2 Exploring Substances: Acidic, Basic, and Neutral

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On 28 February, the school hosted a science fair to celebrate National Science Day. At the entry gate, siblings Ashwin and Keerthi were greeted with a white sheet of paper. They were curious to know why a white sheet of paper was given to them!

A few steps ahead, there was a volunteer spraying a liquid on these sheets of paper. The siblings also got their white sheets sprayed. To their surprise, the words 'Welcome to the Wonderful World of Science' appeared on the papers the moment the liquid was sprayed (Fig. 2.1). They were excited and eager to know how this happened and the **reason** behind it.

Their curiosity was partly satisfied at the 'Colourful World of Substances' stall. They saw many activities showing colour changes on mixing different substances. They decided to **explore** these changes further. Let us join them on this learning adventure.

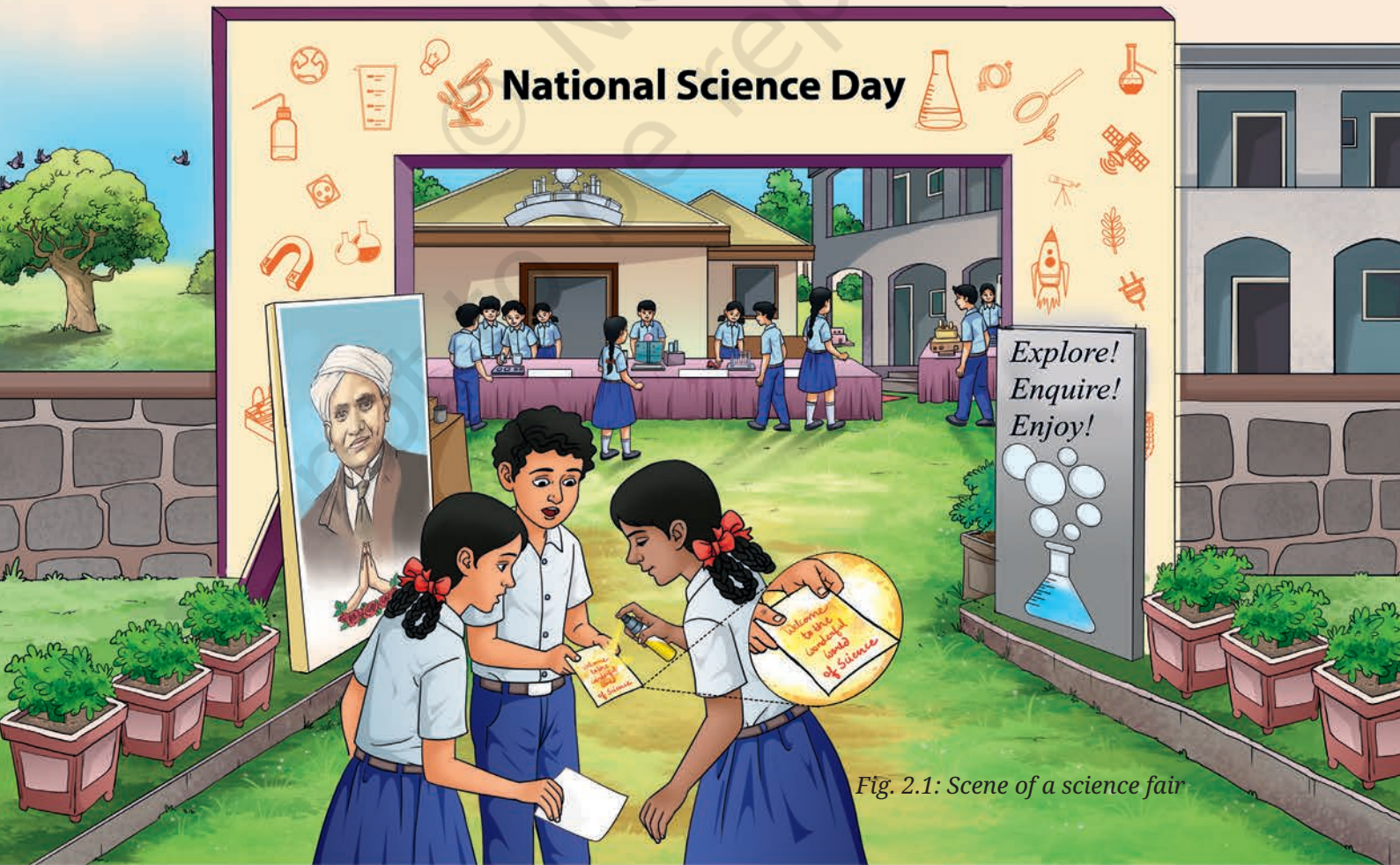


Fig. 2.1: Scene of a science fair

2.1 Nature — Our Science Laboratory

2.1.1 Litmus as an indicator

Activity 2.1: Let us explore

- Collect samples of lemon juice, soap solution, *amla* juice, tamarind water, vinegar, baking soda solution, lime water, tap water, washing powder solution, sugar solution, and salt solution.

Fig. 2.2(a): Colour change in blue litmus paper

- Take a strip of blue litmus paper and cut it into small pieces.
- Spread these pieces on a clean and dry white tile.
- Using a dropper, put one drop of each of the samples, one-by-one, on these litmus paper pieces, as shown in Fig. 2.2a.

- Do you **observe** any change in the colour of the blue litmus pieces?
- **Record** your observations in Table 2.1.
- Repeat the same activity with pieces of red litmus paper as shown in Fig. 2.2b and record your observations in Table 2.1.

Fig. 2.2(b): Colour change in red litmus paper

How to prepare lime water?

Do not confuse lime water with the word lime, which is a fruit similar to lemon.

Lime water (solution of calcium hydroxide in water) can be easily prepared by mixing lime (*chuna,* i.e. calcium oxide) in water and leaving it undisturbed for some time, say an hour. Filter the liquid into another container and use it as lime water.

