The pH scale and neutralisation

5.4.2.4 · Chemistry · revision notes

What pH tells you, how to measure it with universal indicator or a pH probe, and which ions make solutions acidic or alkaline. Neutralisation between an acid and an alkali is summed up by the ionic equation $H^+ + OH^- \rightarrow H_2O$.

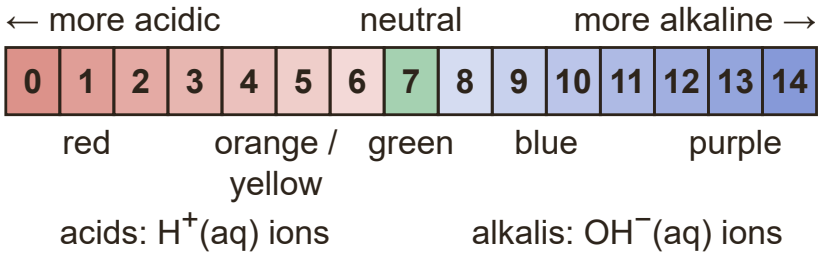
Key facts

- pH below 7 = acidic; pH 7 = neutral; pH above 7 = alkaline
- Alkalis produce $OH^-(aq)$ ions
- Universal indicator: red → orange → yellow → green (pH 7) → blue → purple
- Acids produce $H^+(aq)$ ions
- $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
- pH probe: numerical reading, more precise than indicator

Notes

The pH scale

- The pH scale runs from **0 to 14**. It measures how acidic or alkaline a solution is.
- pH 7 is **neutral**, e.g. pure water. Acids have a pH **below 7**. Alkalis have a pH **above 7**.
- The lower the pH, the more acidic the solution. The higher the pH, the more alkaline.



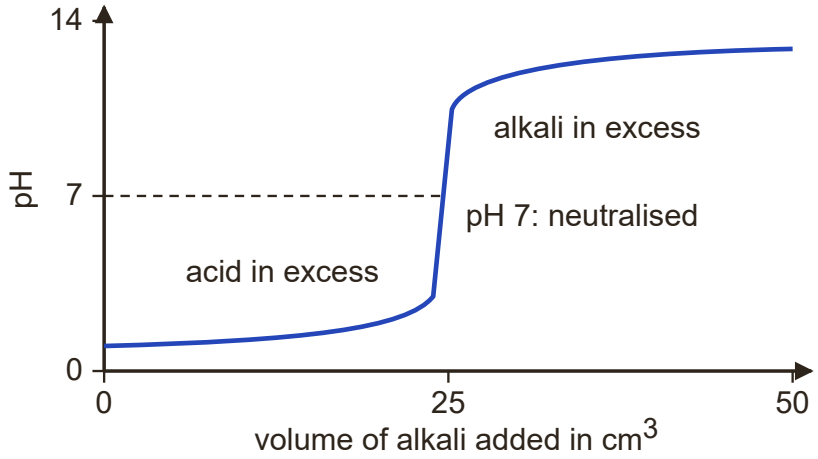
The words under the scale are the universal indicator colours.

Measuring pH

- **Universal indicator** is a wide range indicator: its colour changes across the whole pH scale.
- Colours: red (strongly acidic), orange and yellow (weakly acidic), green (neutral), blue (weakly alkaline), purple (strongly alkaline).
- Add a few drops to the solution, or dip universal indicator paper into it, and match the colour to a pH chart. This gives an approximate pH, as a whole number.
- A **pH probe** (pH meter) gives a numerical reading, usually to one or two decimal places. It is more precise and does not depend on judging a colour.

Ions and neutralisation

- Acids produce **hydrogen ions, H^+**, in aqueous solution.
- Alkalis produce **hydroxide ions, OH^-**, in aqueous solution.
- When an acid reacts with an alkali, hydrogen ions react with hydroxide ions to make water: **$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$**.
- The other ions, e.g. Na^+ and Cl^-, stay in the solution and make up the salt.
- Adding alkali to an acid makes the pH rise: it is 7 when the acid is exactly neutralised and goes above 7 if more alkali is added.



