Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 30 October 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 8 3 9 4 A 0 1 1 6

Pearson

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

1 (a) Compounds **P** and **Q** are crystalline solids.

P is white and contains one cation and one anion.

Q is pale violet and contains two cations and one anion.

A student carried out tests to identify **P** and **Q**.

(i) Complete the table to show, by name or formula, the products of the tests.

(4)

Test	Observation	Name or formula of product
Aqueous silver nitrate and dilute nitric acid were added to a sample of an aqueous solution of **P** Concentrated ammonia solution was then added	A yellow precipitate was formed which was insoluble in concentrated ammonia	The **precipitate** was .....
A sample of solid **Q** was added to 5 cm^3 of aqueous sodium hydroxide and the mixture was warmed	A pungent gas was evolved which turned damp red litmus paper blue A red-brown precipitate was formed which was insoluble in excess alkali	The **gas** was ..... The **precipitate** was .....
Aqueous barium chloride and dilute hydrochloric acid were added to a sample of a solution of **Q**	A white precipitate was formed	The **precipitate** was .....

(ii) A green flame was seen when a flame test was carried out on a sample of solid **P**. Identify **P** by name or formula.

(1)

P

.....

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(iii) Give the formulae of the three ions present in **Q** and hence the formula of compound **Q**.

(2)

Ions in **Q**

.....

Formula of **Q**

.....

(b) The student added a sample of a pale-brown, aqueous solution of **Q** to a colourless aqueous solution of **P**. The student observed the formation of a darker brown solution along with a white precipitate.

The student concluded from the formation of the darker brown solution that a redox reaction had taken place.

Explain why the student came to this conclusion.

(2)

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(Total for Question 1 = 9 marks)

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2 A group of students investigated the kinetics of the reduction of peroxydisulfate ions by iodide ions in aqueous solution, as shown in Reaction **1**.

Reaction **1** $S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$

Some of the iodine produced in Reaction **1** may be removed by including a portion of sodium thiosulfate in the reaction mixture.
The thiosulfate ions react with the iodine as shown in Reaction **2**.

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

After all the thiosulfate ions have reacted, any further iodine produced can be detected by the formation of a starch-iodine complex. Student **M** carried out a sequence of experiments to determine the order of the reaction with respect to **iodide ions**.

The volumes of the solutions used in the mixtures are shown in Table **1**.

Table **1**

Mixture	Volume KI(aq) / cm^3	Volume $K_2S_2O_8$(aq) / cm^3	Volume $Na_2S_2O_3$(aq) / cm^3	Volume H_2O(l) / cm^3
1	18.0	20.0	5.0	2.0
2	15.0	20.0	5.0	5.0
3	11.0	20.0	5.0	9.0
4	7.5	20.0	5.0	12.5
5	4.0	20.0	5.0	16.0

The concentrations of the solutions used were

Potassium iodide	KI(aq)	0.200 mol dm^{-3}
Potassium peroxydisulfate	$K_2S_2O_8$(aq)	0.100 mol dm^{-3}
Sodium thiosulfate	$Na_2S_2O_3$(aq)	0.00500 mol dm^{-3}

Procedure

Step **1** A few drops of starch solution are added to 5.0 cm^3 sodium thiosulfate solution in a small beaker.

Step **2** The potassium peroxydisulfate solution and water are added to the beaker.

Step **3** Then potassium iodide solution is added, the mixture stirred and a timer is started. The time taken to change colour is recorded.
The procedure is repeated for each mixture using the volumes shown in Table **1**.

(a) (i) Suggest a suitable piece of apparatus for measuring the volume of the potassium iodide solution.

(1)

.....

(ii) State the final colour of the reaction mixture in Step **3**.

(1)

.....

(iii) The reciprocal of the time taken for the mixture to change colour (1 / time), can be used as an approximate measure of the initial rate.

State why the amount of added thiosulfate ions should be much smaller than the amount of peroxydisulfate or iodide ions for this approximation to be valid.