Table 2.1: Testing the nature of samples with blue and red litmus papers

S.No.	Name of the sample	Colour of blue litmus paper after putting a drop of sample	Colour of red litmus paper after putting a drop of sample
1.	Lemon juice		
2.	Soap solution		
3.	*Amla* juice		
4.	Tamarind water		
5.	Vinegar		
6.	Baking soda solution		
7.	Lime water		
8.	Tap water		
9.	Washing powder solution		
10.	Sugar solution		
11.	Salt solution		
12.	Any other		

Now, let us **analyse** Table 2.1 and sort the samples into three groups as follows—

- Group A with samples that turn the blue litmus paper to red.
- Group B with samples that turn the red litmus paper to blue.
- Group C with samples that do not affect either of the two litmus papers.

Record the data in Table 2.2.

Table 2.2: Grouping of samples tested in Table 2.1

Group A	Group B	Group C

I am curious to know—what are these red and blue litmus paper strips made of? Why do they change colour when drops of some samples are put on them?

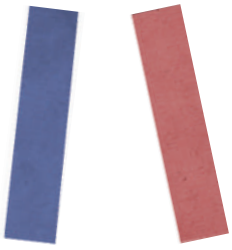


Fig. 2.3: Blue and red litmus paper strips

Let us find out!

Litmus is a natural substance obtained from lichens. It is available both as a solution and in the form of paper strips, known as litmus paper. The litmus paper is available in two colours—blue and red, as shown in Fig. 2.3.

Substances that turn blue litmus paper to red are **acidic** in nature, while those that turn red litmus paper to blue are **basic** in nature. Since litmus shows different colours in acidic and basic solutions, it is called an **acid-base indicator**.

Some other substances, both natural and synthetic, can also be used as indicators. Synthetic indicators are made in laboratories, and you will learn more about them in higher grades.

Lichens

Holistic Lens

Lichens are formed by the association of two living organisms, a fungus and an alga. They grow on rocks and trees in regions that have abundant rainfall and clean air. Do you find lichens on trees in your neighbourhood?

Now, let us **classify** the substances sorted in Group A, Group B, and Group C in Table 2.2.

