Acids and Bases (Level 3)

Description	Learners will learn about acids, bases, their properties, the pH scale, indicators, and neutralisation reaction. At the end of the project, they will use these concepts to create a bath bomb, a painting or an indicator to test water quality.
Leading question	What can we make with acids and bases?
Subjects covered	Science, Art and Design, English, Math
Total time required	40-60 minutes a day for 5 days
Resources required	White paper, turmeric, water, detergent, lemon, containers or bowls, strainer or cloth, tomato juice, hibiscus/ blue pea flowers, glass/ plastic/ paper cups, baking soda, paint brushes/ ear bud/ cotton balls for painting, baking soda, coconut oil, water bottle, deflated balloons, vinegar
Learning outcomes:	By the end of this project, learners will be able to: Knowledge-Based Outcomes: 1. Distinguish between acids, bases and salts. 2. Identify natural indicators and how they change colour on reacting with acids/bases. 3. Identify a substance as acidic or basic using indicators available in the environment. 4. Explain how pH levels of a solution vary with concentration. 5. Understand neutralisation reactions. 21st Century Skill Outcomes: 1. Express their creativity by crafting their own paintings and exploring ways to create colours using available acids, bases and indicators. 2. Think critically as they make observations about the colour changes in various substances when using indicators. 3. Effectively communicate their observations, inferences and findings with an adult.
Previous Learning	NA
Supervision required	Medium

Day 1 -

Today, you will learn about acids, bases and their properties.

Time	Activity and Description

<table>
<tr><td>5 minutes</td><td>Introduction
- Have you painted before? Where do you think we get paints from to make a painting? (Take responses)
- Webuy paints from the market, but did you know that we can make our own paint?
- This week, we will be making paints using acids and bases! There are many other interesting things that can also be made using acids and bases.</td></tr>
<tr><td>15 minutes</td><td>Acid and Bases
- Do you know what acids and bases are? (Acids and bases are two types of compounds that we commonly use in our daily lives.)
Tip: Give them a hint (if needed), that sour things contain acids, and soapy/ bitter things contain bases.

Note: Ask learners to create a list of things around them that are acidic (sour) and basic (soapy/bitter) and then classify them as acids or bases. If they are unable to come up with a list of things, please provide the things mentioned in the table below. Do not give away the answer in the beginning, give learners time to think and answer on their own.

<table>
<tr><th>Things</th><th>Acid</th><th>Base</th></tr>
<tr><td>Lemon juice</td><td>✔</td><td></td></tr>
<tr><td>Toothpaste</td><td></td><td>✔</td></tr>
<tr><td>Orange juice</td><td>✔</td><td></td></tr>
<tr><td>Yogurt</td><td>✔</td><td></td></tr>
<tr><td>Soap</td><td></td><td>✔</td></tr>
</table>
</td></tr>
<tr><td>15 minutes</td><td>Why does turmeric stain change its colour when soap is added to it?
- What happens when you wash a shirt that has a turmeric stain using soap?
- Does the colour change? If so, how?
- What if we put lemon juice on the turmeric stain? What colour would it change to?

Note: Ask learners to draw this table, and write your hypothesis about what happens to the turmeric stain when soap or lemon juice is added to it. Then you will test it and complete the table.

<table>
<tr><td>Hypothesis:</td><td>Turmeric stain changes to ____ when soap is added.
Turmeric stain changes to _____ when lemon juice is added.</td></tr>
<tr><td>Materials Needed:</td><td>Turmeric, water, soap, lemon juice, paper</td></tr>
</table>
</td></tr>
</table>

	Method:	
	Observations:	
	Inferences:	

Share your observations.

- You saw that the turmeric stain changes to red when a base is added to it, and it does not change colour when an acid is added to it.
- On a piece of paper or in your notebook, make a small drawing with the two colours you created using turmeric and soap solution (yellow and red).

Tip: *If learners are struggling, ask them to paint the paper with turmeric solution first and then use an earbud/ cotton to draw using the soap solution. You can show students the video given in* ***Appendix 1*** *if required.*

See if you can identify a different base to use instead to make the colour red!