Adding alkali to acid: the pH rises slowly, then jumps through 7 when the acid is just neutralised.

How to answer each type of question

Use pH values to identify solutions

1 mark each | **Grade 3**

1. Below 7 is acidic, 7 is neutral, above 7 is alkaline.
2. The further from 7, the more strongly acidic or alkaline.

Example. The pH values of four solutions are shown.

Solution	A	B	C	D
pH	1	7	9	13

(a) Which solution is neutral?
(b) Which solution is the most strongly alkaline?
(c) What colour would universal indicator turn in solution A?

Model answer.

(a) B (1)
(b) D (1)
(c) Red (1)

Describe how to measure pH

2 marks | Grade 4

1. Say what you use: universal indicator (solution or paper) or a pH probe.
2. Say how you read the result: compare with a colour chart, or read the meter.

Example. Describe how a student could use universal indicator to find the pH of a sample of rainwater.

Model answer.

Add a few drops of universal indicator to a sample of the rainwater (1)

Match the colour to a pH colour chart to find the pH (1)

Give advantages of a pH probe

2 marks | Grade 5

1. A probe gives a number, often to decimal places, so it is more precise.
2. It does not rely on someone judging a colour.

Example. Give two advantages of using a pH probe rather than universal indicator to measure the pH of a solution.

Model answer.

Gives a more precise value / reads to decimal places (1)

Does not depend on judging a colour / not affected by the colour of the solution (1)

Write the ionic equation and describe pH changes in neutralisation

2 to 5 marks | Grade 6

1. The acid supplies H^+ ions and the alkali supplies OH^- ions.
2. Write $H^+ + OH^- \rightarrow H_2O$, with state symbols if asked.
3. Describe pH changes with direction and values: rises, reaches 7, goes above 7.

Example. Potassium hydroxide solution is added to nitric acid until the potassium hydroxide is in excess.
(a) Write the ionic equation for the neutralisation reaction, including state symbols.
(b) Describe how the pH of the solution in the flask changes.

Model answer.

(a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$: correct equation (1), correct state symbols (1)

(b) Starts below 7 / low and increases (1)

reaches 7 when the acid is neutralised (1)

goes above 7 when the alkali is in excess (1)

Don’t lose marks

- Saying alkalis have a pH below 7, or that pH 7 is weakly acidic.
- Mixing up the ions: acids produce H^+, alkalis produce OH^-.
- Writing the ionic equation with H_2 or O^{2-} instead of H^+ and OH^-.
- Leaving out state symbols when the question asks for them: (aq), (aq), (l).

More tips

Memory tricks

- Think of the pH scale as a number line: acids at the low end, alkalis at the high end, neutral in the middle at 7.
- Universal indicator colours run roughly like a rainbow: red at pH 1 through green at pH 7 to purple at pH 14.
- Neutralisation always makes water: $H^+ + OH^- \rightarrow H_2O$.

Exam technique

- Link pH to ions: a lower pH means a higher concentration of H^+ ions.
- When describing a pH change, give the direction and the values, e.g. 'rises from 1 to 7, then above 7'.
- Learn the universal indicator colours at pH 1, pH 7 and pH 14: red, green, purple.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Use pH to classify solutions**
Below 7 is acidic, 7 is neutral and above 7 is alkaline.

Grade 4 — **Measure pH with universal indicator**
Add the indicator and match its colour to a pH colour chart.

Grade 5 — **Name the ions in acids and alkalis**
Acids produce H^+ ions in water and alkalis produce OH^- ions in water.

Grade 5 — **Compare universal indicator with a pH probe**
A pH probe gives a more precise numerical reading; universal indicator gives an approximate value from a colour.

Grade 5 — **Describe the pH change during neutralisation**
As alkali is added to acid, the pH rises to 7 at neutralisation and above 7 when alkali is in excess.

Grade 6 — **Write the ionic equation for neutralisation**
$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.

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