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Chemistry
Standard level
Paper 2

Wednesday 22 May 2019 (afternoon)

Candidate session number

1 hour 15 minutes

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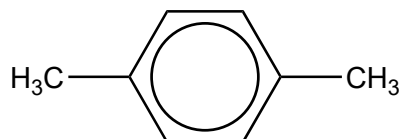
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Answer **all** questions. Answers must be written within the answer boxes provided.

1. Xylene is a derivative of benzene. One isomer is 1,4-dimethylbenzene.



- (a) State the number of ^1H NMR signals for this isomer of xylene and the ratio in which they appear. [2]

Number of signals:

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Ratio:

.....

- (b) Draw the structure of one other isomer of xylene which retains the benzene ring. [1]

(This question continues on the following page)



(Question 1 continued)

(c) Bromine reacts with alkanes.

(i) Identify the initiation step of the reaction and its conditions.

[2]

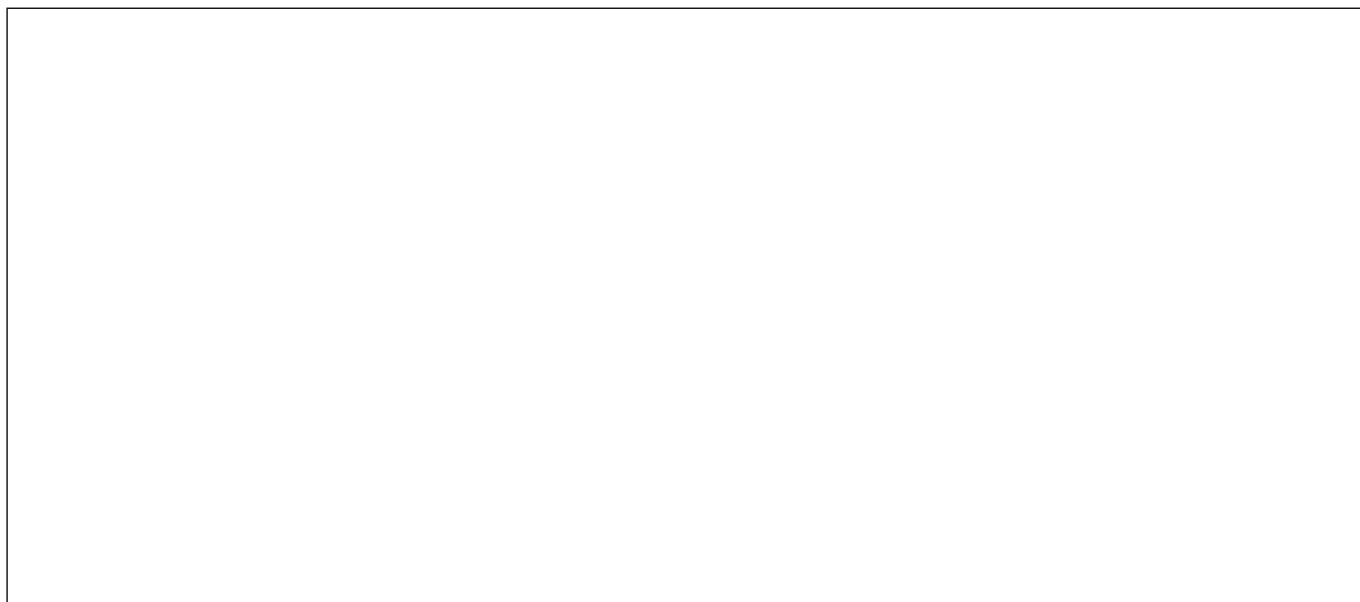
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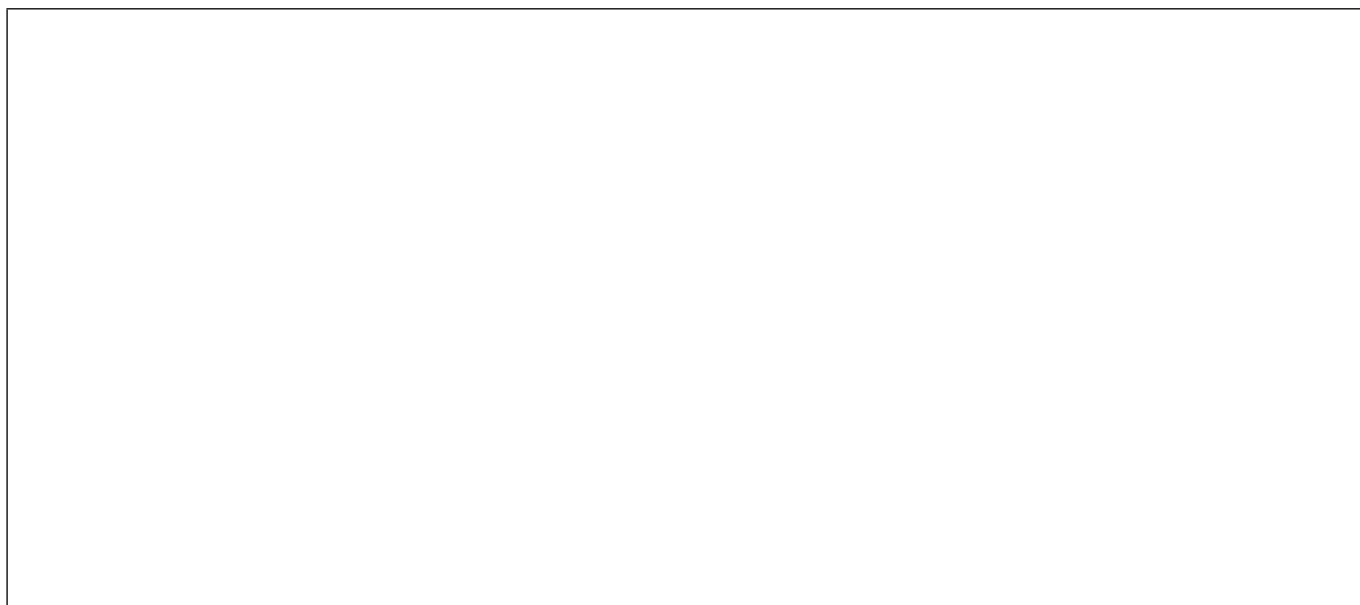
(ii) 1,4-dimethylbenzene reacts as a substituted alkane. Draw the structures of the two products of the overall reaction when one molecule of bromine reacts with one molecule of 1,4-dimethylbenzene.