5 minutes	**Closing** What did you learn today? Today we saw that acids are things that are sour in taste and do not change the colour of turmeric solution when they are added to it. Bases are those things that are soapy/ slippery and they change the colour of turmeric solution to red when they are added to it. - What did you find interesting about today's activities? - What do you want to know more about?
At-home activities	Identify things at home that can be classified as acids and bases and add them to the list that you made today. In the list, you can also write the characteristics of things. For example, whether they are sour or bitter, or whether the texture is wet or wet and or slippery.

Day 2

Today, you will learn about indicators and how to measure how acidic or basic a substance is.

<table>
<tr><th>Time</th><th>Activity and Description</th></tr>
<tr><td>5 minutes</td><td>Review
What are some acids and bases that you found in your home?

Note: Check if learners have identified acids and bases correctly. Tell them that we may not be able to taste or touch everything to find out if it is acidic or basic. So, we use indicators to test this.</td></tr>
<tr><td>5 minutes</td><td>Indicators
- What happened yesterday when we added soap to the turmeric solution?
- The turmeric solution changed its colour to red. Why did this happen?
- This happened because the soap was basic.
- Indicators are substances which when added to an acid or base change their colour. These indicators help us to understand the nature (acidic/basic) of any given substance.
- Turmeric is a natural indicator, which changes its colour when a base such as soap is added to it. It does not change its colour when an acid such as lemon juice is added to it.
- Like turmeric,hibiscus is also a natural indicator. Let us see how hibiscus can be used as an indicator.
Tip: If hibiscus is not available, you can use turmeric or any other natural indicator that is available such as red cabbage, grape juice, blue pea solution, etc.</td></tr>
<tr><td>25 minutes</td><td>pH Value
- Today, we are going to use an indicator (hibiscus solution/ turmeric/ red cabbage juice/ grape juice) to find out how it shows the presence of acid-containing substances such as lemon juice, tomato juice and some base-containing substances such as baking soda solution and soap solution.
- We will test these items for acidity/basicity and note down the different colours you see while testing the things.
Note: Allow learners to use resources that are easily available to them. Alternate for hibiscus solution would be turmeric, red cabbage or grape juice. Refer to Appendix 2 to understand the steps involved in making a hibiscus solution.

Tip: Dilute some solutions by adding more water so students can see how the colour on the indicator differs depending on the concentration of the acid or base.

Make this table to record your hypothesis and observations

<table>
<tr><td>Hypothesis:</td><td></td></tr>
<tr><td>Materials Needed:</td><td></td></tr>
<tr><td>Method:</td><td></td></tr>
</table>
</td></tr>
</table>

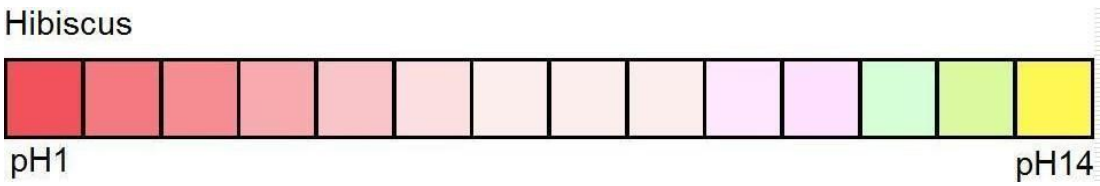
Observations:	
Inferences:	

- What changes did you observe?
- What colour did the acidic items change into?
- What colour did the basic items change into?
- Did you observe any other colour?
- What happened when we diluted the items?

An indicator changes colours depending on whether items are very acidic, slightly acidic, neutral, slightly basic or very basic.

Note: *Ask learners to make a scale with all the colours that you have observed while testing. Put the colours starting from very acidic to very basic.*

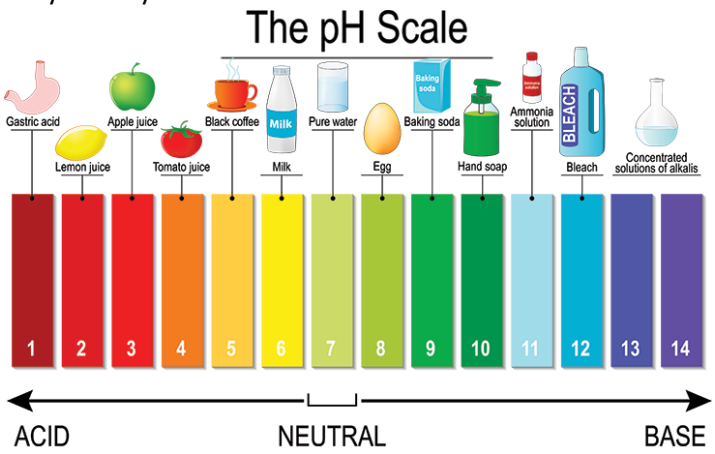
The pH scale of the hibiscus solution indicator would look like this:



