

Surname	Centre Number	Candidate Number
Other Names		2



GCE A LEVEL

1410U30-1



S18-1410U30-1

CHEMISTRY – A2 unit 3

Physical and Inorganic Chemistry

TUESDAY, 5 JUNE 2018 – AFTERNOON

1 hour 45 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
Section A 1. to 7.	10	
Section B 8.	14	
9.	18	
10.	12	
11.	18	
12.	8	
Total	80	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.

Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q.12(b)**.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.



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SECTION A

Answer all questions in the spaces provided.

1. Give the electronic configuration of a copper atom. [1]

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2. Excess sodium hydroxide is added to an aqueous solution of chromium(III) chloride, CrCl_3 . Give the formula of the chromium-containing ion formed. [1]

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3. (a) Write the equation for the reaction of hot concentrated aqueous sodium hydroxide with chlorine. [1]

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- (b) This is an example of a disproportionation reaction. State what is meant by the term *disproportionation*. [1]

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4. Give the observation(s) expected when water is added to SiCl_4 . [1]

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5. A 25.0 cm³ sample of a solution containing iodine is titrated against a sodium thiosulfate solution of concentration 0.0200 mol dm⁻³. This requires 23.25 cm³ of sodium thiosulfate for complete reaction.



Calculate the concentration of the iodine in the solution in g dm⁻³. [2]

Concentration = g dm⁻³

6. The enthalpy of solution of sodium chloride is +4 kJ mol⁻¹. Explain why this compound is soluble in water despite this value being positive. [1]

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7. When a solution containing the weak base ammonia is neutralised using the strong acid sulfuric acid, a solution of ammonium sulfate is formed. Suggest a pH for this solution, giving a reason for your answer. [2]

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SECTION B

Answer **all** questions in the spaces provided.

8. (a) Sodium chloride and sodium bromide both react with concentrated sulfuric acid. Describe the observations in both reactions and explain why they are different. [3]

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- (b) Fluorine can form the weak acid hydrofluoric acid, HF. This acid has a K_a value of $7.20 \times 10^{-4} \text{ mol dm}^{-3}$.

(i) Write an expression for the K_a of hydrofluoric acid. [1]

(ii) Calculate the pH of a solution of hydrofluoric acid of concentration $0.100 \text{ mol dm}^{-3}$. [3]

pH =



- (iii) The concentration of a solution of hydrofluoric acid can be found by titrating against sodium hydroxide. Not all acid-base indicators would be suitable for this titration. Explain what features would make an indicator suitable for use in a weak acid-strong base titration. [2]

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- (iv) Addition of 12.5 cm^3 of $0.100 \text{ mol dm}^{-3}$ sodium hydroxide to 25.0 cm^3 of hydrofluoric acid of concentration $0.100 \text{ mol dm}^{-3}$ forms a buffer solution.

- I. Explain how this buffer solution works. [3]

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- II. Calculate the pH of this buffer solution. [2]

pH =



9. Cobalt forms a range of complex ions. Two of these are $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{CoCl}_4]^{2-}$.

(a) Draw the structures of the $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{CoCl}_4]^{2-}$ ions. [2]

(b) Explain why the $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ ion is coloured. [3]

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- (c) A student was given a pink-coloured solution containing $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ ions. Upon addition of hydrochloric acid the solution turned blue as $[\text{CoCl}_4]^{2-}$ ions formed according to the equilibrium shown below.



Aqueous silver nitrate was added to the solution containing $[\text{CoCl}_4]^{2-}$.

State and explain the observation(s) expected.

[4]

