

Chemistry
Higher level
Paper 1B

Specimen paper

Candidate session number

2 hours [Paper 1A and Paper 1B]

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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 paper 1B is **[35 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.



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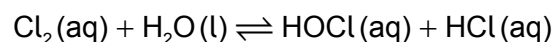
Answers written on this page
will not be marked.



Section B

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

1. Hypochlorous acid, HOCl, is a sterilizing agent used in swimming pools and is produced when chlorine reacts with water.



- (a) Deduce the oxidation states of chlorine in the reactants and products.

[2]

Reactant: Cl_2 :

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Products: HOCl:

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HCl:

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- (b) Explain why more chlorine reacts with water when NaOH(aq) is added.

[1]

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- (c) Researchers studying the solubility of chlorine in pure water at different temperatures compile the following data from different sources.

Source	Temperature / °C	Solubility of chlorine
A	0	1.46 g per 100 cm ³
B	10	310 cm ³ per 100 cm ³
C	20	0.70 g per 100 cm ³
D	25	6300 mg per 1000 cm ³
E	30	177 cm ³ per 100 cm ³
F	30	0.57 g per 100 cm ³

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12EP03

Turn over

(Question 1 continued)

- (i) Identify a problem in comparing the data from different sources.

[1]

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- (ii) The units of solubility are converted to
- mol dm^{-3}
- .

Source	Temperature / °C	Solubility of chlorine	Solubility of chlorine / mol dm^{-3}
A	0	1.46 g per 100 cm^3	0.206
B	10	310 cm^3 per 100 cm^3	0.13
C	20	0.70 g per 100 cm^3	0.099
D	25	6300 mg per 1000 cm^3	0.089
E	30	177 cm^3 per 100 cm^3	
F	30	0.57 g per 100 cm^3	0.080

Complete the table by calculating the value for source E.

Assume the density of chlorine is 2.86 g dm^{-3} at 30°C .

[2]

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- (iii) Suggest an explanation for the effect of temperature on solubility.

[1]

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- (d) Suggest why chlorine is not often added to swimming pools directly.

[1]

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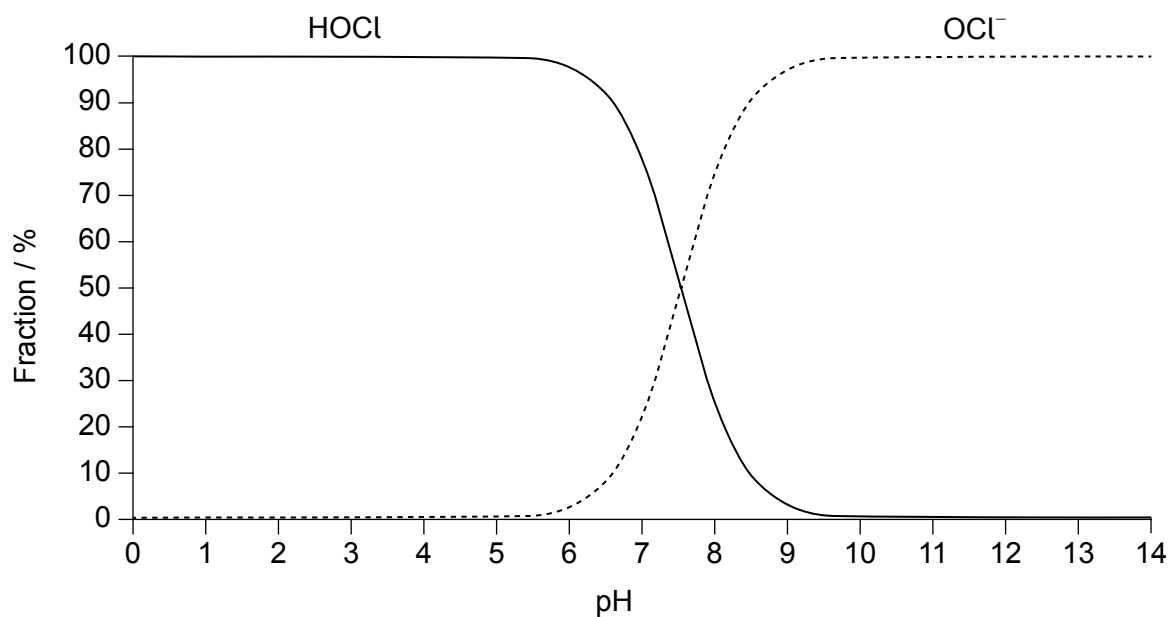
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(Question 1 continued)

