# Where’s the pHun in that?

Students will look at the idea of changing levels of acidity and basicity in a variety of substances as a context for exploring the use of logarithms.

Students will need at least one digital device per pair to interact with online interactives.

## Visible learning

This learning episode incorporates Path content and assumes students are confident with related Core content.

### Learning intention

* To develop an understanding of the relationship between logarithms and indices.

### Success criteria

* I can apply my knowledge of logarithms to solve problems involving base 10.
* I can solve equations that involve exponents or logarithms.

### Syllabus outcomes

A student:

* develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
* establishes and applies the laws of logarithms to solve problems **MA5-LOG-P-01**

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## Activity structure

### Launch

1. Using the interactive found at [bit.ly/phscaleinteractive](https://bit.ly/phscaleinteractive) have students access the ‘Macro’ pH simulation.
2. Using the drop-down menu, students can select from a variety of different substances with varying levels of pH.
3. To visualise the pH level of their mixtures, students need to click and drag the green target over the mixture in the container which will provide a reading on the pH scale to the left of the screen.
4. Students can then add water using the tap towards the right-hand side of the screen, or more of their chosen substance by clicking on the dropper towards the middle of the screen, which will change the ratio (and pH) of their virtual mixture.
5. They can also use the tap at the base of the container to remove quantities of their mixture to be able to create more room to perform step 4 again.
6. Provide ample time for students to engage with the interactive and explore ways they can increase and decrease the pH levels by adding water to the starting substance in varying amounts.
7. Students should undertake a notice and wonder ([bit.ly/noticewonderstrategy](https://bit.ly/noticewonderstrategy)) as they interact with the simulation.
8. Randomly select students to share some of their thoughts with the class.

**Students may notice:**

* not all of the substances have changes in their pH levels as rapidly as others when water is added
* that adding water will only ever bring the mixture towards a pH of 7, and never continue to move past that value.

**Students may wonder:**

* Why do different substances change at a faster or slower rate than others?
* Is it possible to get every mixture to arrive at a pH of 7 just by adding water?
* What would happen if it was possible to add 2 different substances together in this interactive, other than water?

### Explore

1. Using a Think-Pair-Share strategy ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)), ask students what they know about the pH scale.

The pH scale is a way to measure the acidity of a liquid solution. It is based on the concentration of positive hydrogen ions in the liquid. A smaller pH indicates more hydrogen ions and higher acidity. A larger pH indicates less hydrogen ions and lower acidity.

1. Once students have had a chance to share with their partner, use slide 2 of the *Where’s the pHun in that?* PowerPoint to provide a concise explanation of pH and add to this information if students have any additional information.
2. Inform students that to be able to calculate pH, they need to efficiently swap between the large numbers that represent the concentration of positive hydrogen ions in a solution and a more manageable way to represent this relationship. This relies on a method of converting between an expression involving indices to one that is based on logarithms.

The need to be able to convert between pH, which is a measure of acidity and basicity, and the concentration of positive hydrogen ions is related to the concentration and molarity of substances. These concepts are not explored in greater detail as they are addressed in Stage 6 Chemistry; however the mathematics is appropriate for students.

1. Use slides 3–14 of the *Where’s the pHun in that?* PowerPoint to build upon student’s previous knowledge to better establish that is equivalent to .

The explicit teaching technique used in the associated PowerPoint is ‘Your turn.’ The first slide is a worked example which should be displayed for the students before using the following steps.

1. Reveal the question to students and its solution.
2. Students read in silence.
3. Students individually think and explain to themselves what is happening in each step.
4. Students hold up a thumbs up to the teacher when they have finished reading and have some sort of understanding.
5. Think-Pair-Share. Students explain the solution to their partner.
6. In pairs, students then answer the self-explanation questions.
7. Finally, randomly select students to share their answers with the whole class.
8. Use slide 15 of the *Where’s the pHun in that?* PowerPoint to introduce the formula for calculating pH to the students.
9. Have students return to using the online interactive found at ([[bit.ly/phscaleinteractive](https://bit.ly/phscaleinteractive)](https://phet.colorado.edu/sims/html/ph-scale/latest/ph-scale_all.html)) but this time access the ‘Micro’ pH simulation by clicking on the icon towards the middle of the screen when it first loads, or towards the bottom of the screen when already loaded.
10. Students are to choose any 5 of the substances listed and determine if the pH value listed is correct. They calculate this by inputting the concentration of hydronium ion (H3O+) into the pH formula: .