(Image source: https://images.app.goo.gl/p2uP7JbF6jF72CQU6)

- The pH scale has values starting from pH 1 to pH 14. These values are called pH values. The pH value of a substance can tell if the substance is very acidic, slightly acidic, neutral, slightly basic or very basic.
- Based on your experiments and the colours of the scale, what pH value is the most acidic? And what pH value is the most basic?
- If the pH value is 1, the substance is very acidic and if it is 14, the substance is very basic.
- pH 7 is neither acidic nor basic and is called neutral. What are some examples of neutral items?
- Try to guess and write the pH values of the things that you have tested today.
- Make sure that you use the hibiscus solution and pH scale the next time you have to check for the acidity or basicity of any item.

5 minutes	**Closing** What did you learn today? Today, you learned about what is an indicator and the different types of natural indicators. You also used hibiscus as an indicator to find out the different colours that are obtained while testing different acids and bases. You also saw what a pH scale is, and also created

	one and learnt that the pH value of a substance can tell if it is very acidic, slightly acidic, neutral, slightly basic or very basic. ***Tip:*** *To challenge learners, inform them that There are 2 types of indicators:* *1) Natural - Such as turmeric, hibiscus solution, beetroot juice, litmus solution, purple cabbage juice and blue pea flower solution* *2) Synthetic - Such as methyl orange and phenolphthalein*
At home activities	- Learners test different items in their household for acidity or basicity using a hibiscus solution, and use the pH scale to rank them. - Learners can experiment at home to see what happens when an acid-containing substance (such as lemon or tomato juice) and a base-containing substance (such as soap or toothpaste) are mixed with each other.
Optional Literacy/Numeracy Activity	Numeracy activity:  - Calculate the average acidity of a breakfast meal consisting of an egg, tomatoes and milk Literacy activity: - Did you know that we have acids inside our bodies? Consuming too many acidic foods can lead to acid reflux, which is when your stomach acid comes up through the oesophagus. Work with your parents to test and identify the highly acidic foods in your diet and suggest alternatives for those to avoid digestive issues. Create an alternative meal plan that is more balanced using the following template

Meal (name): e.g. Oatmeal Porridge		
Ingredients	Acidic or basic?	Nutritional benefits
E.g. Oats, water/milk, salt	Low acidity	Fibre, vitamins

Day 3 –

Today, you will explore and understand neutralisation through various activities.

Time	Activity and Description
15 minutes	**Neutralisation Experiment - 1** So far we have learned what acidic and basic substances are, and how to detect their presence using indicators. Today, we will find out what happens when we mix an acid with a base. Let us perform two experiments to find out! ***Note:*** *Give learners baking soda and lemon juice to test what would happen if they both are mixed together. Ask them to fill in the hypothesis in the table below:*

Hypothesis:	
Materials Needed:	
Method:	
Observations:	
Inferences:	

1. Put a teaspoonful of baking soda into a glass.
2. Add some dishwashing liquid/ detergent powder, and water if needed.
3. Add lemon juice into the mixture. (Other citrus fruit juices work too, but lemon juice works the best.)
4. You can extend the reaction by adding more lemon juice and baking soda.

(Image source: https://images.app.goo.gl/JDoQXyZA4WiNBdTi7)

- What did you observe after adding the lemon juice to the mixture of baking soda and detergent? (*As you stir the juice into the baking soda and the detergent, bubbles will start to form in the glass.*)