(1)

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.....

.....

(iv) State why is it important that the rate of Reaction **2** is much faster than that of Reaction **1**.

(1)

.....

.....

(b) The results that Student **M** obtained are shown.

Table **2**

Mixture	$[I^-]$ / mol dm^{-3}	time / s	1 / time / s^{-1}
1	0.080	130	0.0077
2	0.067	157	0.0064
3		202	0.0050
4	0.033	320	0.0031
5	0.018	658	0.0015

(i) Complete Table **2** with the iodide ion concentration in Mixture 3, using the information from Table **1** and the concentration of the potassium iodide solution.

(1)

(ii) Plot a graph of 1 / time against the iodide ion concentration.

(2)

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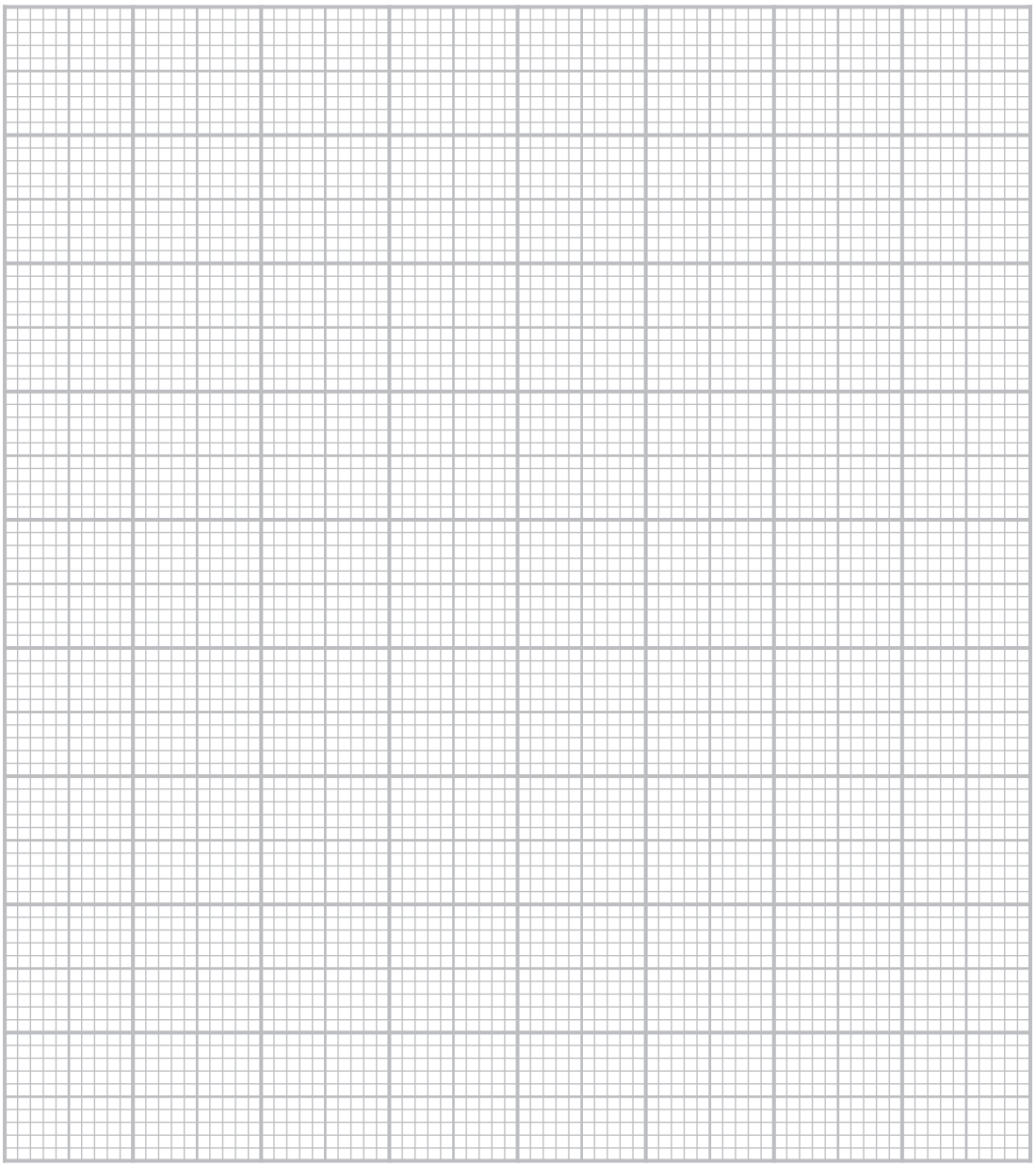