- The substances in Group A, such as lemon juice, *amla* juice, tamarind water, and vinegar turned the blue litmus paper to red, implying that these substances are acidic in nature.
- The substances in Group B, such as soap solution, baking soda solution, lime water, and washing powder solution turned the red litmus paper to blue. Hence, these substances are basic in nature.
- The substances in Group C, such as tap water, sugar solution, and salt solution, did not change the colour of either litmus paper. Can you **predict** their nature?

These substances are said to be **neutral** because they are neither acidic nor basic.

Activity 2.2: Let us relate and explore

Are all the substances in Group A of Table 2.2 edible? Have you ever tasted these edible substances? Can you recall their taste? You will find that all these substances taste sour. Thus, we can say that substances that taste sour tend to contain **acids** and are acidic in nature.

Caution — Do not taste anything until asked to do so. Do not taste any unknown substance.

Some common edible substances and the names of the most common acids present in them are given in Fig. 2.4.

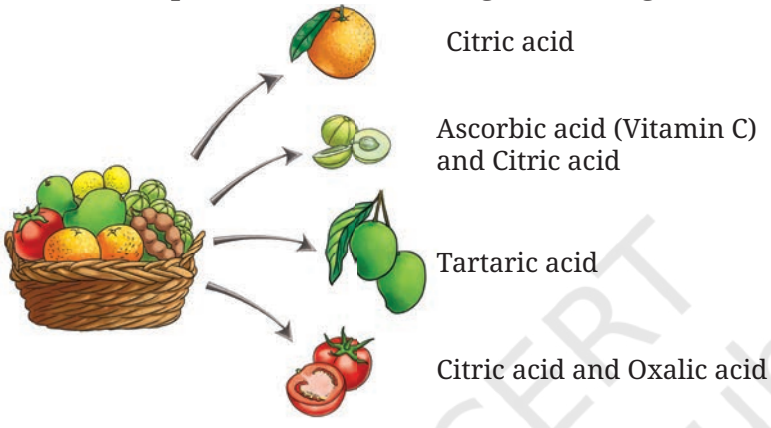


Fig. 2.4: The most common acids present in some edible substances

Find out and write the names of the most common acids present in the following substances —

Lemon_____, Curd_____, Tamarind_____, Vinegar_____.

Now, let us take one of the substances — baking soda solution — from Group B. Rub the baking soda solution between your fingers. What do you observe?

It feels soapy or slippery. Basic substances are generally slippery to touch.

Also, **bases** generally taste bitter, but everything that tastes bitter may not contain a base. For example, bitter gourd (*karela*) possesses a bitter taste but is not basic in nature.

Now, I can check the nature of floor cleaning liquid using an indicator!

If litmus is not available, are there some other natural substances that can serve as acid-base indicators?

2.1.2 Red rose as an indicator

You might have observed many coloured flowers in your surroundings. Try making your indicators using these flowers.

Activity 2.3: Let us prepare

Fig. 2.5: Red roses

- Collect some fallen petals of red roses available in your surroundings (Fig. 2.5). It is advised not to pluck flowers. You may pick petals or flowers fallen on the ground.
- Take a fistful of the collected petals of red roses and wash them with water.
- Crush the petals using a mortar and pestle.
- Place them in a glass tumbler.
- Pour some hot water into the glass tumbler to ensure that the crushed flower petals are completely immersed.

Fig. 2.6: Red rose petals immersed in hot water

Caution — Perform this step under the supervision of an adult.

- Cover the glass tumbler with a lid. Wait for 5 – 10 minutes till the water becomes coloured (Fig. 2.6), and filter it.
- The filtrate (liquid after filtration) is the required flower extract (Fig. 2.7) to be used as an acid-base indicator.