	- When lemon juice (an acid) was mixed with the mixture of baking soda and detergent liquid (base), bubbles started forming and within a few seconds, bubbles started coming up and out of the glass. - So what exactly did we get after mixing them? What were the products of this reaction? - Fill your answers in this equation. Acid + Base =_____ + _____ - When any acid and base are mixed together, they form salt and water, sometimes with a gas, too. - We can write the equation as Acid + Base = Salt + Water + Gas - This reaction, and other reactions in which you mix an acid or a base together, ise called a neutralisation reaction. - Who do you think this reaction is called neutralisation? (*Because the resulting solution is typically close to a neutral pH of 7*) ***Tip:*** *In the neutralisation experiment, if your students know the names of the chemical compounds in the acid and base you can explain that the sodium bicarbonate of the baking soda reacts with the citric acid in lemon juice to form carbon dioxide gas. The gas bubbles are trapped by the dishwashing soap, forming fizzy bubbles.* *Then they can write the equation as* *Sodium bicarbonate + Citric acid = Sodium citrate + Water + Carbon dioxide*
10 minutes	**Neutralisation Experiment - 2** Let's do another experiment to see the gas being released during neutralisation: 1. Pour some baking soda into a balloon. 2. Pour some vinegar or lemon juice into a bottle. 3. Stretch the balloon over the lid of the bottle making sure that the baking soda inside does not fall into the balloon. *Note: Ask learners what they think will happen when the baking soda is released into the bottle.* 4. Release the baking soda from the balloon into the bottle - Observe what happens - the balloon is filled up with the gas that is the byproduct of neutralisation. - This gas that was released is carbon dioxide (written as CO_2) ***Note:*** *Ask learners to rewrite the neutralisation equation with this new information.*

	 (Image Source: https://owlcation.com/stem/hands-on-experiments-to-learn-about-chemistry)
10 minutes	**Create a bath bomb using acid and base** ***Note**: Check **Appendix 3** for more details about bath bomb.* - We are going to now see one of the many things you can create using an acid and a base. - Have you ever seen a soap that would create a fizz when mixed with water? - Let's see how to create a fragrant fizzy soap using an acid and a base. ***Note:** Demonstrate the experiment to learners.* 1. *Take some baking soda/ baking powder in a bowl.* 2. *Then add some coconut oil. The oil clumps at first. Keep incorporating and blending until the lumps are gone and the consistency is even throughout. The oil doesn't cause a reaction with the baking powder, so add all of it at once.* 3. *Next, add one tablespoon of lemon juice or vinegar and mix very quickly and vigorously to incorporate the vinegar. If possible, spray the lemon juice or vinegar instead of pouring it to make sure that very little is added each time. This step is crucial: you will see a reaction where the vinegar comes in contact with the baking powder. The fizz dies down once everything is stirred together, but you must be fast.* 4. *The bath bomb mixture should feel like damp sand. The mix is perfect when you press a small amount in the palm of your hand and drop it back into the mixing bowl, and the lump holds together.* 5. *Now add any additional ingredients, such as dried flower petals. When adding petals don't over-mix as these ingredients can bleed and lead to discoloration.* 6. *Then press the mixture in the palm of your hands to form a ball that is slightly moist, and the bath bomb is ready. If a bath bomb crumbles, simply use it as bath fizzy powder or powder soap. The drying time isn't necessary, the bath bombs can be used immediately.*

	 *(Image source: https://images.app.goo.gl/jN5RUmA4Q3tGgdMKA)* - What did you observe in this experiment? - What do we need to keep in mind, while adding lemon juice to baking soda? - Now, let us put these bath bombs in the water. ***Tip:** It can be used for washing their hands after their playtime.*
At home activities	Learners will start to think of things they can create using acids and bases. They can consult with parents/ family to see if their ideas make sense and they can also solicit additional ideas from their families to share with the class the following day.
Optional Literacy/Numeracy Activity	Learners can find out the ratio and percentage of the acidic vs. basic items they have tested so far in the class: - For example, if students tested the following items: lemon juice, tomato juice, toothpaste, vinegar, and baking soda. Three of those items are acidic and two are basic - Therefore the items tested had an acidic to basic ratio of 3:2, or 60% of items tested were acidic and 40% were basic.

Day 4 –

Today, you will work on your end products and then present them to an adult for feedback.