- (e) HOCl ionizes to form the hypochlorite ion, OCl^- , which is a less effective disinfectant than the undissociated acid.

The graph shows the concentrations of HOCl(aq) and OCl^- (aq) at different pH values at 25 °C.



- (i) Deduce the pH range where the water is most effectively sterilized.

[1]

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- (ii) Determine, with reference to the graph in (e), the $\text{p}K_a$ of HOCl.

[2]

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12EP05

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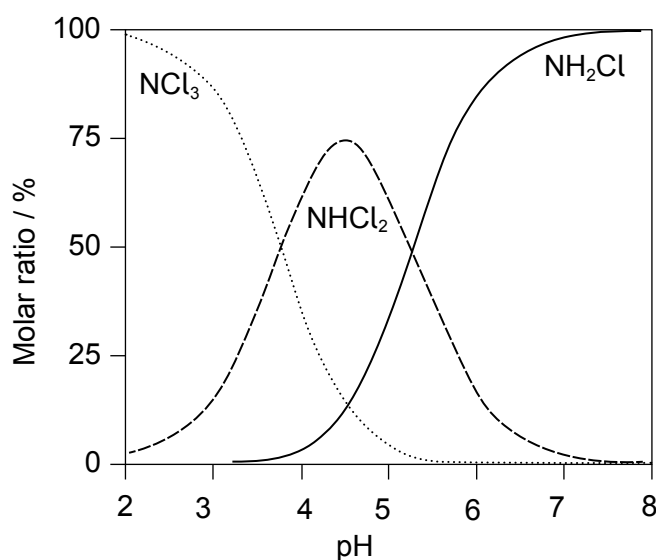
(Question 1 continued)

- (f) Ammonia released from sweat and urine reacts with HOCl to form a range of compounds including chloramines.
- (i) Deduce an equation for the formation of dichloramine, $\text{NHCl}_2(\text{aq})$, from ammonia and HOCl (aq). [1]

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- (ii) The graph shows the molar ratio of chloramines formed at different pH values at 25°C . Trichloramine, NCl_3 , causes pool water to smell bad.



State **two** conditions needed to prevent the bad smell.

[2]

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- (g) Suggest **two** reasons why operating a swimming pool at a lower temperature is favourable for the environment.

[2]

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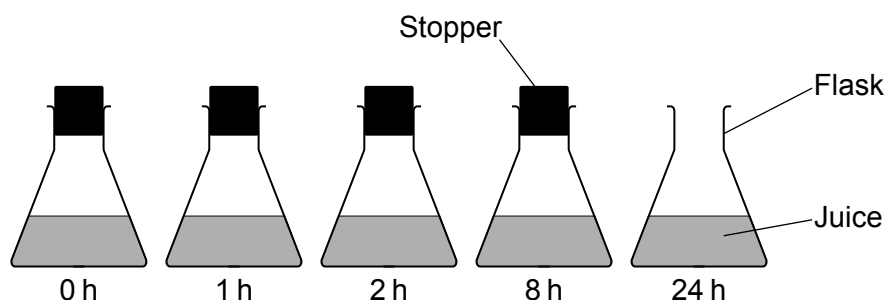
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2. A student investigates the effect of exposure to the air on the ascorbic acid (vitamin C) concentration in a specific orange juice. Equal volumes of orange juice are sealed into identical flasks and placed in a refrigerator for two weeks. The samples in the refrigerator are exposed to the air by removing the stopper for a different number of hours each day as shown.