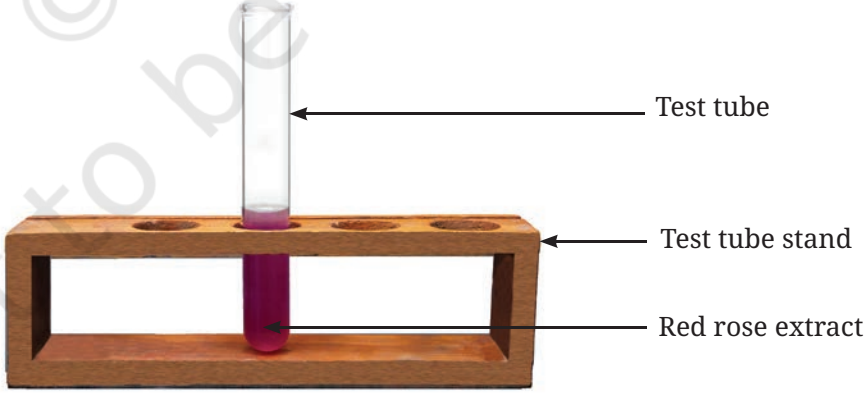


Fig. 2.7: Test tube containing the red rose extract

Activity 2.4: Let us find out

- Place 10 – 20 drops of the prepared red rose extract in each of two small transparent bottles or test tubes. Mark them A and B.

- Add 20–30 drops of lemon juice in test tube A and 20–30 drops of soap solution in test tube B with the help of droppers.
- Observe and record any colour changes (Fig. 2.8) to the extract in Table 2.3.
- Repeat the same with the other samples used in Activity 2.1 and record your observations in Table 2.3.

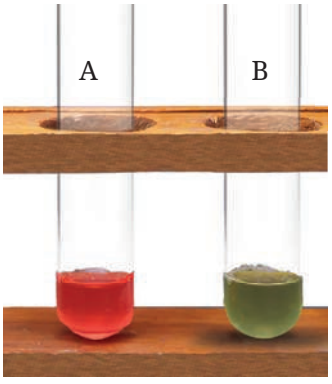


Fig. 2.8: The changes in colour of the red rose extract on adding lemon juice (A) and soap solution (B)

Table 2.3: Testing the nature of samples with the red rose extract

S.No.	Name of the sample	The colour of the red rose extract after adding the sample	Nature of the substance
1.	Lemon juice		
2.	Soap solution		
3.	*Amla* juice		
4.	...		

Discuss your observations with your classmates.

- Are the samples that change the colour of the flower extract to a shade of red the same as those that changed the colour of blue litmus paper to red? (Group A, Table 2.2)
- Are the samples that change the colour of the flower extract to a shade of green the same as those that changed the colour of red litmus paper to blue? (Group B, Table 2.2)
- Are the samples that do not change the colour of the flower extract the same as those that did not change the colour of red and blue litmus papers? (Group C, Table 2.2)

From the above activity, we can **conclude** that the red rose extract can also be used to test the nature of the substances; hence, it is another example of an acid-base indicator. We can conclude that the red rose extract seems to give red colour in an acidic solution and green colour in a basic solution.

Can you now fill in the nature of the substances in Table 2.3?

We are sure that you will be excited about the above results. You may repeat the process of preparing the extract and testing substances with some vegetables, fruits, or flowers, such as beetroot, purple cabbage, turmeric, Indian blackberry (*jamun*), and red hibiscus (*gudhal*) flower. They can also act as acid-base indicators.

Fascinating Facts

Hydrangea is a plant that grows in cooler climates in the Himalayan region and the North-eastern states. It gives flowers of different colours, depending on the nature of the soil. Acidic soil produces blue-coloured flowers, whereas in basic soil, the flowers are pink or red. Can gardeners alter the colour of hydrangea flowers by adjusting the acidic or basic nature of the soil?

Hydrangea flowers

2.1.3 Turmeric as an indicator

We have used blue and red litmus paper strips in Activity 2.1. Can you also make paper strips with some other natural indicators? Find out by performing the following activity.

Activity 2.5: Let us prepare

- Take a spoonful of turmeric (*haldi*) in a petri dish or container and add a little water to make a paste (Fig. 2.9a). You may also grind a piece of fresh turmeric.
- Carefully dip a piece of filter paper in the turmeric paste until it gets yellow colour.
- Take it out and allow it to dry.
- Cut this yellow paper into thin strips, which are used as 'turmeric paper' (Fig. 2.9b).

⚠ **Caution** — Perform this step under the supervision of an adult.

