

Ages 12–15 · Science

LESSON SLIDES

Acids, Bases and the pH Scale

Chemistry · Measuring how acidic or alkaline a solution is

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Acids, Bases and the pH Scale

SPEAKER NOTES

Hold up a lemon, a bottle of vinegar and a packet of indigestion tablets. Ask: what could these three things have in common? Accept guesses, then tell students that two are acids and one is a base, and by the end of the lesson they will be able to say which is which and why the tablets work.

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By the end of this lesson you can

- 🎯 Describe acids and alkalis with everyday examples
- 🎯 Tell a base apart from an alkali
- 🎯 Use the pH scale and indicators
- 🎯 Explain the tenfold steps of the pH scale
- 🎯 Describe neutralisation and name the salt

By the end of this lesson you can

SPEAKER NOTES

Tell students there is a short practical in the middle of the lesson, so eye protection will be needed. Ask what they already know about the word 'acid'; many will associate it only with danger, which this lesson will broaden.

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Acids and alkalis are everywhere

- Lemon and lime juice contain citric acid
- Vinegar contains ethanoic (acetic) acid
- Your stomach makes hydrochloric acid to help digest food
- Many household cleaners are alkaline
- Indigestion tablets contain bases that cancel out stomach acid

Acids and alkalis are everywhere

SPEAKER NOTES

Edible acids taste sour, but in the laboratory you must never taste anything to test it. Ask students to sort a list of kitchen and bathroom items into 'probably acid' and 'probably alkali'; keep the list to test later with indicator.

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Acids and alkalis compared

Acids

- pH less than 7
- Turn blue litmus paper red
- Edible ones taste sour (never taste in the lab)
- React with many metals to give hydrogen gas
- Concentrated acids are corrosive

Alkalis

- pH more than 7
- Turn red litmus paper blue
- Are bases that dissolve in water
- Neutralise acids
- Concentrated alkalis are corrosive too

Acids and alkalis compared

SPEAKER NOTES

Point out the symmetry: acids and alkalis are opposites that cancel each other out. A common misconception is that only acids are dangerous; concentrated alkalis such as oven cleaner and drain cleaner can cause serious burns, especially to the eyes.

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Base or alkali?

- A base is any substance that reacts with an acid to make a salt and water
- An alkali is a base that dissolves in water
- So every alkali is a base, but not every base is an alkali
- Sodium hydroxide is a base and an alkali
- Copper oxide is a base but does not dissolve, so it is not an alkali

Base or alkali?

SPEAKER NOTES

Draw a big circle labelled 'bases' with a smaller circle inside labelled 'alkalis'. Ask students where magnesium hydroxide in an antacid suspension would go: it is a base that is only slightly soluble, which is why it is sold as a cloudy 'milk'.

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The pH scale

- A number scale, usually shown from 0 to 14
- pH 7 is neutral, like pure water
- Below 7 is acidic: the lower the number, the more acidic
- Above 7 is alkaline: the higher the number, the more alkaline
- pH measures the concentration of hydrogen ions in a solution

The pH scale

SPEAKER NOTES

Stress that a lower pH means more acidic; students often assume a bigger number means a stronger acid. Values below 0 and above 14 are possible for very concentrated solutions, but 0 to 14 covers almost everything met at school. Neutral is exactly pH 7 at 25 °C.

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Each step on the pH scale is ten times

×10

A solution at pH 3 has ten times the hydrogen ion concentration of one at pH 4

Each step on the pH scale is ten times

SPEAKER NOTES

So pH 3 is 10 times more acidic than pH 4, and 100 times more acidic than pH 5. This is why a small change in pH can matter a lot, for example in a fish tank or in the blood. Ask: how many times more acidic is pH 2 than pH 5? Answer: $10 \times 10 \times 10 = 1,000$ times.

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Everyday substances on the pH scale

- From strong acid at pH 0 to strong alkali at pH 14, with pure water neutral at pH 7.



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Everyday substances on the pH scale

SPEAKER NOTES

Use the poster to place everyday substances on the scale: gastric juice about 1.5, lemon juice about 2, coffee about 5, clean rain about 5.6, pure water 7, seawater about 8, milk of magnesia about 10.5, household ammonia about 12. Ask students to predict where their sorted kitchen items will go before they test them.