[2]

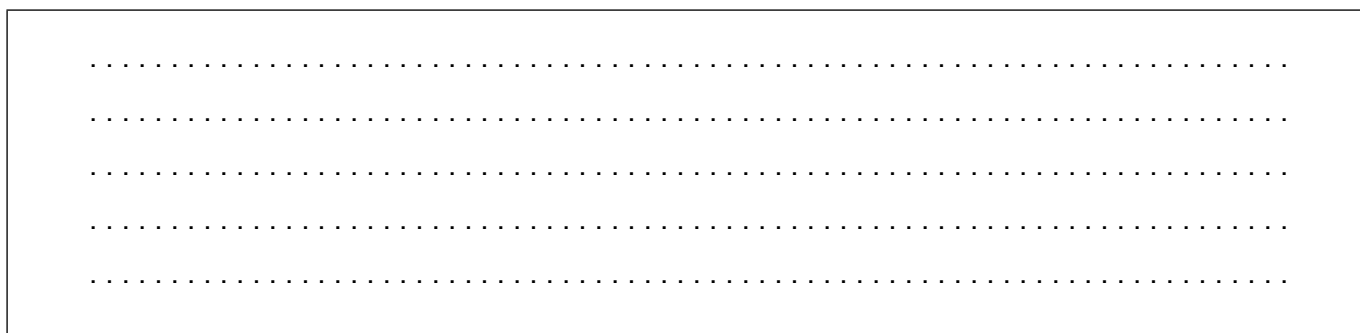


2. Benzoic acid, C_6H_5COOH , is another derivative of benzene.

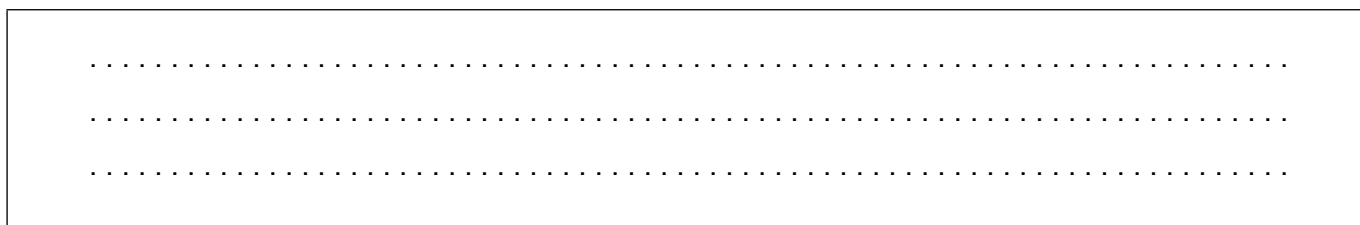
- (a) Draw the structure of the conjugate base of benzoic acid showing **all** the atoms and **all** the bonds. [1]



- (b) (i) The pH of an aqueous solution of benzoic acid at 298 K is 2.95. Determine the concentration of hydroxide ions in the solution, using section 2 of the data booklet. [2]



- (ii) Formulate the equation for the complete combustion of benzoic acid in oxygen using only integer coefficients. [2]



(This question continues on the following page)



(Question 2 continued)

- (c) Suggest how benzoic acid, $M_r = 122.13$, forms an apparent dimer, $M_r = 244.26$, when dissolved in a non-polar solvent such as hexane. [1]

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3. This question is about compounds of sodium.

- (a) (i) Describe the structure and bonding in solid sodium oxide. [2]

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- (ii) Write equations for the separate reactions of solid sodium oxide and solid phosphorus(V) oxide with excess water and differentiate between the solutions formed. [3]

Sodium oxide, Na_2O :

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Phosphorus(V) oxide, P_4O_{10} :

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Differentiation:

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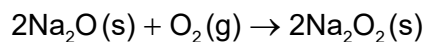


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(Question 3 continued)

- (b) Sodium peroxide, Na_2O_2 , is formed by the reaction of sodium oxide with oxygen.

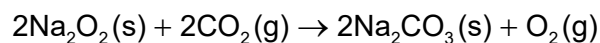


Calculate the percentage yield of sodium peroxide if 5.00 g of sodium oxide produces 5.50 g of sodium peroxide.

[2]

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- (c) Sodium peroxide is used in diving apparatus to produce oxygen from carbon dioxide.



- (i) Determine the enthalpy change, ΔH , in kJ, for this reaction using data from the table and section 12 of the data booklet.

[3]

	$\Delta H_f / \text{kJ mol}^{-1}$
$\text{Na}_2\text{O}_2(\text{s})$	-510.9
$\text{Na}_2\text{CO}_3(\text{s})$	-1130.7

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(Question 3 continued)

- (ii) Outline why bond enthalpy values are not valid in calculations such as that in (c)(i). [1]

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- (d) The reaction of sodium peroxide with excess water produces hydrogen peroxide and one other sodium compound. Suggest the formula of this compound. [1]

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- (e) State the oxidation number of carbon in sodium carbonate, Na_2CO_3 . [1]

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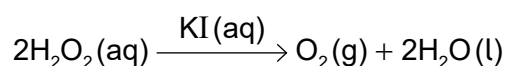
4. This question is about peroxides.