(a) Turmeric paste

(b) Turmeric paper strips

Fig. 2.9: Preparing turmeric paper

- Using a dropper, put a drop of each of the samples used in Activity 2.1, one by one, on separate pieces of turmeric paper.
- Record your observations in Table 2.4.

Table 2.4: Testing the nature of samples with turmeric paper

S.No.	Name of the sample	The colour of the turmeric paper after putting a drop of the sample
1.	Lemon juice	
2.	Soap solution	
3.	*Amla* juice	
4.	...	

What did you observe?

- Do all samples change the colour of the turmeric paper?
- Group the samples which do not change the colour of the turmeric paper.

Compare them with the samples in Group A, Group B, and Group C in Table 2.2.

I got a curry stain on my white shirt and on applying soap it changed its colour! Wow! Now I know the reason.

Can turmeric paper be used as an indicator for acidic substances? Discuss your observations with your classmates.

Based on the observations, we can conclude that turmeric paper can be used to test basic substances. However, it cannot differentiate between acidic and neutral substances.

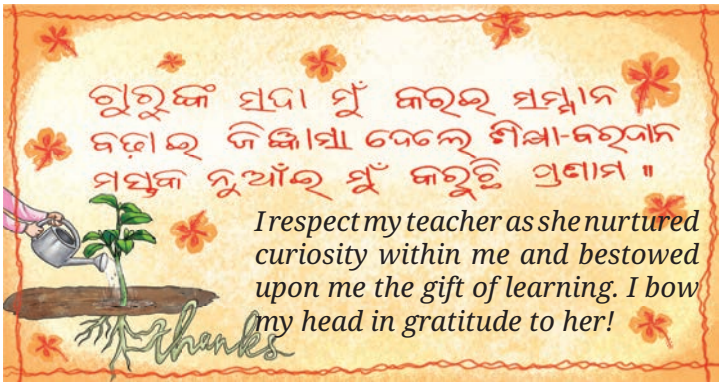
Fascinating Facts

Why is turmeric known as a 'Golden' spice?

Turmeric is a member of the ginger family, which is grown in India and other countries. A common spice in daily households, it is being researched for benefits beyond the taste and colour it provides to the food! In the Ayurvedic system of medicine, turmeric is considered to have numerous health benefits, and is commonly used in several traditional home remedies.

Turmeric (Haldi)

Ashwin created a greeting card to pay gratitude to his teacher on the day of Guru Purnima. He applied turmeric paste on white paper and dried it. He wrote his wishes in the teacher's mother tongue (Odia language) on the dried paper using one of the solutions tested in Table 2.4. Which solution can be used to write the message? His teacher applauded his creative use of this concept.



Are there any substances whose odours change on adding acidic or basic substances?

There are some substances whose odours change in an acidic or basic medium. These are called **olfactory indicators**.

Let us explore more!

Activity 2.6: Let us investigate

- Take some finely chopped onions in a container, along with some strips of clean cotton cloth or filter paper.
- Tightly close the container and leave it overnight.
- Take two of the cotton cloth or filter paper strips from the container and check their odour.
- Keep them on a clean surface and put a few drops of tamarind water on one strip and a few drops of baking soda solution on the other. Allow the drops to spread on the strips.
- Check the odour again.
- Do you notice any change in the odour of the onion strips before and after putting tamarind water and baking soda solution on them?
- Note your observations.
- Similarly, test the change in the odour with other acidic and basic substances and record your observations.

Know A Scientist

Acharya Prafulla Chandra Ray (P.C. Ray) is known as the 'Father of Modern Indian Chemistry'. He earned a doctorate in chemistry from the United Kingdom and returned to India. He contributed towards advancing scientific research in India. He also established India's first pharmaceutical company (a company in the field of medicines) in 1901. He was a person rooted in Indian culture and knowledge traditions. Through his writings on the history of chemistry in India, he highlighted the achievements and expertise of ancient Indian scientists to the modern world. Ray, a social reformer, also advocated the use of the mother tongue as a medium of instruction in educational institutions.