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Indicators show acid or alkali

- An indicator changes colour depending on pH
- Litmus: red in acid, blue in alkali
- Universal indicator: red (strong acid), green (neutral), purple (strong alkali)
- Red cabbage juice is a natural indicator
- A pH meter gives a more precise number

Indicators show acid or alkali

SPEAKER NOTES

Universal indicator is a mixture of several indicators, which is why it shows a whole rainbow of colours instead of just two. Coloured liquids such as cola can hide the indicator colour, which is one reason a pH meter is useful. Universal indicator solution is flammable, so keep it away from Bunsen flames.

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Litmus or universal indicator?

Litmus

- Only two colours: red or blue
- Tells you acid or alkali
- Does not tell you how acidic
- Neutral: neither paper changes colour

Universal indicator

- A range of colours across the pH scale
- Gives an approximate pH number
- Shows strongly or weakly acidic or alkaline
- Compare the colour with a chart

Litmus or universal indicator?

SPEAKER NOTES

Common confusion: students expect a positive litmus test always to involve a colour change. Teach the phrases 'turns red', 'stays red', 'turns blue' and 'stays blue'. An acid turns blue litmus red but leaves red litmus red.

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 Example

Worked example: comparing two solutions

- 1 Lemon juice: about pH 2. Coffee: about pH 5
- 2 Difference: $5 - 2 = 3$ steps
- 3 Each step is $\times 10$, so $10 \times 10 \times 10$
- 4 Lemon juice is about 1,000 times more acidic
- 5 Coffee is still acidic, just much less so

Worked example: comparing two solutions

SPEAKER NOTES

Work through each line on the board, then give a second pair to try: seawater (about pH 8) and household ammonia (about pH 12). Ammonia is about 10,000 times more alkaline. Remind students that these values are approximate; real samples vary.

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Neutralisation

- Acid + base → salt + water
- Hydrogen ions from the acid react with hydroxide ions: $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$
- The pH moves towards 7
- Universal indicator changes towards green
- Too much alkali makes the mixture alkaline again

Neutralisation

SPEAKER NOTES

In chemistry, 'salt' means a whole family of compounds, not just table salt. Ask students to predict what happens to the colour of universal indicator as alkali is added drop by drop to an acid: red, orange, yellow, then green at neutral, then blue and purple if too much alkali is added.

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 Example

Naming the salt

- 1 Hydrochloric acid + sodium hydroxide → sodium chloride + water
- 2 First part of the name comes from the base (sodium)
- 3 Second part comes from the acid (chloride)
- 4 Hydrochloric gives chlorides; sulfuric gives sulfates; nitric gives nitrates
- 5 Antacid: magnesium hydroxide + hydrochloric acid → magnesium chloride + water

Naming the salt

SPEAKER NOTES

Give students three more to name: potassium hydroxide with nitric acid (potassium nitrate), sodium hydroxide with sulfuric acid (sodium sulfate), calcium hydroxide with hydrochloric acid (calcium chloride). Older students can write the balanced symbol equation, for example $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$.

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Working safely with acids and alkalis

- Wear eye protection throughout
- Use dilute solutions in small volumes
- Never taste or smell chemicals to identify them
- Rinse spills on skin with plenty of cold water and tell the teacher
- Alkalis are especially harmful to eyes

Working safely with acids and alkalis

SPEAKER NOTES

Show the hazard symbols on the bottles you will use. Explain that 'dilute' and 'concentrated' describe how much acid is dissolved, while 'strong' and 'weak' describe how fully the acid releases hydrogen ions; older students meet this difference at GCSE and IGCSE level.

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 Quick check

A solution turns universal indicator purple. What is its approximate pH?

A pH 1

B pH 7

C pH 5

D pH 13

Quick check

SPEAKER NOTES

Answer: D, pH 13. Purple means strongly alkaline. Students who chose A have mixed up the two ends of the scale; ask them which colour a strong acid gives (red).

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Key takeaways

- ✓ Acids have pH below 7; alkalis have pH above 7; pH 7 is neutral
- ✓ An alkali is a base that dissolves in water
- ✓ Each pH step is a tenfold change
- ✓ Litmus shows acid or alkali; universal indicator shows the approximate pH
- ✓ Acid + base → salt + water

Key takeaways

SPEAKER NOTES

Return to the lemon, vinegar and indigestion tablets and ask students to explain how the tablets work, using the word neutralisation. Then move to the five-question quiz. Homework idea: research one use of neutralisation in farming, medicine or industry and explain it in three sentences.