Time	Activity and Description
5 minutes	**Ideas for final product** Yesterday we saw how we can use acids and bases to create bath bombs. Now that you know more about acids, bases, indicators and the acid-base reaction, what would you like to create using these? ***Note:** You can give prompts like could we create an indicator that we can use to test the quality of water to see if it's safe to use? Could we use an acid and a base to create a cleaning product? What about a beautiful painting? You can also just create bath bombs of different colours and add your own twist to it by adding fragrance, flower petals, food colours etc.*

15 minutes	**Create your own colours and paint!** - Let's make something else using the acids and bases you have. - We are going to paint using colours created when acids and bases of different strengths are mixed. - What are the different colours we can make for our painting? ***Note:*** *Encourage learners to mix acids/bases with different indicators to derive at different colours. Refer to* ***Appendix 4*** *to understand the key to achieving certain colours.* - Start with a pencil sketch of your design (be creative!) and then use paint brushes, cotton balls or tissue paper to paint on a piece of paper or your notebooks. ***Note:*** *If paint brushes are not available, you can provide them with cotton balls, earbuds or leaves. If these are also not possible, the learners can simply use their fingers to paint. Assist learners as they create their own paints in small amounts and paint their drawings.*  (Image source: https://images.app.goo.gl/RBL3NCZJBEqNuYjj7) - What did you see as you increased/decreased the amount of acid/base added to the indicator? Did the colour change? Why/Why not? - Did you try mixing two colours to make a third colour? Did it work? Why/Why not?
20 minutes	**Work on the end product** Use the items you just tested to work on the final product you will be presenting tomorrow. Remember, your product can be a unique bath bomb, a painting or anything you like as long as it meets the following criteria: - It must contain at least one acid and one base - It must involve a reaction between the acids and bases - It must have a practical use (for example, a painting can be hung at home as decoration) ***Note:*** *Assist the students wherever required. Ask them to present their ideas, after which you can share your feedback.*

At home activities	Identify the types of acids and bases in your household by asking your parents or elders questions like the following: 1. How do you remove tough stains or grease on cooking vessels? 2. What do you use to unclog drains in the house? 3. How do you remove rust from metal surfaces like bicycle chains, etc.? 4. What products do you use to wash clothes? 5. What do you take to treat acidity (acid reflux)? 6. How do you treat ant stings? If the elders mention any products they use to solve the aforementioned problems, take a closer look at that product and note its ingredients down in your notebook with the answer. Remember to be careful while dealing with these products as some of them may be strong and might cause you harm if not handled properly. Do this under the supervision of your elders. Refer to **Appendix 5** to understand the uses of acids and bases.
Optional Literacy/Numeracy Activity	Write a short reflection paragraph about the uses of acids and bases or facts about them that surprised you.

Day 5 -

Today, you will work on the end product based on the feedback and present your product to friends/ family.

Time	**Activity and Description**
10 minutes	**Acids and Bases at home** - What are some items in your households that use bases or acids? - How did you know? What are the ingredients that indicate this? - You can identify bases present in the product labels from the following list:

Items	**Base in them**
Hand Soap	Sodium hydroxide
Detergent	Sodium hydroxide
Baking soda	Sodium bicarbonate
Digene tablet	Magnesium hydroxide
Toothpaste	Calcium carbonate

10 minutes	**Complete the end product** *Note: Learners complete their final product based on the feedback they received yesterday, making sure to customise their products.*

15 minutes	**Presentation** Presents your end products one by one explaining: - Acids used - Bases used - The reaction observed - How the product can be used
5 minutes	**Reflection** Reflect on the following questions: - What was the most interesting thing you learned about acids and bases in this project? - Did you enjoy working on this project? Why or why not? - Which experiment or activity related to acids and bases did you find most fun? - What was the most challenging part of the project, and how did you overcome it?

Additional enrichment activities:

- Learners can see an acid-base reaction through this experiment as acetic acid in vinegar dissolves the calcium carbonate eggshell: https://www.imaginationstationtoledo.org/education-resources/diy-activities/naked-eggs

- You can put a chart on the wall showing the actual names of the acids and bases that are present in the things around us:

Edible items	**Acid in them**
Lemon	Citric acid
Tomato	Ascorbic acid
Curd	Lactic acid
Grapes	Tartaric acid
Apple	Malic acid
Tamarind	Tartaric acid
Unripe mango	Citric acid

Modifications for simplification

- The final product can be a simple painting using acids and bases based on their interests.

ASSESSMENT CRITERIA

A majority of my learners were able to:
☐ Distinguish between acids, bases and salts.
☐ Identify natural indicators and how they change colour on reacting with acids/bases.
☐ Identify a substance as acidic or basic using indicators available in the environment.
☐ Explain how pH levels of a solution vary with concentration.
☐ Create pH scale using hibiscus as an indicator.
☐ Understand the neutralisation reaction.
☐ Create a product using acids and bases.

