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 13 June 2025

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.*
- There is a Periodic Table on the back cover of this paper.

Advice

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

Turn over ▶

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Pearson

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

1 A student carries out tests on two inorganic salts, **A** and **B**.

(a) Salt **A** contains one type of cation and one type of anion.

Complete the table for the tests on a sample of the solid salt **A**.

	Test	Observations	Inference	
(i)	Heat a small amount of solid **A** in a test tube, holding some cobalt chloride paper at the mouth of the test tube.	1 .... 2	**A** is a hydrated salt.	**(2)**
(ii)	Add excess aqueous sodium hydroxide to a solution of **A** and leave to stand in air.	A pale brown precipitate forms, which darkens on standing.	The **formula** of the cation in **A** is	**(1)**
(iii)	....	A white precipitate forms on adding a mixture of two solutions to a solution of **A**. The white precipitate dissolves on adding an excess of another solution.	The formula of the anion in **A** is Cl^-.	**(2)**
	Conclusion			
(iv)	Give the **formula** of salt **A**, which has a molar mass of 197.9 g mol^{-1}.			**(2)**

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(b) Salt **B** contains two types of cation and one type of anion.

Tests were carried out on separate samples of a solution of salt **B**.

Test **1**

Excess dilute aqueous sodium hydroxide was added and the solution warmed.
A green precipitate was observed. The precipitate turned brown on standing in air.
A piece of damp red litmus paper was held at the mouth of the test tube. The litmus paper turned blue.

Test **2**

Acidified barium chloride solution was added.
A white precipitate was observed.

(i) Write **ionic** equations to account for the following observations.
State symbols are **not** required.

(3)

Formation of **green** precipitate in Test **1**

Formation of gas that turned the litmus paper blue in Test **1**

Formation of white precipitate in Test **2**

(ii) The brown precipitate from Test **1** was dissolved in sulfuric acid.
A yellow-brown solution formed.

Give the **formula** of the **complex ion** present in the yellow-brown solution.

(1)

.....

(iii) State the **formula** of salt **B**.

(1)

.....

(Total for Question 1 = 12 marks)

2 When excess calcium hydroxide is added to water, a reversible reaction occurs resulting in this equilibrium.

$$Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$$

The equilibrium constant, K_c, for this reaction is

$$K_c = [Ca^{2+}(aq)]\,[OH^-(aq)]^2$$

A student carries out an experiment to determine the concentration of a saturated solution of calcium hydroxide, and the value of K_c.

Procedure

Step **1** Weigh approximately 2 g of powdered calcium hydroxide into a conical flask.

Step **2** Add about 100 cm^3 of deionised water to the flask. Stopper the flask and shake for about a minute. Leave the stoppered flask for one day.

Step **3** Filter the contents of the flask.

Step **4** Titrate 25.0 cm^3 portions of the filtrate with 0.100 mol dm^{-3} hydrochloric acid in the presence of a suitable indicator.

(a) Give the reason why the conical flask is left for one day at the end of Step **2**.

(1)

.....

.....

(b) Give the name of a suitable indicator to use in Step **4**, including the expected colour change at the end-point.

(2)

Name of indicator .....

Colour change from ..... to .....

(c) Results from the titrations are shown.

Titration	1	2	3
Final burette reading / cm^3	9.95	19.50	28.95
Initial burette reading / cm^3	0.00	9.95	19.50
Titre of HCl(aq) / cm^3	9.95		

(i) Complete the table and calculate the mean titre in cm^3.

(2)

(ii) The equation for the titration is shown.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

A data book value for the concentration of a saturated solution of calcium hydroxide at 20 °C is 1.56 g dm^{-3}.

Calculate the expected titre, using this information and that given in Step **4**.

(4)

(iii) The solubility of calcium hydroxide decreases with increasing temperature.

Suggest why the mean titre from the experiment in (c)(i) does **not** agree with the expected titre from (c)(ii).

(1)

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(d) From the results of the experiment, the student determined the concentration of the saturated solution of calcium hydroxide to be 0.0190 mol dm^{-3}.

Calculate the value of K_c, including units, from the student's result.

$$K_c = [Ca^{2+}(aq)] [OH^-(aq)]^2$$

(2)

(Total for Question 2 = 12 marks)

3 A 'clock' reaction may be used to determine the activation energy for the reduction of peroxodisulfate(VI) ions, $S_2O_8^{2-}(aq)$, by iodide ions, $I^-(aq)$.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

A small amount of thiosulfate ions, $S_2O_3^{2-}(aq)$, is added to the reaction mixture, which also contains some starch indicator.

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

Procedure

Step **1** Prepare a water bath by heating a half-full beaker of water to approximately 50 °C.

Step **2** Using a burette, add 10.0 cm^3 of 0.020 mol dm^{-3} $S_2O_8^{2-}(aq)$ ions into a boiling tube.