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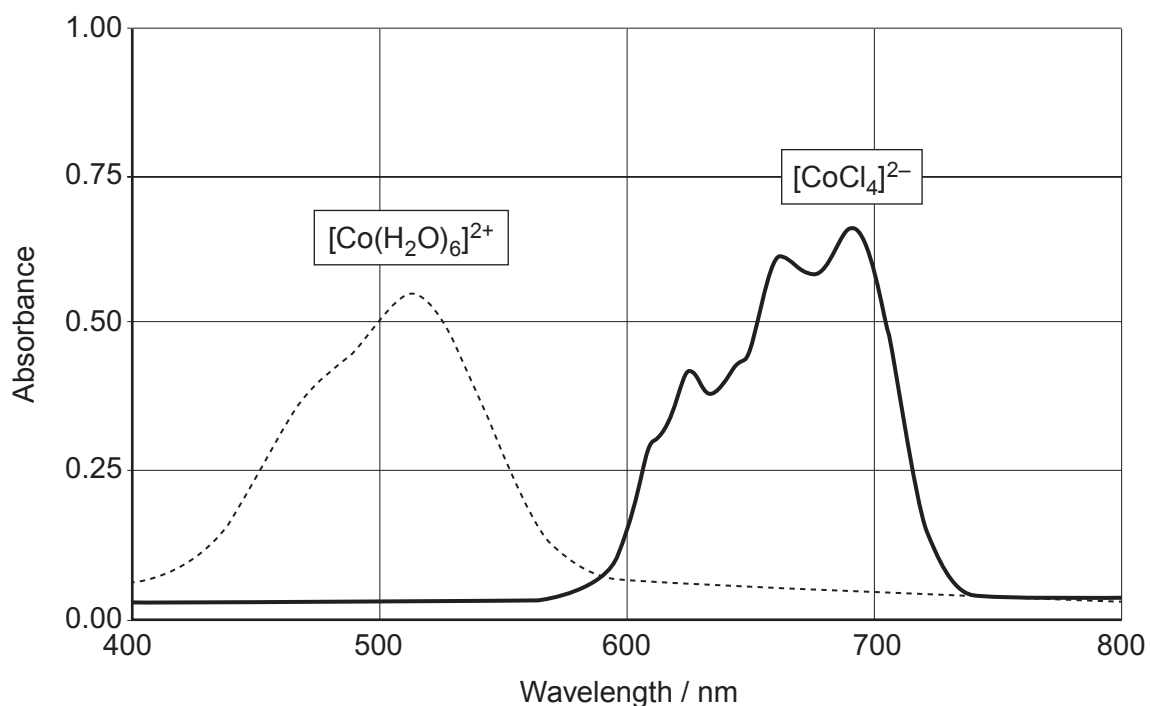
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- (d) These two cobalt-containing ions absorb different frequencies of light. The spectra below show the absorbance at different wavelengths of visible light by the two ions.



- (i) The maximum absorbance for the $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ ion occurs at a wavelength of 518 nm. Calculate the energy of this absorbance in kJ mol^{-1} . [3]

Energy = kJ mol^{-1}

- (ii) A colorimeter was used to study the equilibrium between the two ions.

Suggest, giving a reason, an appropriate wavelength to use for the experiment. [1]

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- (iii) Write the expression for the equilibrium constant, K_c , for this reaction **giving its unit**. [2]



$K_c =$

Unit

- (iv) A student carries out an experiment starting with separate non-aqueous solutions of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and Cl^- .

When the two solutions are mixed the initial concentrations of both $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ and Cl^- in the mixture are $0.720 \text{ mol dm}^{-3}$. When the mixture reaches equilibrium the concentration of the water is $0.744 \text{ mol dm}^{-3}$.

Calculate the value of the equilibrium constant, K_c . [3]

$K_c =$



10. (a) (i) Tin and carbon are both more stable in oxidation state +4 whilst lead is more stable as +2. Explain the difference in the stabilities of these oxidation states. [1]

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- (ii) Lead(IV) oxide can act as an oxidising agent when it reacts with concentrated hydrochloric acid. Write an equation for this reaction. [1]

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- (b) Tin(II) ions can be used to reduce iron(III) ions in **acidic** solution.



$[\text{Fe}^{3+}] / \text{mol dm}^{-3}$	$[\text{Sn}^{2+}] / \text{mol dm}^{-3}$	pH	Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
0.200	0.100	0	1.4×10^{-2}
0.300	0.200	0	2.8×10^{-2}
0.400	0.100	1	1.4×10^{-3}
0.400	0.200	1	2.8×10^{-3}

- (i) Find the rate equation for this reaction. [3]

- (ii) Calculate the value of the rate constant, k , for this reaction. [2]

$k =$



- (iii) A student suggests that the rate determining step for this reaction is:



State, giving a reason, whether this is a possible rate determining step for this reaction. [2]

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- (c) The rate of this reaction can be followed using sampling and quenching.

- (i) Explain what is meant by *sampling and quenching*. [1]

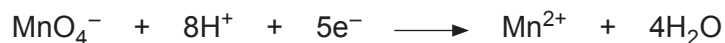
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- (ii) A 5.00 cm³ sample of the solution was analysed by titration against acidified potassium manganate(VII). The sample required 27.20 cm³ of manganate(VII) solution of concentration 0.00205 mol dm⁻³ for complete reaction.