- (a) Identify **two** variables that are controlled.

[1]

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- (b) The concentration of ascorbic acid is determined by titration with a standard iodine solution. Every few days, 10.00 cm^3 of orange juice is removed from each sample, diluted to 100.0 cm^3 , and titrated.

- (i) Suggest why the juice is diluted before titration.

[1]

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- (ii) Identify a possible systematic error with this method regarding the sample that is exposed for zero hours.

[1]

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- (iii) Suggest how an additional flask could be set up to verify whether the systematic error in (ii) has occurred.

[1]

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(Question 2 continued)

- (c) The following data are collected during a titration.

Final burette reading = $16.10 \pm 0.05 \text{ cm}^3$ Initial burette reading = $1.10 \pm 0.05 \text{ cm}^3$

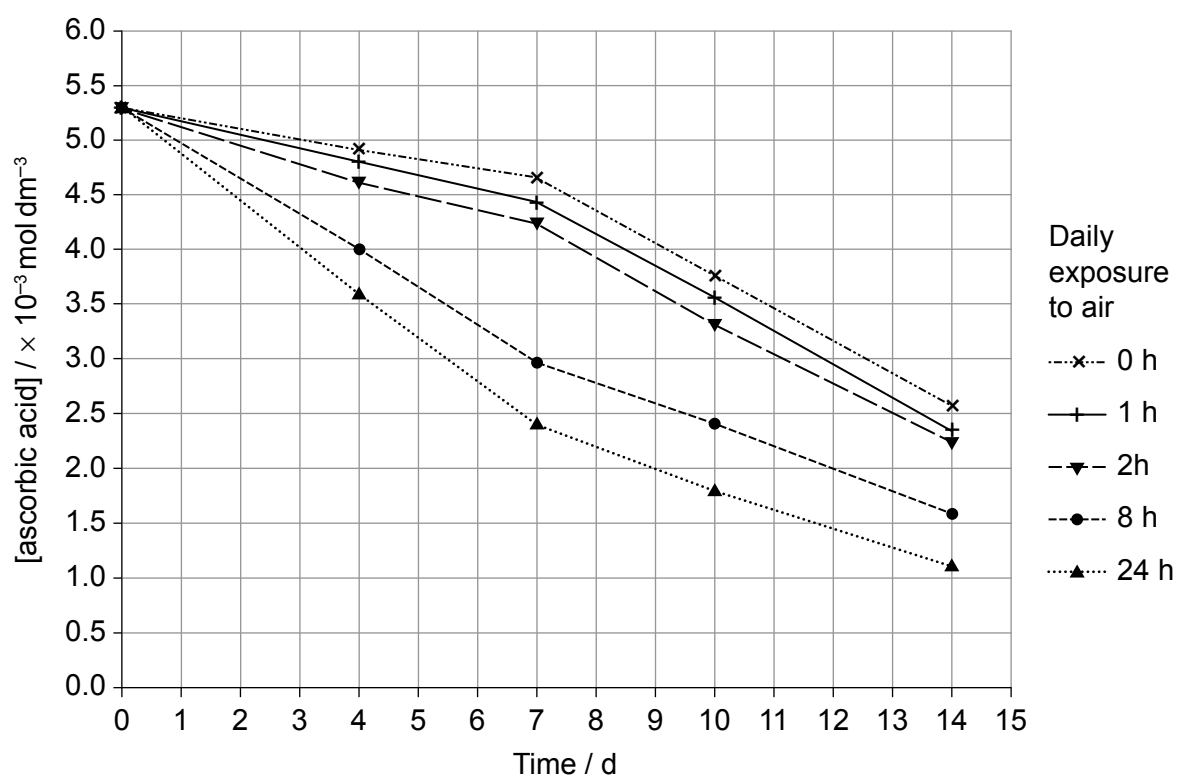
Calculate the percentage uncertainty of the titre.

[1]

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- (d) The following graph shows the student's results.



- (i) Calculate the average rate of decrease in ascorbic acid concentration for the 24 h sample over the period of 14 days, including units.