- (a) Suggest why many chemicals, including hydrogen peroxide, are kept in brown bottles instead of clear colourless bottles. [1]

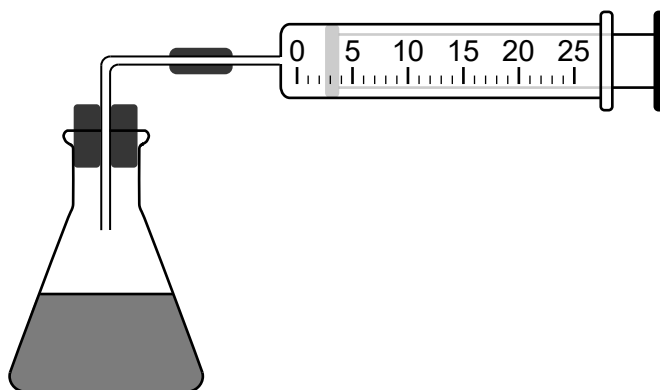
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- (b) Hydrogen peroxide decomposes to water and oxygen when a catalyst such as potassium iodide, KI, is added.



- (i) In a laboratory experiment solutions of potassium iodide and hydrogen peroxide were mixed and the volume of oxygen generated was recorded. The volume was adjusted to 0 at $t = 0$.



The data for the first trial is given below.

Time / s	Volume of O ₂ (g) / cm ³
100	2.5
300	6.5
500	11.0
700	15.0

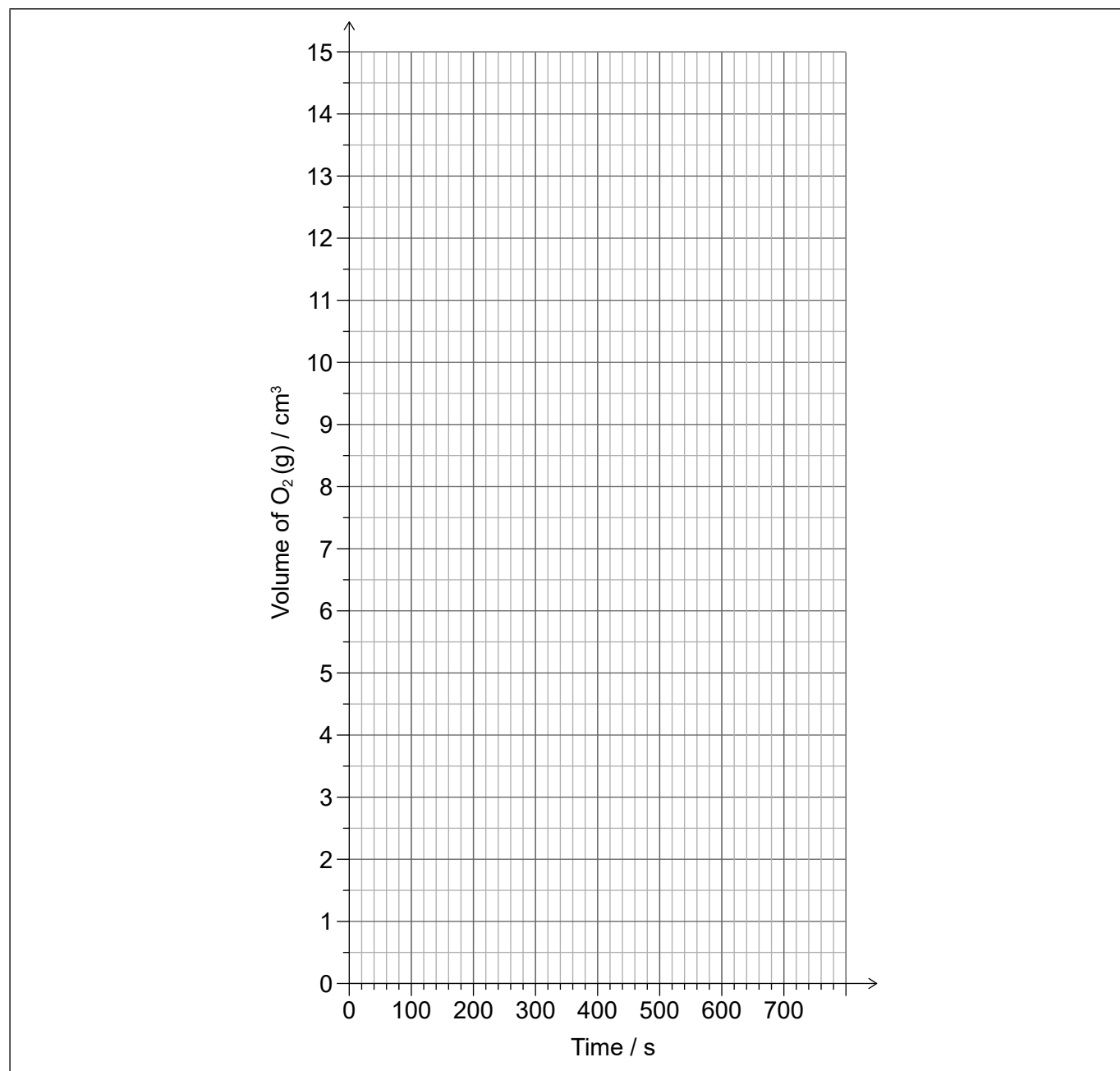
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(Question 4 continued)