(iii) Deduce the order of the reaction with respect to iodide ions.

Justify your answer.

(2)

(c) (i) Student **N** carried out a sequence of experiments to find the order of reaction with respect to **peroxydisulfate ions**, using solutions of the same concentration.

The volumes of potassium peroxydisulfate solution used were different.

State **two** variables which should be kept the same.

(2)

(ii) Student **N** found that the reaction is first order with respect to peroxydisulfate ions.

Write the overall rate equation for the reaction of peroxydisulfate ions with iodide ions.

(1)

(d) Student **R** carried out experiments to find the activation energy of this reaction. A similar procedure was used to determine the rate of reaction at two different temperatures.

The results of these experiments are shown.

T / °C	T / K	$1 / T / K^{-1}$	t / s	k / $dm^3 mol^{-1} s^{-1}$	ln k
12	285	0.00351	265	2.4×10^{-3}	–6.03
45	318	0.00314	20	3.1×10^{-2}	–3.47

Calculate, without drawing a graph, the activation energy of the reaction.

You should include a sign and units in your answer.

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

(3)

(Total for Question 2 = 15 marks)

3 Ethanedioic acid, $(COOH)_2.xH_2O$, in solution is an acidic bleach for wood.

A student determined the value of x in a sample of ethanedioic acid by titration with potassium manganate(VII) solution.

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

Procedure

Step **1** A sample of 1.27 g of the solid acid was dissolved in deionised water to make 250.0 cm^3 of solution.

Step **2** 25.0 cm^3 of the ethanedioic acid solution was transferred to a conical flask, 25 cm^3 dilute sulfuric acid was added and the mixture warmed to 60 °C.

Step **3** The mixture was titrated with potassium manganate(VII) solution of concentration 0.0203 mol dm^{-3}.

(a) (i) Describe how to make 250.0 cm^3 of a solution of ethanedioic acid in Step **1**.

(3)

(ii) Explain why, in Step **2**, the ethanedioic acid solution was measured using a 25.0 cm^3 volumetric pipette but the dilute sulfuric acid was measured using a 25 cm^3 measuring cylinder.

(2)

(iii) State why the titration needed no indicator.

(1)

(iv) Suggest why, in Step **2**, the temperature of the mixture at the start should be 60°C but no further warming is needed after a small quantity of the potassium manganate(VII) solution has been added.

(3)

(v) The mean titre was 19.90 cm^3.
Determine the value of x in $(COOH)_2.xH_2O$.

(4)

(b) Ethanedioic acid dissociates in two steps.

The **first** dissociation equation is shown.

$$(COOH)_2(aq) \rightleftharpoons HCOOCOO^-(aq) + H^+(aq)$$

The acid dissociation constant, K_{a1}, for **this** dissociation is 5.6×10^{-2} mol dm^{-3}.
The corresponding pK_{a1} is 1.25 .

Outline a practical method that would enable a student to confirm the value for this first acid dissociation constant.
You may use the Indicator data provided.

Assume that equimolar solutions of ethanedioic acid and sodium hydroxide, titration apparatus and a pH meter are available.

You are not expected to include details of any calculations needed.