[2]

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(Question 2 continued)

- (ii) The student's hypothesis is: "A lower ascorbic acid concentration will be found in juice exposed to the air for longer, due to oxidation of ascorbic acid by oxygen."

Discuss whether or not the data support the hypothesis.

[2]

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- (iii) State the implications of the results of the experiment for avoiding loss of vitamin C in the storage of orange juice.

[1]

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- (e) Suggest an extension to the investigation that would generate further recommendations for the storage of orange juice.

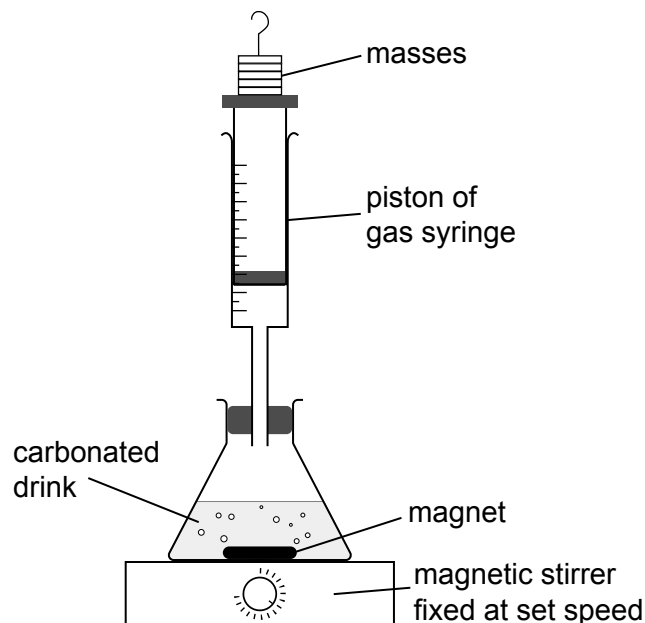
[1]

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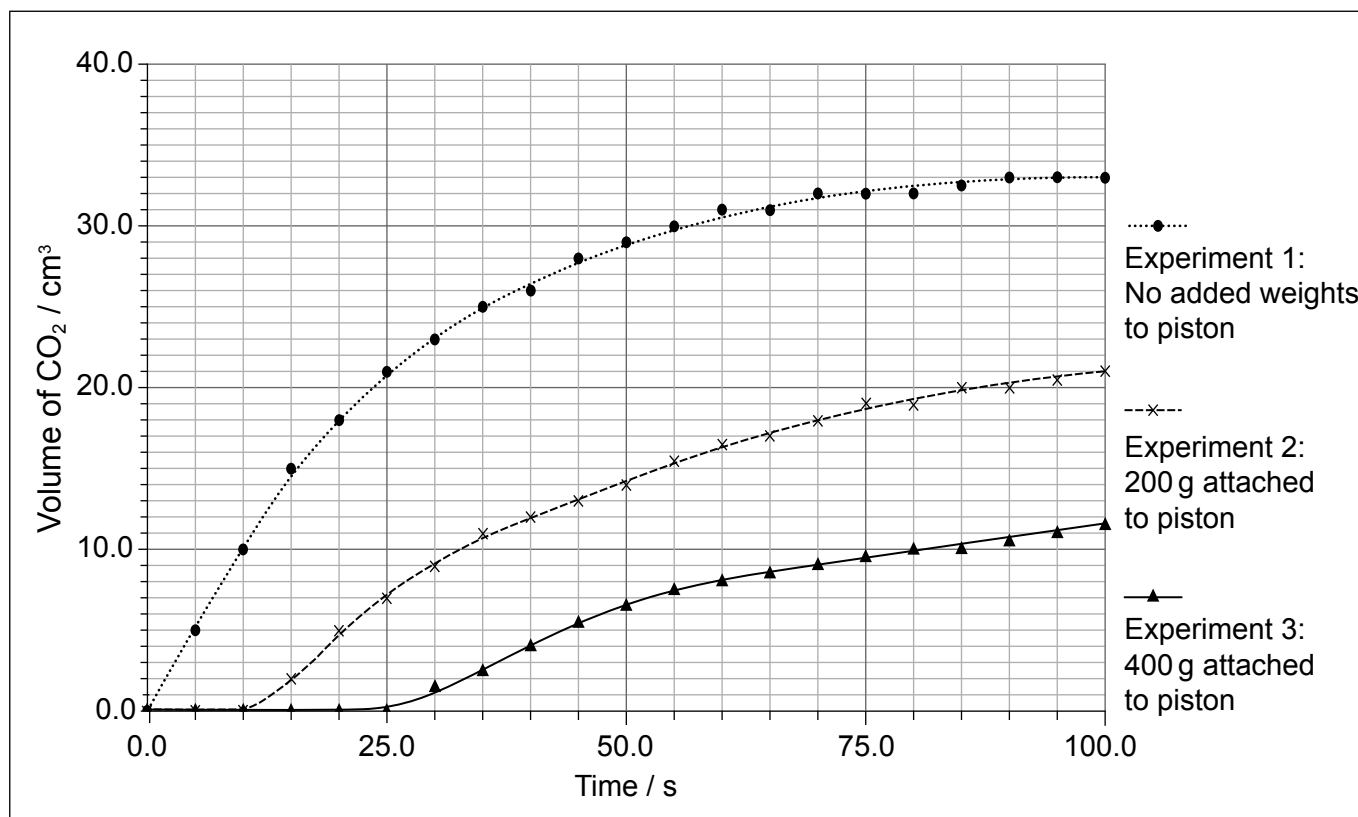


