

Stage 6 Chemistry

HSC style questions

The following activity allows students to further understand the chemistry behind the treatment process they observed during their site visit to Orchard Hills Water Filtration Plant.

Instructions

There are three equations for the students to complete. The elements for each equation are colour coded, question 7 is orange, question 8 is green and question 9 is blue. Cut up each element board (keeping each colour set separate). Hand the three sets to groups of 3 or 4 students. Ask the students to turn to page 6 of their worksheet and work as a group to determine the chemical equation for each of the questions. The answers are provided for you in red below.

Chemical Equations

7. Identify the reasons why calcium hydroxide (lime) is added to the water after screening.

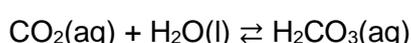
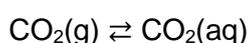


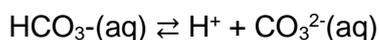
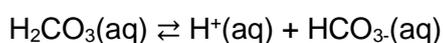
OH⁻ increases pH to reach the targeted pH range for Water Filtration Plants (6.3 < pH < 10.3) so to:

- allow optimal environment for stable floc formation (occurs better in a mildly alkaline environment)
- boost pH at the beginning to cater for acidic reactions that occur from subsequent additions of particular chemicals

8. Write the relevant chemical equations to explain how the water is buffered and why this is required.

In all surface waters, carbon dioxide dissolves into water forming the carbon dioxide/carbonic acid buffer system. Water that is pumped through pipes tends to fill the entire pipe, so the amount of carbon dioxide gas in the pipes is reduced. However, in gravity fed pipes (such as those feeding water from Warragamba Dam to Orchard Hills Water Filtration Plant), the pipes are only $\frac{3}{4}$ of the way full leaving an air space above the water containing carbon dioxide. This allows the following to occur in the water flowing in the pipes:





As this is an equilibrium system, different species will dominate at different pH ranges.

When $\text{pH} < 6.3$, H_2CO_3 dominates

When $\text{pH} > 10.3$, CO_3^{2-} dominates. When $\text{Ca}(\text{OH})_2$ is added to the water at this pH, the following will occur:

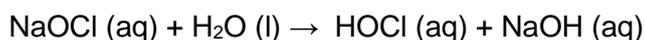
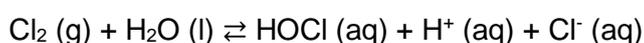
$\text{Ca}^{2+} + \text{CO}_3^{2-} \rightarrow \text{CaCO}_3(\text{s})$ This solid is not harmful but will require a great deal more filtration at the plants in order to remove it. It is not efficient and hence costly.

When $6.3 < \text{pH} < 10.3$, HCO_3^- dominates. When $\text{Ca}(\text{OH})_2$ is added to the water at this pH, the following will occur:

$\text{Ca}^{2+} + \text{HCO}_3^- \rightarrow \text{Ca}(\text{HCO}_3)_2(\text{aq})$ This ensures the ions remain in solution and decreases the amount of solid to be filtered.

HCO_3^- is also a proton donor and proton acceptor. This means that when chemicals are added to the system that may produce acidic (or alkaline) conditions, it can resist changes in pH.

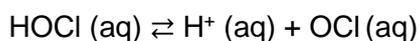
9. Write the chemical equations to help explain how chlorine gas or sodium hypochlorite can act to disinfect the water.



HOCl (hypochlorous acid) is the disinfectant.

Chlorine gas is a better oxidising agent than sodium hypochlorite. Sodium hypochlorite is easier and safer to use. Chlorine gas is what is used at Orchard Hills.

Being a weak acid, HOCl is partially dissociated to hypochlorite ion (OCl^-).



The degree of dissociation varies with temperature and pH. An increase in pH will shift the equilibrium to the right.

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If you would like further information on our water treatment processes please visit our education webpage at www.sydneywater.com.au/education or email us education@sydneywater.com.au