Calculate the concentration of Fe²⁺ in the solution. [2]

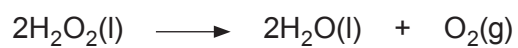


Concentration of Fe²⁺ = mol dm⁻³

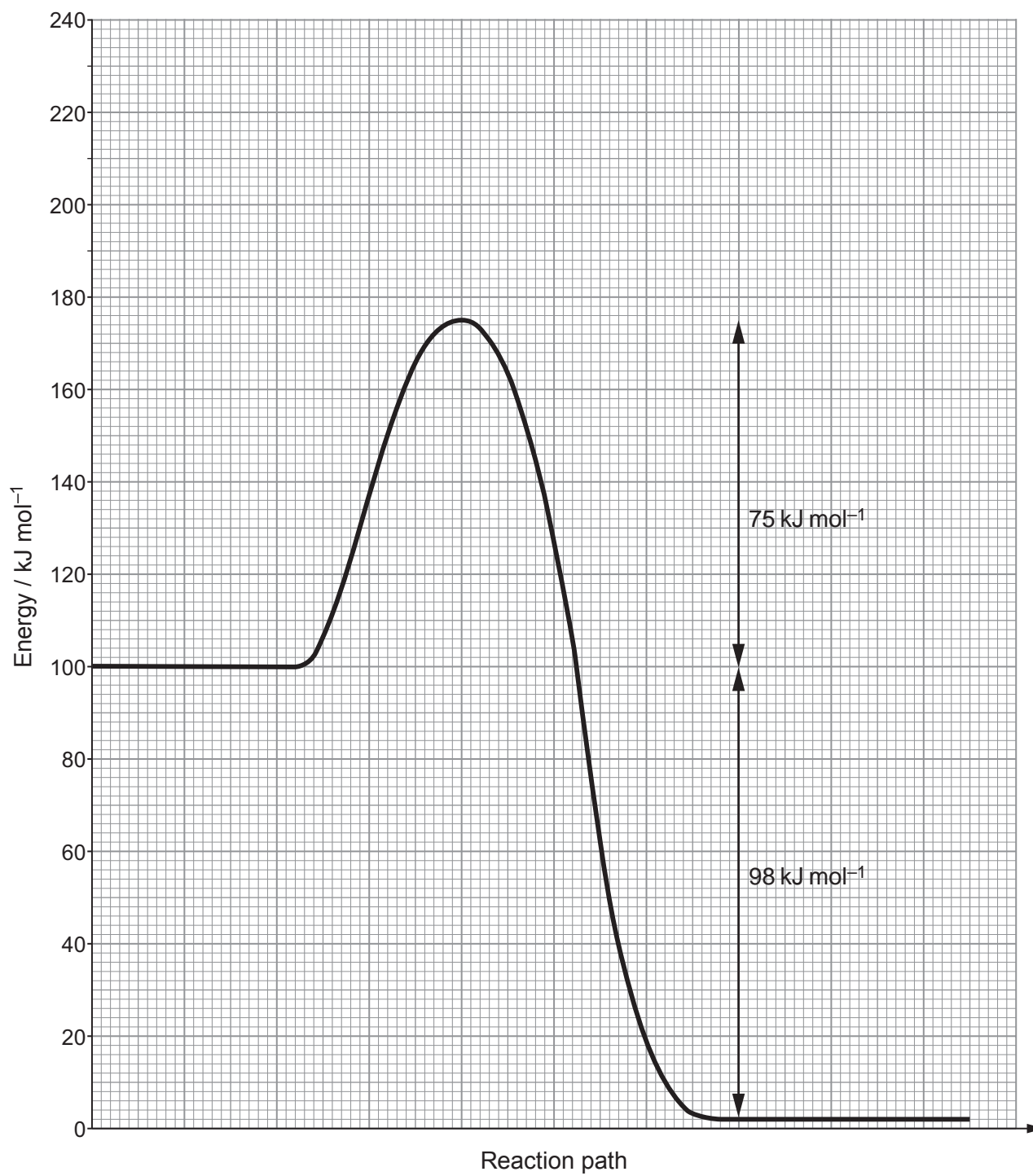
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11. Hydrogen peroxide, H_2O_2 , decomposes slowly at 300 K to form water and oxygen gas.



The reaction profile for this reaction is shown below.



- (a) The rate of decomposition of hydrogen peroxide can be influenced by a range of catalysts. The activation energy when using MnO_2 as a catalyst is 58 kJ mol^{-1} .

Draw the reaction profile for the catalysed reaction **on the grid opposite**. [1]

- (b) Another catalyst was used and this gave a value for the rate constant, k , of $1.68 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$ and the frequency factor, A , of $1.41 \times 10^4 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$ at a temperature of 300K.

- (i) State the Arrhenius equation. [1]

- (ii) Calculate the activation energy using this catalyst and hence state whether it is a more effective catalyst than MnO_2 . [3]

Activation energy = kJ mol^{-1}

- (c) The standard enthalpy change of formation, $\Delta_f H^\theta$, of water is -286 kJ mol^{-1} .