Plot a graph on the axes below and from it determine the average rate of formation of oxygen gas in $\text{cm}^3 \text{O}_2(\text{g}) \text{s}^{-1}$.

[3]



Average rate of reaction:

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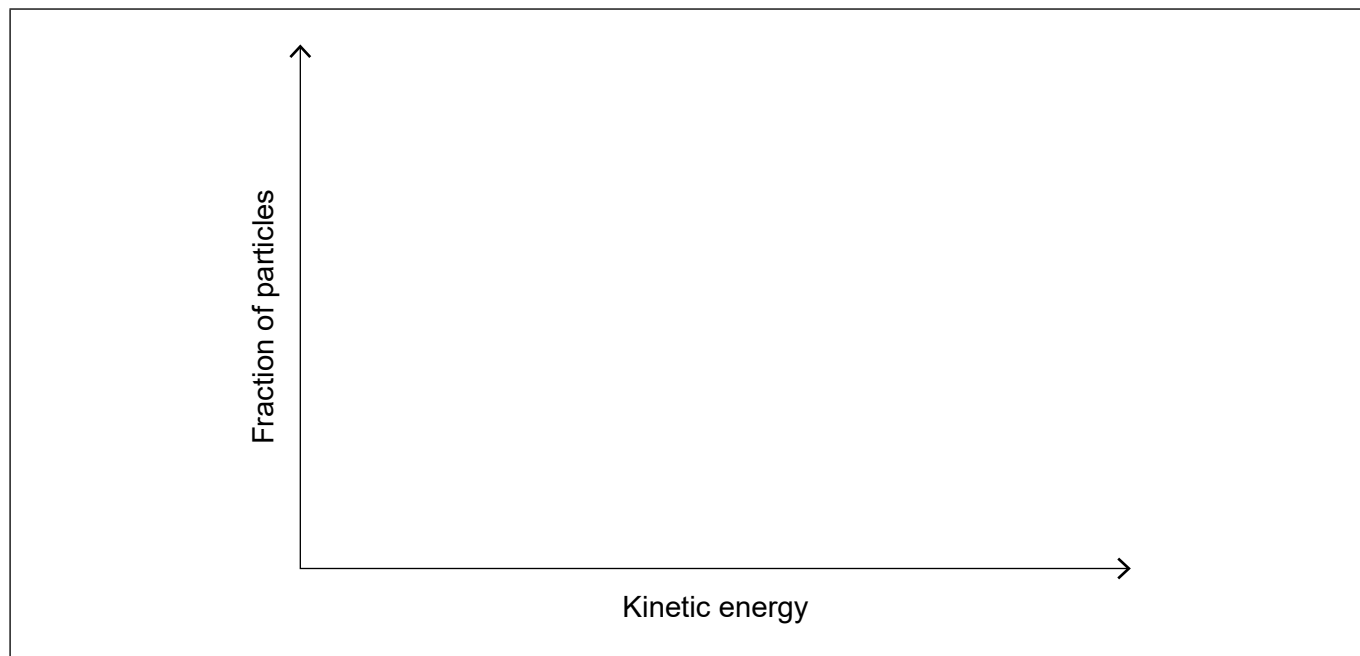


