	(3)

(b) Another cobalt salt, $CoCl_2{\cdot}xH_2O(s)$, decomposes when heated.

$$CoCl_2{\cdot}xH_2O(s) \rightarrow CoCl_2(s) + xH_2O(g)$$

Devise an outline procedure to determine the mass of water produced from a sample of the hydrated salt in this reaction.

You do **not** need to show how x can be calculated from the mass of water produced.

(4)

(Total for Question 1 = 11 marks)

2 A plant fertiliser contains a mixture of sand and ammonium sulfate, $(NH_4)_2SO_4$.

The percentage by mass of ammonium sulfate in the fertiliser is determined by the procedure shown.

Procedure

Step **1** 5.75 g of the plant fertiliser is added to a conical flask containing 20.0 cm^3 of sodium hydroxide solution with a concentration of 1.00 mol dm^{-3}.
Ammonia is formed in the reaction.

$$(NH_4)_2SO_4(aq) + 2NaOH(aq) \rightarrow 2NH_3(g) + Na_2SO_4(aq) + 2H_2O(l)$$

Step **2** The flask is heated for several minutes, to ensure that all the ammonia formed is boiled off.

Step **3** The solution containing excess sodium hydroxide is separated from the sand.

Step **4** The aqueous solution containing the **excess** sodium hydroxide is then made up to 250.0 cm^3 using deionised water.

Step **5** 25.0 cm^3 samples of solution containing sodium hydroxide from Step **4** are titrated with hydrochloric acid of concentration = 0.0500 mol dm^{-3}.

(a) Describe how **all** the solution containing excess sodium hydroxide is separated from the sand in Step **3**.

(2)

(b) Describe how to make the 250.0 cm^3 of sodium hydroxide solution in Step **4**.

(2)

(c) The mean titre was 12.75 cm^3.

Calculate the percentage by mass of ammonium sulfate, $(NH_4)_2SO_4$, in the sample of plant fertiliser.

[Relative formula mass of $(NH_4)_2SO_4$ = 132.1]

(5)

(d) A student carrying out the experiment did not heat the sample for long enough in Step **2** to boil off all the ammonia.

(i) Explain the effect, if any, on the titre value and hence on the calculated percentage of ammonium sulfate in the fertiliser.

(3)

....

....

....

....

....

....

(ii) State how the student could have confirmed that all the ammonia was boiled off in Step **2**.

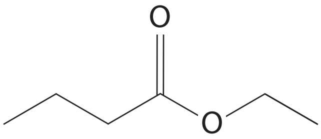
(1)

....

....

(Total for Question 2 = 13 marks)

3 The ester ethyl butanoate is found in mangoes.



ethyl butanoate

Ethyl butanoate can be synthesised from butanoic acid.

Procedure

Step **1** Add 5 cm^3 of ethanol and 10 cm^3 of butanoic acid to a round-bottomed flask containing anti-bumping granules. Add 1 cm^3 of concentrated sulfuric acid drop by drop to the flask.

Step **2** Heat the mixture under reflux for 60 minutes. Allow the reaction mixture to cool before transferring it to a separating funnel.

Step **3** Add 15 cm^3 of cold water to the separating funnel and shake the mixture to wash the product. Remove the lower aqueous layer from the funnel.

Step **4** Wash the organic layer that remains in the separating funnel with 10 cm^3 of aqueous sodium hydrogencarbonate solution, $NaHCO_3(aq)$.

Step **5** Remove the aqueous layer from the funnel. Transfer the organic layer to a dry conical flask. Add a drying agent and leave for 10 minutes. Then add more drying agent if required. Remove the drying agent by filtration.

Step **6** Purify the dry organic liquid.

(a) Calculate which reactant is in excess in this synthesis.

Compound	Molar mass / g mol^{-1}	Density / g cm^{-3}
ethanol	46.0	0.79
butanoic acid	88.0	0.96

(2)

(b) Explain why it is important from time to time in Step **4** either to invert the separating funnel and open the tap, or to remove its stopper.

Include an equation to justify your answer. State symbols are not required.

(2)

....

....