2.2 What Happens When Acidic Substances Mix with Basic Substances?

Let us investigate by performing the following **experiment**.

Activity 2.7: Let us experiment

- Take one drop of lemon juice in a test tube and add around twenty drops of water to it. Observe the colour.
- Add a drop of blue litmus solution to it.
- Do you observe any colour change (Fig. 2.10a)?
- Slowly add drops of lime water to this test tube with the help of a dropper and swirl it well.
- What do you observe? Is there any change in the colour of the solution?
- A stage comes when the colour of the solution changes from red to blue (Fig. 2.10b).
- Again, add one drop of lemon juice to the above solution.

Can you predict why there is a change in colour?

Fig. 2.10(a): The colour of the solution on adding blue litmus solution

Fig. 2.10(b): The colour of the solution on adding lime water

Initially, when a drop of blue litmus solution is added to the lemon juice solution, the colour of the solution turns red. When lime water is added to this test tube, the colour of the solution eventually changes from red to blue. This shows that the solution in the test tube is no longer acidic. Lime water has neutralised the effect of the acid.

When the solution of an acid is mixed with the solution of a base in sufficient quantity, we find that the resulting solution is neither acidic nor basic. Such reactions are called **neutralisation** reactions. In a neutralisation reaction, **salt** and water are formed with the evolution (i.e., release) of heat.

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water} + \text{Heat}$$

There are many examples in everyday life where you can observe the use of neutralisation processes.

Let us find out!

2.3 Neutralisation in Daily Life

Fig. 2.11: Stinging effect of an ant bite

Situation 1: Keerthi was observing a butterfly in the garden with her hand resting on a tree trunk. Suddenly, a red ant bit her, leaving her skin red with stinging pain (Fig. 2.11). Her brother helped her by applying moist baking soda to the affected area, which relieved the pain. What do you think might be the reason for this?

When an ant bites, it injects an acidic liquid (formic acid) into the skin. The effect of the acid can be neutralised by rubbing moist baking soda, which is a base.

What remedies do people use to treat ant bites in your region?

Fig. 2.12: Neutralising the acidic nature of soil

Situation 2: On the Farmer's Portal (an online platform from the Department of Agriculture, Cooperation and Farmers Welfare), a query from a farmer states, "My plants are not growing well lately". After a detailed discussion, it was found that the excessive use of chemical fertilisers (substances added to soil to help plants grow better) made the soil acidic. What remedy might be provided to him?

When the soil is too acidic, the plants do not grow well. It can be treated with lime, which is a base. (Fig. 2.12).

If the soil is basic, organic matter like manure and composted leaves are added to it. Organic matter releases acids that neutralise the basic nature of the soil.

Sometimes, the soil may be neutral, but the plants growing in it may still show poor health, which can be due to the deficiency of nutrients in the soil.

Situation 3: Ashwin's friend Gurbir stays near an industrial area. He shared with him that the fish population in his neighbourhood lake was declining day by day! What do you think might be the causes for this? It may be due to factory waste being released into the lake.

If the factory waste is acidic in nature, what could be done to save the fish in the lake?

The factory waste can be neutralised by adding basic substances before releasing into the lake.

Let us wrap up!

Now, can you explain why the words 'Welcome to the Wonderful World of Science' appeared on Ashwin and Keerthi's paper sheets when the liquid was sprayed on them?

Do you think that one possibility could be using a turmeric solution for the spraying liquid and a soap solution for writing on the paper?

In a Nutshell

- Substances around us may be classified as acidic, basic, and neutral in nature.
- Extracts of lichen, red rose, red hibiscus, purple cabbage, turmeric, etc., can be used to indicate the nature of substances.
- Substances that show different colours in acidic and basic solutions are called acid-base indicators.
- Acids turn the colour of blue litmus to red. Bases turn the colour of red litmus to blue.
- Extract of red rose gives red colour in acidic solutions and green colour in basic solutions.
- The yellow colour of turmeric turns red in basic solutions but remains unchanged in acidic and neutral solutions.
- An acid and a base neutralise each other, forming salt and water, along with the evolution of heat.
- Many day-to-day problems like a red ant bite, acidic or basic nature of soil, and industrial waste can be attempted to be managed by the process of neutralisation.