For example, battery acid has a H3O+ concentration of .  
So its pH will be:

Students need to establish what the Log button and function represent on their calculators.

Students may need to be guided to discover this by entering in multiples of 10, otherwise allowing students to work through this on their own could be helpful for students that require an increased challenge.

1. Students can verify their answers with the pH value at the top centre of the screen.

Where access to technology is limited or unavailable, provide students with a copy of Appendix A ‘H+ concentration of substances’ to complete this task.

Solutions have also been provided.

1. Next, for their choice of 5 of the available substances, have students dilute the solution with an equal amount of water using the function available in the online interactive.
2. To ‘dilute’ the solutions with water, students will need to first select their starting substance and then select the ‘Water’ handle towards the top right of the screen on the interactive, and ‘pull’ it towards the left.
3. This will fill the virtual container below the tap and the handle will need to be released once the level reaches 1.00 L, as will be indicated by the sliding value along the right-hand side.
4. Students will then be required to use the pH value to determine the concentration of H+ in mol/L by changing the subject of the pH formula explored earlier.
5. Students should be working towards verifying the answers shown on the concentration information (indicated by the red label with H3O+ on the concentration label) before moving to the next substance.

Where technology is not available, provide students with a copy of Appendix B ‘Concentrating on pH’.

### Summarise

1. Using slides 16– 24 of the *Where’s the pHun in that?* PowerPoint, have students consider the idea of equivalency when using base 10 and introduce the concepts of applying this to different base values.
2. Students are to create notes to their future forgetful self ([bit.ly/notesstrategy](https://bit.ly/notesstrategy)) and should be guided towards developing the general form of equivalency for the relationship between logarithms and exponentials as part of these.

The general concept of equivalency can be considered as the following:  
 is equivalent to .

1. Provide students with access to the intelligent practice examples found at the Logarithms – Variation Theory site ([bit.ly/variationlogs](https://bit.ly/variationlogs)).

If students have not yet explored solving logarithmic problems using a calculator, questions 3, 6, 15, 16, 17 and 18 will not be able to be solved. However, students should be encouraged to make estimates for the missing values based on the surrounding problems. This practice will help to establish good principles of checking their answers for reasonableness moving forward.

### Apply

1. Direct students to ‘The Importance of Soil Type – And How to Manage Yours’ ([bit.ly/soiltypeblog](https://bit.ly/soiltypeblog)) to be able to follow the steps necessary to investigate the type of soil found in the school and classify it according to the definitions in Appendix C ‘Gardening pHun with pH testing’ or Appendix D ‘Gardening pHun without pH testing’.

The choice of appendix in this case will depend on whether pH testing of the soil is able to be undertaken or not.

1. Show students the video on the webpage ‘Soil pH – Gardening Australia (1:14)’ ([ab.co/41nvmF6](https://ab.co/41nvmF6)) or have them visit the site ‘Soil pH – Gardening Australia’ ([ab.co/3RHK06M](https://ab.co/3RHK06M)).

Where possible, through collaboration with members of the science faculty or their equivalent in your setting, arrange to take test samples of and record the soil pH levels in your school.

1. Students will use this information to investigate establishing a plot to grow vegetables somewhere in the school grounds (or an appropriate alternative location).
2. Refer to the relevant appendix, either Appendix C or D, depending on the ability to be able to undertake pH testing and have students answer the questions provided. Students will determine the amount of liming product that would be required to adjust the pH levels in the soil.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Explore**

* Students may be challenged to explore how the ratio of the number of particles in the solution as shown on the interactive ([[bit.ly/phscaleinteractive](https://bit.ly/phscaleinteractive)](https://phet.colorado.edu/sims/html/ph-scale/latest/ph-scale_all.html)) relates to the calculation of the pH,. They may make predictions about how the addition of water will impact the pH instead of manipulating the interactive through trial and error.