3. A student investigates the effect of pressure on the volume of carbon dioxide gas released from a carbonated drink poured into a flask.

To alter the pressure on the carbonated drink, masses are placed on top of the piston of the gas syringe as shown.



The graph shows some of the data collected.



- (a) Determine, by annotating the graph, the initial rate of release of CO_2 in Experiment 1 in $\text{cm}^3 \text{s}^{-1}$.

[2]

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(Question 3 continued)

- (b) Estimate the time at which the piston would begin to move if a 600 g mass is used. [1]

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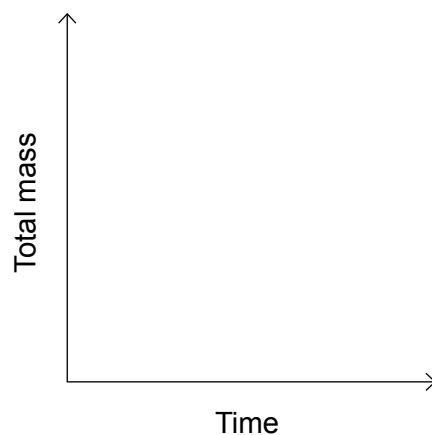
- (c) Suggest **two** reasons why the volume of CO₂ collected in the gas syringe is smaller when more masses are placed on top of the piston. [2]

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- (d) Calculate the percentage decrease in the final volume of CO₂ per 100 g mass placed on the piston, using the results of Experiment 1 and Experiment 3 at 100 s. [1]

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- (e) Sketch and give a reason for a graph of the total mass of the apparatus in Experiment 1 against time. [2]



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References:

- 1(c) National Center for Biotechnology Information, 2020. *PubChem Compound Summary for CID 24526, Chlorine* [online] Available at: <<https://pubchem.ncbi.nlm.nih.gov/compound/Chlorine>> [Accessed 23 September 2020].
- 1(e) Norlex, 2020. *Chlorine for water disinfection*. [online] Available at: <<https://norlexpoolspa.com/guidance/about-the-right-water-balance/safe>> [Accessed 23 September 2020].
- 1(f)(ii) ResearchGate, 2015. *Distributions of chloramines as a function of pH*. [image online] Available at: <https://www.researchgate.net/figure/Distribution-of-chloramines-as-a-function-of-pH_fig8_273449675> [Accessed 23 September 2020].



12EP12