Let Us Enhance Our Learning

1. A solution turns the red litmus paper to blue. Excess addition of which of the following solution would reverse the change?
   (i) Lime water
   (ii) Baking soda
   (iii) Vinegar
   (iv) Common salt solution
2. You are provided with three unknown solutions labelled A, B, and C, but you do not know which of these are acidic, basic, or neutral. Upon adding a few drops of red litmus solution to solution A, it turns blue. When a few drops of turmeric solution are added to solution B, it turns red. Finally, after adding a few drops of red rose extract to solution C, it turns green.

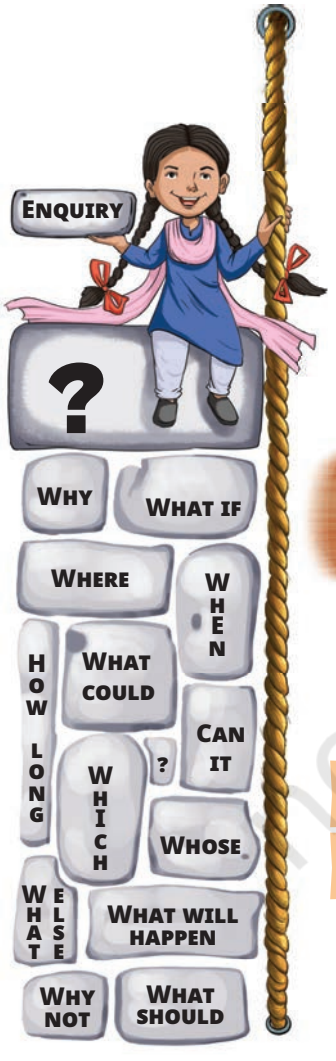
   Based on the observations, which of the following is the correct sequence for the nature of solutions A, B, and C?
   (i) Acidic, acidic, and acidic
   (ii) Neutral, basic, and basic
   (iii) Basic, basic, and acidic
   (iv) Basic, basic, and basic
3. Observe and analyse Figs. 2.13, 2.14, and 2.15, in which red rose extract paper strips are used. Label the nature of solutions present in each of the containers.

Fig. 2.13 *Fig. 2.14* *Fig. 2.15*

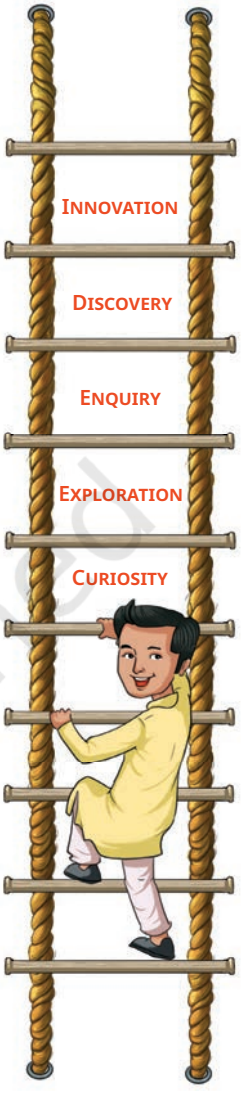
4. A liquid sample from the laboratory was tested using various indicators:

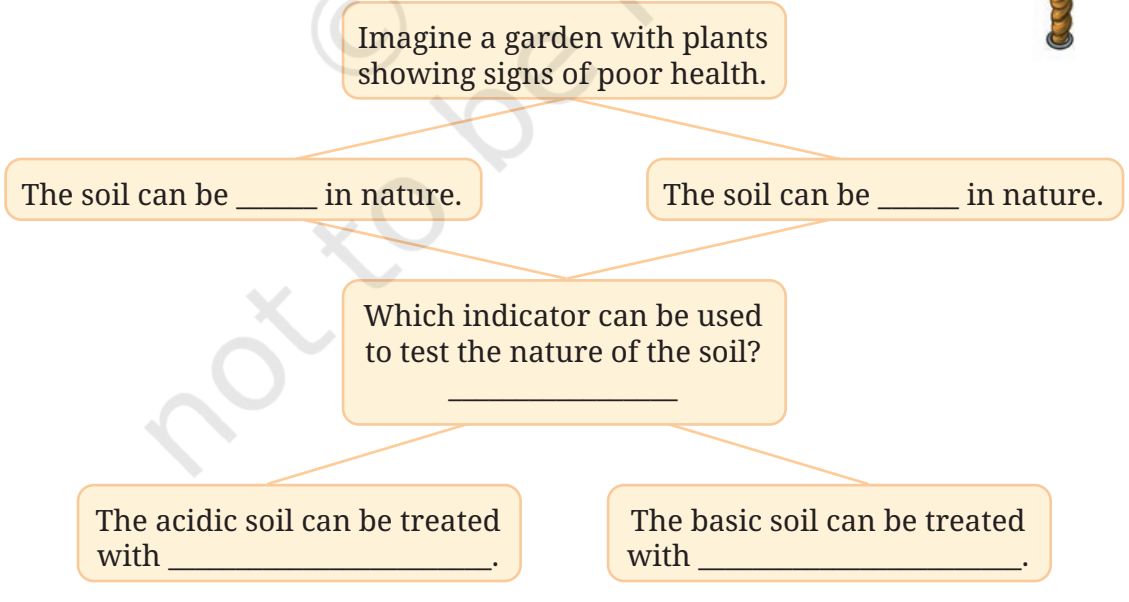
Indicator	Red litmus	Blue litmus	Turmeric
Change	No change	Turned red	No change in colour

   Based on the tests, identify the acidic or basic nature of the liquid and justify your answer.



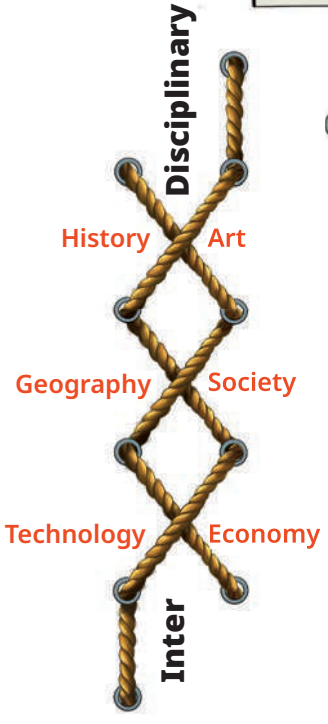
5. Manya is blindfolded. She is given two unknown solutions to test and determine whether they are acidic or basic. Which indicator should Manya use to test the solutions and why?
6. Could you suggest various materials which can be used for writing the message on the white sheet of paper (given at the beginning of the chapter) and what could be in the spray bottle? Make a table of various possible combinations and the colour of the writing obtained.
7. Grape juice was mixed with red rose extract; the mixture got a tint of red colour. What will happen if baking soda is added to this mixture? Justify your answer.
8. Keerthi wrote a secret message to her grandmother on her birthday using orange juice. Can you assist her grandmother in revealing the message? Which indicator would you use to make it visible?
9. How can natural indicators be prepared? Explain by giving an example.
10. Three liquids are given to you. One is vinegar, another is a baking soda solution, and the third is a sugar solution. Can you identify them only using turmeric paper? Explain.
11. The extract of red rose turns the liquid X to green. What will the nature of liquid X be? What will happen when excess of *amla* juice is added to liquid X?
12. Observe and analyse the information given in the following flowchart. Complete the missing information.





DIVE DEEPER

Aman accidentally spilt vinegar on some pieces of an eggshell or marble and noticed bubbling. He then poured a soap solution on another piece of eggshell or marble, but no bubbles appeared. Why did bubbles occur with vinegar but not with soap solution?



Exploratory Projects

- Create rangoli using acidic or basic substances and natural indicators.
- You may discuss in your class the acidic, basic, or neutral nature of water obtained from various sources. You may like to test the water samples available from sources such as rain, taps, rivers, etc.
- Collect a soil sample of your area and find out whether it is acidic, basic, or neutral in nature.