**Summarise**

* Students can be challenged to communicate their thinking and explain why and when considering logarithms and their equivalency where is equivalent to .
* Students that may require additional support can refrain from exploring bases other than 10 when considering logarithms and could instead develop questions for their peers to attempt as part of a gallery walk ([bit.ly/DLSgallerywalk](https://bit.ly/DLSgallerywalk)) or similar.

**Apply**

* Students only calculate the liming material required based on a per hectare premise as per the suggested application rate.
* Students could measure out a plot for a garden in the school, calculate the soil required to fill that plot and then determine the amount of liming material required to adjust the pH of the soil in that plot to the appropriate levels.

### Suggested opportunities for assessment

**Explore**

* Observations of student work and discussions could be recorded as a formative assessment process during their work with the online interactive.

**Summarise**

* Student work samples could be collected and retained as part of a formative assessment process and added to an ongoing portfolio.

## Appendix A

### H+ concentration of substances

Table 1 – pH calculations

|  |  |  |
| --- | --- | --- |
| Substance | H+ concentration (mol/L) | pH |
| Battery acid |  |  |
| Blood |  |  |
| Chicken soup |  |  |
| Coffee |  |  |
| Drain cleaner |  |  |
| Hand soap |  |  |
| Milk |  |  |
| Orange juice |  |  |
| Soda water |  |  |
| Saliva |  |  |
| Stomach acid |  |  |
| Water |  |  |

## Appendix B

### Concentrating on pH

Table 2 – H+ calculations

|  |  |  |
| --- | --- | --- |
| Solution diluted with equal amount of water | pH | H+ concentration (mol/L) |
| Battery acid | 1.30 |  |
| Blood | 7.25 |  |
| Chicken soup | 6.07 |  |
| Coffee | 5.29 |  |
| Drain cleaner | 12.70 |  |
| Hand soap | 9.70 |  |
| Milk | 6.68 |  |
| Orange juice | 3.80 |  |
| Soda water | 2.80 |  |
| Saliva | 7.24 |  |
| Stomach acid | 2.30 |  |
| Water | 7.00 |  |

## Appendix C

### Gardening pHun with pH testing

1. Using the descriptions below or a testing method such as the one found at ‘The Importance of Soil Type – And How to Manage Yours’ ([bit.ly/soiltypeblog](https://bit.ly/soiltypeblog)), determine which soil type or types you have in your school and record your findings in the table below.
2. Record the results of testing the pH of the soil type(s) in your school in the table below.
3. Answer the questions found below the table.

Table 3 – soil pH with testing

|  |  |  |  |
| --- | --- | --- | --- |
| Soil type | Description | Tick your soil type | Calculated pH |
| Clay | Clay soils feel very sticky and rolls up like plasticine when wet. |  |  |
| Sandy | Sandy soils are light and gritty to touch; they fall easily through your hands. |  |  |
| Silty loam | Silty loam soils are somewhere between sand and clay soil. When dry they are floury to touch, but when wet they can be rolled into a ball in your hand. Silty soil is slippery when wet, not grainy or rocky. |  |  |

1. Determine a size for your proposed vegetable garden. You will need to establish:
   * 1. the length of the garden
     2. the width of the garden
     3. the height (or depth) of the garden.
2. Determine the volume of the soil that would fill your garden bed.
3. Vegetables grow best in soil that has a pH around 6.5.

Lime used to adjust soil pH has a pH around 12.4.

Applying your work from throughout the lesson, determine how much lime would be needed to reach a pH of 6.5.

