

## ACID BASE PRACTICE QUESTIONS 4

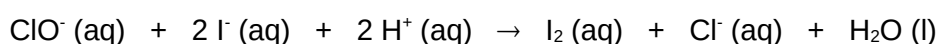
### Question 38

(20 marks)

Sam had just added some 'hypo' (sodium hypochlorite) solution to his pool and wanted to check that the chlorine content of the water was at an appropriate level.

He added 1.43 L of the 'hypo' solution, which the label stated contained approximately 1.00 mol L<sup>-1</sup> NaClO, into his 25 000 L capacity pool. He then left the pool overnight to ensure the chemicals had spread throughout the water.

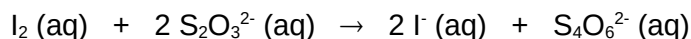
The following day he took five 20.00 mL aliquots of pool water and treated them with an excess of potassium iodide solution to convert all the ClO<sup>-</sup> to Cl<sup>-</sup> in a reaction that also produces iodine.



- (a) What colour change would be observed in the conical flask during this reaction? (1 mark)

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Since the end point of this reaction can't be detected, the iodine produced in this initial process was then titrated against a standard 1.65 x 10<sup>-4</sup> mol L<sup>-1</sup> sodium thiosulfate solution using starch as an indicator. As the blue colour of the starch fades, the end point has been reached.



- (b) State two characteristics sodium thiosulfate would need to have if it was to be considered for use as a primary standard. (2 marks)

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The results of the titration are shown in the table below.

Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	1	2	3	4	5
Final (mL)	21.05	34.85	48.60	19.20	32.95
Initial (mL)	7.10	21.05	34.85	5.60	19.20
Titre (mL)					

- (c) Calculate the average titre of sodium thiosulfate used. (1 mark)

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(d) Calculate the concentration (in  $\text{mol L}^{-1}$ ) of NaClO in the pool water. (4 marks)

(e) Calculate the concentration (in  $\text{mol L}^{-1}$ ) of NaClO in the original 'hypo' solution and comment on whether this value corresponds to the stated  $1.00 \text{ mol L}^{-1}$  concentration advertised on the bottle. (3 marks)

Sodium hypochlorite (NaClO) takes part in many different reactions. When sodium hypochlorite crystals are heated, they decompose to form sodium chlorate (NaClO<sub>3</sub>) and sodium chloride. This process is known as disproportionation because the NaClO is both oxidised and reduced.

- (f) Write the oxidation and reduction half equations (assuming acidic conditions) and the overall redox equation for this decomposition reaction. (6 marks)

Oxidation half equation	
Reduction half equation	
Overall redox equation	

Sodium hypochlorite will also decompose when it is dissolved in water. This process occurs slowly and is represented by the following equation.



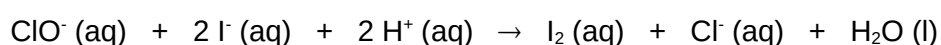
- (g) If 85.4 g of NaClO was dissolved in excess water, what **total volume of gas** would be produced at 101.7 kPa on a warm 33 °C day. (3 marks)

**ANSWER****Question 38****(20 marks)**

Sam had just added some 'hypo' (sodium hypochlorite) solution to his pool and wanted to check that the chlorine content of the water was at an appropriate level.

He added 1.43 L of the 'hypo' solution, which the label stated contained approximately 1.00 mol L<sup>-1</sup> NaClO, into his 25 000 L capacity pool. He then left the pool overnight to ensure the chemicals had spread throughout the water.

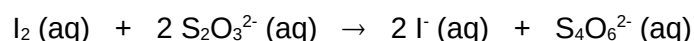
The following day he took five 20.00 mL aliquots of pool water and treated them with an excess of potassium iodide solution to convert all the ClO<sup>-</sup> to Cl<sup>-</sup> in a reaction that also produces iodine.



- (a) What colour change would be observed in the conical flask during this reaction? (1 mark)

**colourless to brown**

Since the end point of this reaction can't be detected, the iodine produced in this initial process was then titrated against a standard 1.65 x 10<sup>-4</sup> mol L<sup>-1</sup> sodium thiosulfate solution using starch as an indicator. As the blue colour of the starch fades, the end point has been reached.