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(Question 4 continued)

- (ii) Additional experiments were carried out at an elevated temperature. On the axes below, sketch Maxwell–Boltzmann energy distribution curves at two temperatures T_1 and T_2 , where $T_2 > T_1$. [2]



- (iii) Apart from a greater frequency of collisions, explain, by annotating your graphs in (b)(ii), why an increased temperature causes the rate of reaction to increase. [2]

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- (iv) MnO_2 is another possible catalyst for the reaction. State the IUPAC name for MnO_2 . [1]

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(This question continues on the following page)



(Question 4 continued)

- (c) Comment on why peracetic acid, CH_3COOOH , is always sold in solution with ethanoic acid and hydrogen peroxide.



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- (d) Sodium percarbonate, $2\text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}_2$, is an adduct of sodium carbonate and hydrogen peroxide and is used as a cleaning agent.

$$M_r(2\text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}_2) = 314.04$$

Calculate the percentage by mass of hydrogen peroxide in sodium percarbonate, giving your answer to two decimal places. [2]

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5. Both vinegar (a dilute aqueous solution of ethanoic acid) and bleach are used as cleaning agents.

(a) Outline why ethanoic acid is classified as a weak acid.

[1]

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(b) A solution of bleach can be made by reacting chlorine gas with a sodium hydroxide solution.



Suggest, with reference to Le Châtelier's principle, why it is dangerous to mix vinegar and bleach together as cleaners.

[3]

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(c) Bleach reacts with ammonia, also used as a cleaning agent, to produce the poisonous compound chloramine, NH_2Cl .

(i) Draw a Lewis (electron dot) structure of chloramine.

[1]

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(This question continues on the following page)



(Question 5 continued)

- (ii) Deduce the molecular geometry of chloramine and estimate its H–N–H bond angle. [2]

Molecular geometry:

.....

H–N–H bond angle:

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6. This question is about iron.

- (a) State the nuclear symbol notation,
- ${}^A_Z\text{X}$
- , for iron-54. [1]

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- (b) Mass spectrometry analysis of a sample of iron gave the following results:

	% abundance
Fe-54	5.84
Fe-56	91.68
Fe-57	2.17
Fe-58	0.31

- Calculate the relative atomic mass,
- A_r
- , of this sample of iron to two decimal places. [2]

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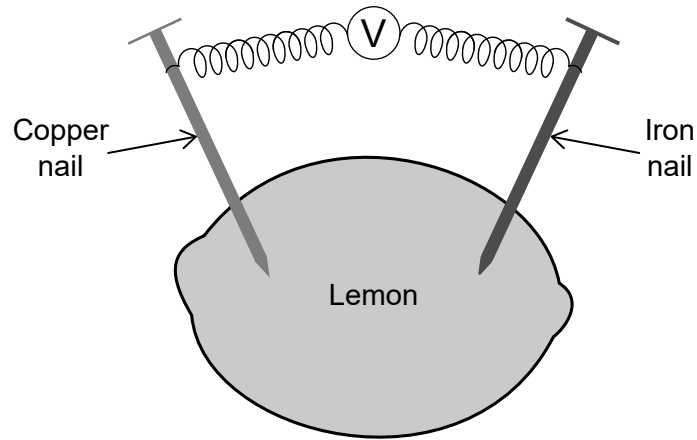
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(Question 6 continued)

(c) An iron nail and a copper nail are inserted into a lemon.



Explain why a potential is detected when the nails are connected through a voltmeter. [2]

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