1. According to the Western Australian Department of Agriculture and Food (GRDC 2019), for every tonne of lime (calcium carbonate) added to one hectare of soil the following changes should be seen if the starting pH of those soil types was 4.5:

Table 4 – pH changes from liming

|  |  |
| --- | --- |
| Soil type | pH change |
| Sand | Increases by 0.5–0.7 |
| Loam | Increases by 0.3–0.5 |
| Clay | Increases by 0.2–0.3 |

* + 1. Provide your thoughts on why each soil type has different changes to their pH. Justify your response.
    2. Do you believe there is a range for the pH of the lime? Why or why not?

## Appendix D

### Gardening pHun without pH testing

1. Using the descriptions below or a testing method such as the one found at ‘The Importance of Soil Type – And How to Manage Yours’ ([bit.ly/soiltypeblog](https://bit.ly/soiltypeblog)), determine which soil type or types you have in your school and indicate these in the table.
2. The pH ranges that are often (but not always) found for the soil types have been listed in the table below.
3. Answer the questions found below the table.

Table 5 – soil pH without testing

|  |  |  |  |
| --- | --- | --- | --- |
| Soil type | Description | Tick your soil type | General pH range |
| Clay | Clay soils feel very sticky and rolls up like plasticine when wet. |  | 5.0–7.5 |
| Sandy | Sandy soils are light and gritty to touch; they fall easily through your hands. |  | 5.8–6.3 |
| Silty loam | Silty loam soils are between sand and clay soil. When dry they are floury to touch, but when wet they can be rolled into a ball in your hand. Silty soil is slippery when wet, not grainy or rocky. |  | 3.5–8.5 |

1. Determine a size for your proposed vegetable garden. You will need to establish:
   * 1. the length of the garden
     2. the width of the garden
     3. the height (or depth) of the garden.
2. Determine the volume of the soil that would fill your garden bed.
3. Vegetables grow best in soil that has a pH around 6.5.  
   Lime used to adjust soil pH has a pH around 12.4.   
   Applying your work from throughout the lesson, determine how much lime would be needed to reach a pH of 6.5.
4. According to the Western Australian Department of Agriculture and Food, for every tonne of lime (calcium carbonate) added to one hectare of soil the following changes should be seen if the starting pH of those soil types was 4.5:

Table 6 – pH changes from liming

|  |  |
| --- | --- |
| Soil type | pH change |
| Sand | Increases by 0.5–0.7 |
| Loam | Increases by 0.3– 0.5 |
| Clay | Increases by 0.2– 0.3 |

* + 1. Provide your thoughts on why each soil type has different changes to their pH. Justify your response.
    2. Do you believe there is a range for the pH of the lime? Why or why not?

## Sample solutions

### Appendix A – H+ concentration of substances

|  |  |  |
| --- | --- | --- |
| Substance | H+ concentration | pH |
| Battery acid |  | **1.00** |
| Blood |  | **7.40** |
| Chicken soup |  | **5.80** |
| Coffee |  | **5.00** |
| Drain cleaner |  | **13.00** |
| Hand soap |  | **10.00** |
| Milk |  | **6.50** |
| Orange juice |  | **3.50** |
| Soda water |  | **2.50** |
| Saliva |  | **7.40** |
| Stomach acid |  | **2.00** |
| Water |  | **7.00** |

### Appendix B – concentrating on pH

|  |  |  |
| --- | --- | --- |
| Solution diluted with equal amount of water | pH | H+ concentration (mol/L) |
| Battery acid | 1.30 |  |
| Blood | 7.25 |  |
| Chicken soup | 6.07 |  |
| Coffee | 5.29 |  |
| Drain cleaner | 12.70 |  |
| Hand soap | 9.70 |  |
| Milk | 6.68 |  |
| Orange juice | 3.80 |  |
| Soda water | 2.80 |  |
| Saliva | 7.24 |  |
| Stomach acid | 2.30 |  |
| Water | 7.00 |  |

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Grain Research and Development Corporation (GRDC) (2019)[*Lime and liming – managing soil health*](https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/lime-and-liming-managing-soil-health), GRDC website, accessed 6 February 2024.

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