- (b) State two characteristics sodium thiosulfate would need to have if it was to be considered for use as a primary standard. (2 marks)

**high M, pure form, stable, reacts according to known equations, not deliquescent / hygroscopic (any 2)**

The results of the titration are shown in the table below.

Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	1	2	3	4	5
Final (mL)	21.05	34.85	48.60	19.20	32.95
Initial (mL)	7.10	21.05	34.85	5.60	19.20
Titre (mL)	<b>13.95</b>	<b>13.80</b>	<b>13.75</b>	<b>13.60</b>	<b>13.75</b>

- (c) Calculate the average titre of sodium thiosulfate used. (1 mark)

**13.77 mL (average of 2, 3 and 5)**

(d) Calculate the concentration (in mol L<sup>-1</sup>) of NaClO in the pool water. (4 marks)

$$\begin{aligned}n(\text{S}_2\text{O}_3^{2-}) &= cV \\&= 1.65 \times 10^{-4} \times 0.01377 \\&= 2.27205 \times 10^{-6} \\n(\text{I}_2) &= n(\text{S}_2\text{O}_3^{2-}) / 2 \\&= 1.136025 \times 10^{-6} \\n(\text{ClO}^-) &= n(\text{I}_2) \\c(\text{ClO}^-) &= n/V \\&= 1.136025 \times 10^{-6} / 0.020 \\&= 5.680125 \times 10^{-5} \text{ mol L}^{-1} \\&= 5.68 \times 10^{-5} \text{ mol L}^{-1}\end{aligned}$$

(e) Calculate the concentration (in mol L<sup>-1</sup>) of NaClO in the original 'hypo' solution and comment on whether this value corresponds to the stated 1.00 mol L<sup>-1</sup> concentration advertised on the bottle. (3 marks)

$$\begin{aligned}c_1 &= c_2 V_2 / V_1 \\c_1 &= (5.680125 \times 10^{-5} \times 25\,001.43^*) / 1.43 \\&= 0.993 \text{ mol L}^{-1}\end{aligned}$$

very close, although slightly under, value stated on bottle

*\* also allow  $V_2 = 25\,000$  (final answer is same to 3 sf)*

Sodium hypochlorite (NaClO) takes part in many different reactions. When sodium hypochlorite crystals are heated, they decompose to form sodium chlorate (NaClO<sub>3</sub>) and sodium chloride. This process is known as disproportionation because the NaClO is both oxidised and reduced.

- (f) Write the oxidation and reduction half equations (assuming acidic conditions) and the overall redox equation for this decomposition reaction. (6 marks)

Oxidation half equation	$\text{ClO}^- + 2 \text{H}_2\text{O} \rightarrow \text{ClO}_3^- + 4 \text{H}^+ + 4 \text{e}^-$ <p style="text-align: center;"><u>OR</u></p> $\text{NaClO} + 2 \text{H}_2\text{O} \rightarrow \text{NaClO}_3 + 4 \text{H}^+ + 4 \text{e}^-$
Reduction half equation	$\text{ClO}^- + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$ <p style="text-align: center;"><u>OR</u></p> $\text{NaClO} + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{NaCl} + \text{H}_2\text{O}$
Overall redox equation	$3 \text{ClO}^- \rightarrow \text{ClO}_3^- + 2 \text{Cl}^-$ <p style="text-align: center;"><u>OR</u></p> $3 \text{NaClO} \rightarrow \text{NaClO}_3 + 2 \text{NaCl}$

Sodium hypochlorite will also decompose when it is dissolved in water. This process occurs slowly and is represented by the following equation.



- (g) If 85.4 g of NaClO was dissolved in excess water, what **total volume of gas** would be produced at 101.7 kPa on a warm 33 °C day. (3 marks)

$$\begin{aligned}
 n(\text{NaClO}) &= m/M \\
 &= 85.4 / 74.44 \\
 &= 1.147233 \\
 n(\text{gas}) &= 1.147233 / 4 \times 3 \\
 &= 0.8604245 \\
 V(\text{gas}) &= nRT / P \\
 &= (0.8604245 \times 8.314 \times 306) / 101.7 \\
 &= 21.5 \text{ L}
 \end{aligned}$$