Use this information and the graph to calculate the standard enthalpy change of formation of hydrogen peroxide. [2]

$\Delta_f H^\theta(\text{H}_2\text{O}_2) = \dots\dots\dots \text{kJ mol}^{-1}$

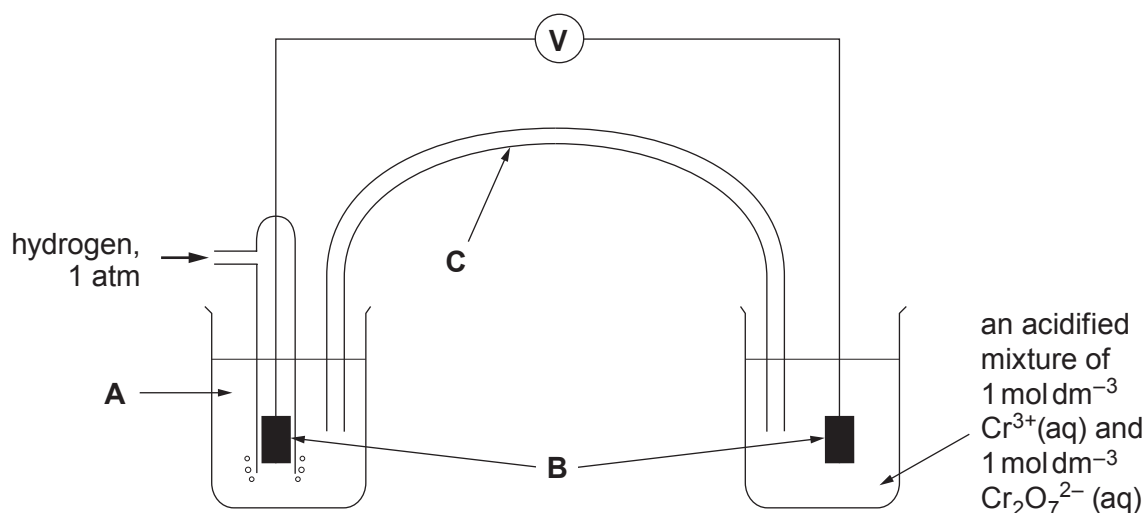
- (d) State whether you would expect the entropy change for the decomposition of hydrogen peroxide to be positive or negative. Give a reason for your answer. [1]



(e) One way of assessing whether a reaction is feasible is to use standard electrode potentials.

	Standard electrode potential / V
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$	+1.77
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1.33

(i) The apparatus below can be used to measure the standard electrode potential for the $\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}$ half-cell.



I. State what is represented by **A** and **B** on the diagram. [1]

A

B

II. **On the diagram** show the direction of flow of electrons in the external circuit. [1]



III. State what is represented by **C** on the diagram and state its function. [1]

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IV. The concentrations of both $\text{Cr}_2\text{O}_7^{2-}$ and Cr^{3+} ions are 1 mol dm^{-3} . State and explain how the value shown on the high resistance voltmeter would change if the concentration of the Cr^{3+} ions were increased whilst the concentration of the $\text{Cr}_2\text{O}_7^{2-}$ was left unchanged. [2]

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(ii) It is suggested that hydrogen peroxide could be used to oxidise Cr^{3+} ions in acidic solution to form dichromate ions.

I. Write an equation for this proposed reaction. [1]

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II. Use the standard electrode potential values given to predict whether this reaction is feasible. [2]

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III. Another method of finding whether a reaction is feasible is to use the Gibbs free energy calculated from standard enthalpy of formation and standard entropy values.

State, giving a reason, whether Gibbs free energies or electrochemical methods are more appropriate for finding whether this reaction is feasible. [2]

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12. A student was provided with five ionic solids containing familiar cations and anions. Each solid contains a different **cation**. The solids were labelled **A**, **B**, **C**, **D** and **E**.

The student attempted to dissolve all five solids in water. She then attempted to dissolve those that did not dissolve in water in a stoichiometric amount of acid.

The results are given below.

Solid	Addition of water	Addition of dilute sulfuric acid to solid	Addition of dilute nitric acid to solid
A	dissolves giving colourless solution 1		
B	dissolves giving colourless solution 2		
C	does not dissolve	pale blue solution 3 forms upon warming with the acid	
D	does not dissolve	effervescence and solution 4 forms	
E	does not dissolve	some effervescence but the solid does not dissolve	effervescence and solution 5 forms

Pairs of the solutions formed were mixed and the observations recorded.

	Solution 5	Solution 4	Solution 3	Solution 2
Solution 1 (formed by dissolving solid A)	no visible change	white precipitate	white precipitate	bright yellow precipitate
Solution 2 (formed by dissolving solid B)	no visible change	no visible change	brown solution with a white solid	
Solution 3 (formed by reacting solid C with acid)	thick white precipitate	no visible change		
Solution 4 (formed by reacting solid D with acid)	thick white precipitate			

Flame tests

Flame tests carried out on solutions **1**, **2**, **3**, **4** and **5** gave no colour with one solution, an apple-green flame with another and a lilac flame with a third. The student noted unfamiliar flame test colours for the other two solutions.



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