Indicator data

Indicator	pK_{in} (at 298 K)	acid	pH range	alkaline
thymol blue (acid)	1.7	red	1.2–2.8	yellow
methyl orange	3.7	red	3.2–4.4	yellow
bromophenol blue	4.0	yellow	2.8–4.6	blue
phenolphthalein	9.3	colourless	8.2–10.0	red

(3)

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(Total for Question 3 = 16 marks)

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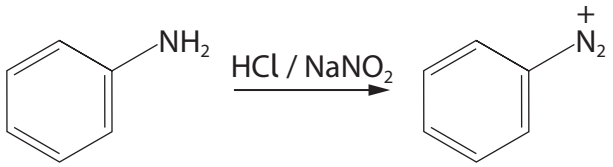
4 Azo dyes are widely used to dye cotton fabric.

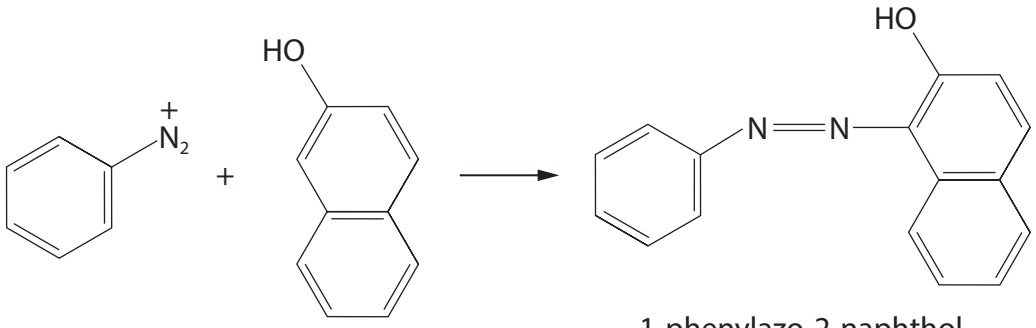
The azo dye, 1-phenylazo-2-naphthol, can be made from phenylamine by reacting it with sodium nitrite and hydrochloric acid.
The diazonium salt produced undergoes a coupling reaction with 2-naphthol.

Reaction **1**



benzenediazonium ion

Reaction **2**



1-phenylazo-2-naphthol

(a) Phenylamine, used in Reaction **1**, is labelled with the following hazard symbols.

State the meaning of each symbol.

(2)

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(b) Practical instructions for the preparation of 1-phenylazo-2-naphthol are shown.

Step **1** Phenylamine, dissolved in hydrochloric acid in a beaker, is placed in an ice bath.

Step **2** When the temperature is between 0 °C and 5 °C, a cooled aqueous solution of sodium nitrite is added drop-by-drop.

Step **3** A solution of 2-naphthol dissolved in aqueous sodium hydroxide in a boiling tube is placed in an ice bath.

Step **4** The mixture from Step **3** is then added very slowly to the solution from Step **2** containing the diazonium salt. The small, red crystals of the product, 1-phenylazo-2-naphthol, form over several minutes.

Step **5** The crystals are filtered off under reduced pressure, washed and recrystallised from ethanoic acid. A data book gives the melting temperature of 1-phenylazo-2-naphthol as 131 °C.

(i) Explain why the temperature for Reaction **1** must be kept between 0 °C and 5 °C.

(2)

.....

.....

.....

(ii) Draw a labelled diagram of the apparatus used to filter off the crystals under reduced pressure in Step **5**.

(2)

(iii) Outline how the melting temperature of the crystals may be measured to ensure that an accurate value is obtained.

(3)

(c) Azo dyes were developed during the nineteenth century but workers in the industry showed high rates of bladder cancer and the production of some dyes was discontinued.

The introduction of a sulfonic acid group into the dye used for black ink for ink-jet printers has significantly reduced the toxic effects.

The formula for a sulfonic acid side group is shown.

$$R—SO_3^-H^+$$

Suggest how the change in solubility caused by the introduction of the sulfonic acid group reduces the toxic effects of the dye.

(1)

(Total for Question 4 = 10 marks)

TOTAL FOR PAPER = 50 MARKS

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