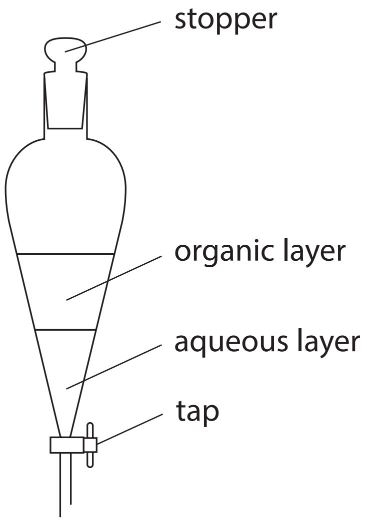
....

....

(c) A student set up a separating funnel in Step **5** as shown and opened the tap to remove the lower layer.

Explain what happens.

Assume that the funnel is supported by suitable clamps.



(2)

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....

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....

(d) Drying agents are used to remove traces of water from an organic liquid.

(i) Identify, by name or formula, a suitable drying agent for use in Step **5**.

(1)

....

(ii) State how a student would decide whether or not more drying agent was needed in Step **5**.

(1)

....

....

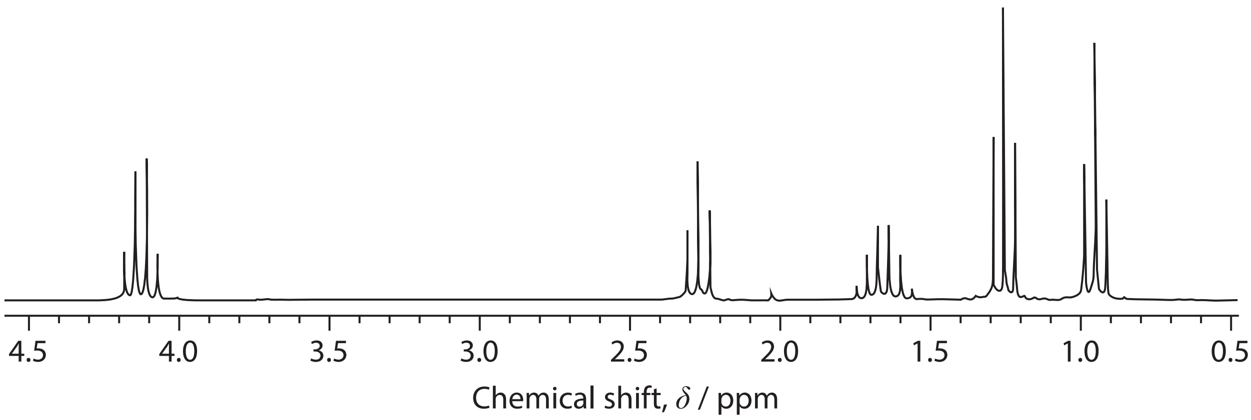
....

(iii) Name the technique used to obtain a pure sample of the dry organic liquid in Step **6**.