APPENDIX 1

Day 1

Turmeric as an indicator

APPENDIX 2

Day 2 - Hibiscus indicator solution

1. Start by collecting fresh hibiscus flowers. The darker the colour of the flower, the better it will work as an indicator.
2. Remove the petals from the hibiscus flowers and place them in a mortar and pestle or a blender. Crush or blend the petals until they form a pulp.
3. Take a small cup or container and pour some water into it. Add the hibiscus petal pulp to the water and stir well. Let it sit for about 10-15 minutes to allow the pigments to dissolve in the water.
4. After the waiting time, strain the hibiscus pulp mixture using filter paper or strainer. This will separate the coloured liquid from any solid particles.
5. Now, you have your hibiscus flower indicator! It should have taken on the colour of the hibiscus petals.

APPENDIX 3

Day 3

Bath bomb - A bath bomb can be used as a soap/ scrub. A bath bomb is prepared by mixing a weak acid and weak base along with oil and some flowers, and then moulding them into a shape. It becomes fizzy when it touches the water. It can be quite a relaxing experience, especially if your bath bomb has a nice fragrance or includes some bath salts.

There are a few key ingredients that most simple bath bomb recipes have: baking soda, citric acid, and cornstarch. When baking soda and citric acid are mixed together with some water, they undergo a chemical reaction. This reaction involves acid-base chemistry, since the baking soda—also known as sodium bicarbonate ($NaHCO3$)—is a weak base, and citric acid ($C6H8O7$) is a weak acid. The acid-base reaction produces carbon dioxide ($CO2$) gas. This gas is what makes the fizzy bubbles when you toss a bath bomb into a tub full of water.

Benefits of bath bombs - Bath bombs contain sodium bicarbonate and citric acid. The combination of these two ingredients helps cleanse and repair our skin. Also, by adding oil and flowers while making the bath bomb results in giving moisture and fragrance for the skin.

APPENDIX 4

Day 4- Key to Colours

Colour needed	Acid/Base	Indicator used
Red/magenta/pink	Acid	Turmeric paste
	Acid	Hibiscus flower solution
Yellow	Base	Turmeric paste
Purple	Acid	Blue pea flower solution
Blue	Base	Blue pea flower solution
	Strong Base	Hibiscus flower solution
Green	Weak Base	Hibiscus flower solution

It's important to note that the exact colour produced may vary depending on the concentration of the acid or base, as well as the specific pH level. Additionally, the intensity and stability of the colour can also be influenced by factors such as temperature, time, and the concentration of the indicator.

APPENDIX 5

Day 4 -Uses of Acids and Bases

Function/Use	Acid/Base	Explanation
Removing tough stains and grease	Acids	When we have tough stains or grease on surfaces like pots or pans, acids can help break them down. Acids have special molecules that react with the stains or grease, weakening their hold. This makes it easier to wipe or scrub them away, leaving the surface clean and shiny.
Unclogging drains	Bases	Sometimes, drains can get clogged with things like hair or food particles. Bases can come to the rescue! Bases have special properties that can dissolve or break down these clogs. When we pour a base like baking soda or drain cleaner down the drain, it reacts with the clog, making it softer and easier to flush away with water.
Removing rust	Acids	When metal gets exposed to water or air for a long time, it can develop a reddish-brown substance called rust. Acids can help remove rust because they can react with it and break it down. The acid molecules work on the rust, weakening it and making it easier to scrub away, revealing the clean metal underneath.
Washing clothes	Bases	When we wash our clothes, we often use laundry detergents that contain bases. Bases help to remove dirt and stains from our clothes. They do this by breaking down the bonds that hold the dirt and stains onto the fabric, allowing them to be washed away more easily in the water.
Treating acidity	Bases	Sometimes, our stomach produces too much acid, which can cause discomfort or heartburn. To treat this, we can use antacids, which are bases. When we take antacids, the base molecules react with the excess acid in our stomach, neutralising it. This helps reduce the discomfort and makes us feel better.
Treating ant stings	Bases	When an ant stings us, it releases a substance called formic acid, which causes the sting and pain. To relieve the pain, we can use a base like baking soda. Bases have special properties that can neutralise acids. When we apply a base like baking soda to the ant sting, it reacts with the formic acid, reducing the sting and soothing the pain.