Step **3** Into a second boiling tube, use separate burettes to add 5.0 cm^3 of 0.50 mol dm^{-3} $I^-(aq)$ ions, 5.0 cm^3 of 0.010 mol dm^{-3} $S_2O_3^{2-}(aq)$ ions, and 2.5 cm^3 of 0.2% starch solution.

Step **4** Place both boiling tubes in the water bath and add a thermometer to each. When the temperatures of the two solutions are the same as the water bath, pour the contents of the second boiling tube into the first, stir and start a timer.

Step **5** Stop the timer when the colour changes and record the time, *t*. The reciprocal of the time, 1 / *t*, is proportional to the initial rate.

Step **6** Repeat the experiment at several temperatures between 45 °C and 25 °C.

(a) Explain why thiosulfate ions, $S_2O_3^{2-}(aq)$, are added to the reaction mixture.

(2)

(b) Explain why a burette, and not a measuring cylinder, is used to add the starch solution in Step **3**, even though the concentration of starch indicator does not need to be exactly the same at each temperature.

(2)

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.....

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.....

(c) State the colour change in Step **5**.

(2)

Colour change from ..... to .....

(d) Some results from the experiment are shown.

T / °C	T / K	$(1 / T) / K^{-1}$	Time, t / s	$(1 / t) / s^{-1}$	ln $(1 / t)$
	322	0.00311	33	0.0303	–3.50
43			47	0.0213	–3.85
36	309	0.00324	72	0.0139	–4.28
31	304	0.00329			–4.60
25	298	0.00336	147	0.00680	

(i) Complete the table.

(3)

(ii) The experimental data was plotted on a graph of $\ln(1/t)$ against $1/T$, giving a straight line with gradient, $m = -6045$ K.

Calculate the activation energy, E_a, for this reaction, in kJ mol^{-1}, using this result.

$$\ln(1/t) = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant} \qquad R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$$

(1)

(Total for Question 3 = 10 marks)

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4 This question is about the preparation and purification of a sample of phenyl benzoate, $C_6H_5COOC_6H_5$.

$$C_6H_5COCl + C_6H_5OH \rightarrow C_6H_5COOC_6H_5 + HCl$$

Procedure

Step **1** Weigh 5.00 g of phenol, C_6H_5OH, into a conical flask and add 90 cm^3 of 2.0 mol dm^{-3} aqueous sodium hydroxide.

Step **2** Working in a fume cupboard, add 9 cm^3 of benzoyl chloride, C_6H_5COCl, into the conical flask. Stopper the flask and shake for 15 minutes, carefully releasing the pressure every few minutes.

Step **3** Cool the flask under cold running water before collecting the impure phenyl benzoate, $C_6H_5COOC_6H_5$, by suction filtration. Wash the crude product with water.

Step **4** Recrystallise the crude product using ethanol.

Step **5** Measure the melting temperature of the pure, dry crystals of phenyl benzoate.

Some data relating to the organic compounds involved in the preparation are shown.

Compound	Hazard	M_r	Melting temperature / °C
Phenol	Corrosive. Toxic by inhalation and skin absorption.	94.0	41
Benzoyl chloride	Corrosive. Toxic by inhalation and skin absorption.	140.5	–1
Phenyl benzoate	Irritating to the skin and eyes.	198.0	71

(a) State the main safety precaution, other than wearing safety spectacles and a laboratory coat, that should be taken when weighing the phenol in Step **1**.

(1)

.....

.....

(b) Give **one** reason why Step **2** must be performed in a fume cupboard.

(1)

.....

.....

.....

(c) Deduce why the volume of benzoyl chloride added in Step **2** does **not** need to be exact.
Include a calculation in your answer.

[Density of benzoyl chloride = 1.21 g cm^{-3}]

(4)

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.....

(d) Give **two** reasons why the crude product is washed with **water** in Step **3**.

(2)

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(e) The recrystallisation in Step **4** was carried out using this method:

- transfer the crude product to a boiling tube and cover in ethanol
- place the boiling tube in a water bath at 60 °C
- add ethanol until the solid completely dissolves after stirring
- cool the solution in an ice-water bath until crystals appear
- filter the crystals by suction filtration
- wash the crystals with **cold** ethanol.

(i) The boiling temperature of ethanol is 78 °C.

Suggest why the crystals are dissolved in ethanol at 60 °C, even though this is lower than the boiling temperature of ethanol.

(1)

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(ii) Explain why the crystals are **washed** with **cold** ethanol.

(2)

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(f) Draw a **labelled** diagram of the apparatus that could be used to measure the melting temperature of phenyl benzoate in Step **5**.
You should assume that electrical equipment for measuring the melting temperature is **not** available.

(3)

(g) Calculate the mass of phenyl benzoate that can be prepared from 5.00 g of phenol if the overall yield, by mass, is 65.0%.

(2)

(Total for Question 4 = 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