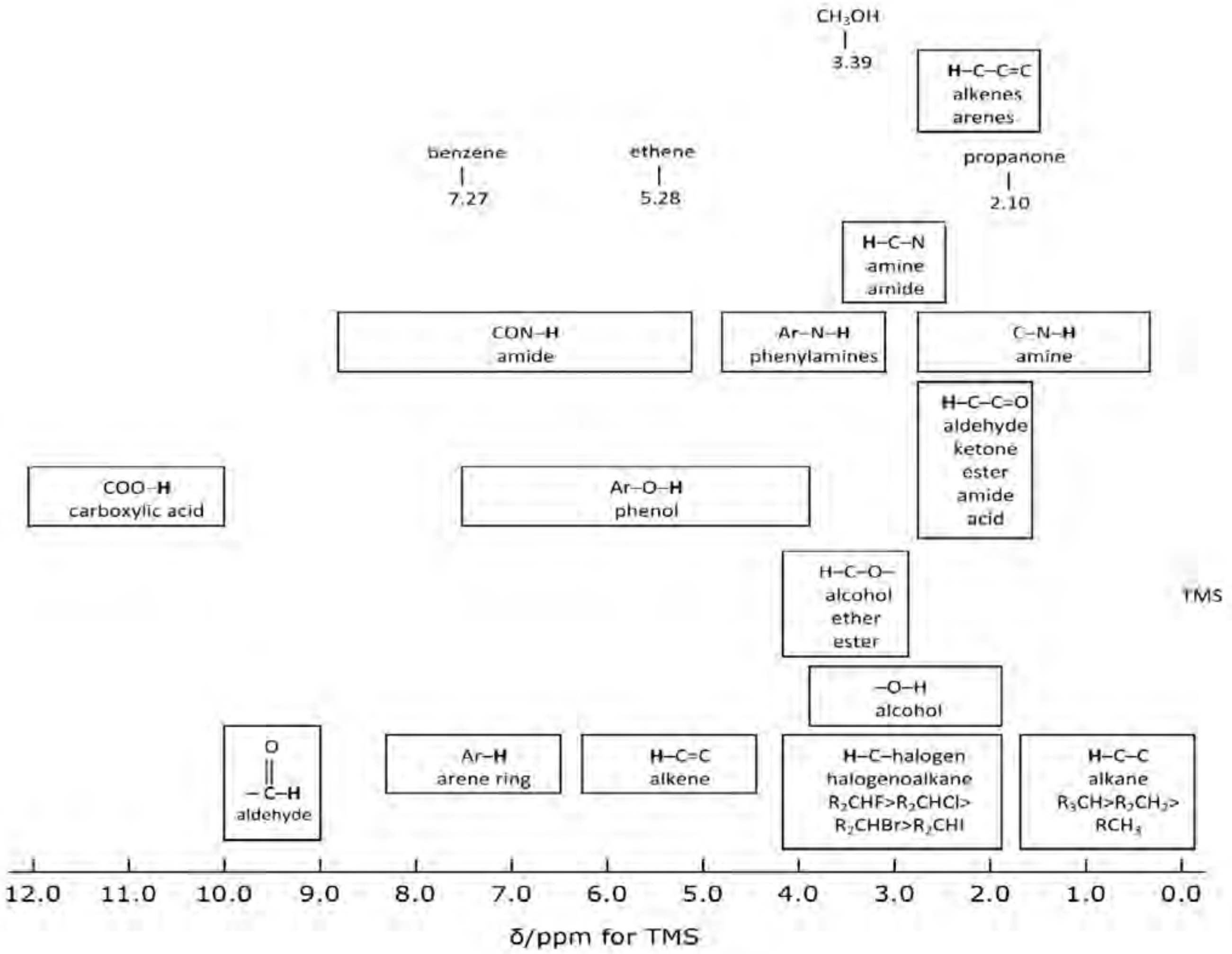
(1)

....

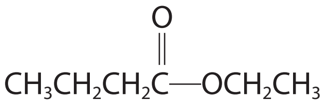
(e) The high resolution proton NMR spectrum of ethyl butanoate is shown.



^{1}H nuclear magnetic resonance chemical shifts relative to tetramethylsilane (TMS)



(i) Explain the peaks in the NMR spectrum between 2.2 and 2.4 ppm.

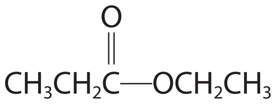


$$CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}\!-\!OCH_2CH_3$$

ethyl butanoate

(2)

(ii) Predict how the high resolution proton NMR spectrum of ethyl propanoate will differ from that of ethyl butanoate in terms of the number of peaks and their splitting patterns.



$$CH_3CH_2\overset{\overset{\displaystyle O}{\|}}{C}\!-\!OCH_2CH_3$$

ethyl propanoate

(3)

(Total for Question 3 = 14 marks)

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4 Ethyl butanoate reacts with water.

$$CH_3CH_2CH_2COOCH_2CH_3 + H_2O \rightarrow CH_3CH_2CH_2COOH + CH_3CH_2OH$$

A student investigated the kinetics of this reaction.

Procedure

Step **1** 50 cm^3 of ethyl butanoate was heated under reflux with **a very large excess** of water.

Step **2** After 30 minutes a sample of known volume was removed from the reaction mixture and placed in a conical flask.

Step **3** This sample was titrated using aqueous sodium hydroxide solution.

Step **4** Further samples were removed from the refluxing mixture at 30-minute intervals. Each sample was titrated until the titres of three consecutive samples were the same.

(a) Name the apparatus which is most suitable to remove the samples from the reaction mixture.

(1)

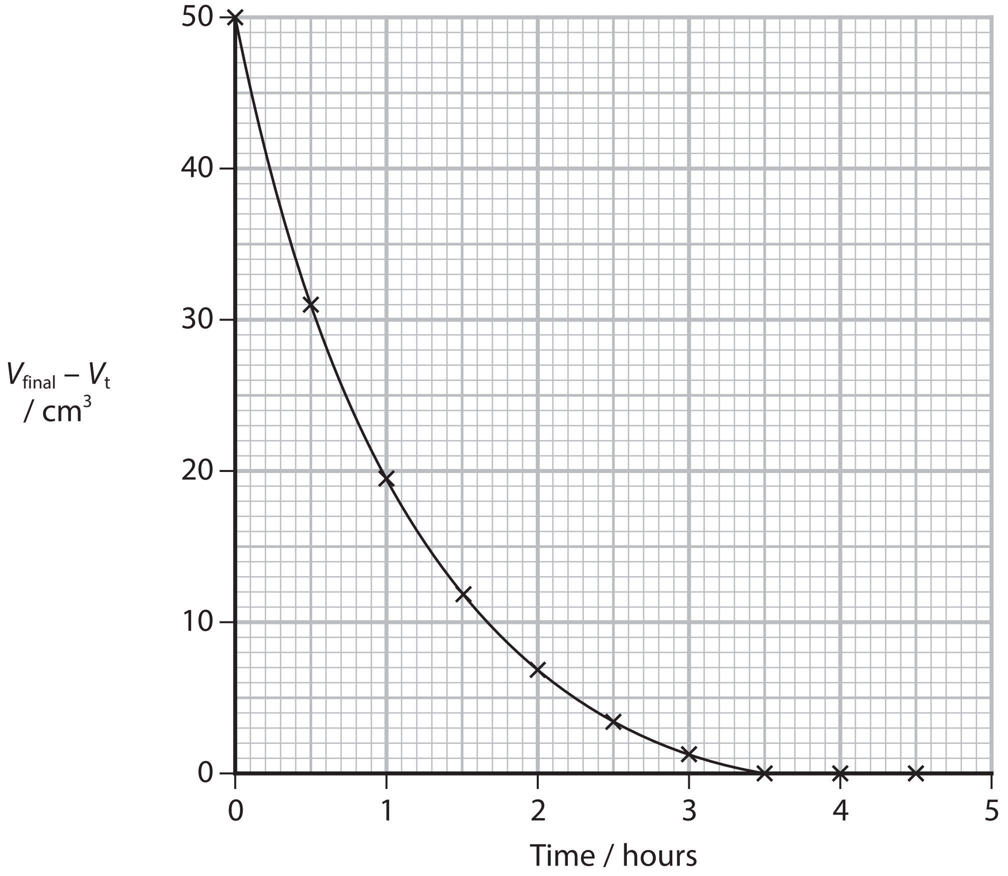
....

(b) A graph of the results obtained by the student is shown.

The student plotted $V_{\text{final}} - V_t$ on the y-axis against time on the x-axis.

V_{final} is the volume of the titre at 4.5 hours.

V_t is the volume of the titre at time t.



(i) Give a reason why $V_{\text{final}} - V_t$ is plotted on the y-axis of the graph, rather than the concentration of sodium hydroxide solution for each titre.

(1)

(ii) Explain how the data collected indicates first order kinetics.

Show your working on the graph.

(2)

(iii) The student concluded that the reaction is first order **overall**.

Explain whether or not this statement is valid.

(2)

(iv) Calculate the rate of the reaction at a time of 2 hours.
Include units with your answer.

Show your working on the graph.

(4)

(c) The student suggested placing ice in the conical flask before carrying out each titration.

Explain whether or not this suggestion would improve the validity of the data collected.

(2)

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....

(Total for Question 4 = 12 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)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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											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