Strong and weak acids

4.4.2.6 · Chemical changes · revision notes

Higher tier only. The difference between strong and weak acids (how much they ionise) and between concentrated and dilute acids (how much acid is in a given volume), and how pH is linked to hydrogen ion concentration by factors of 10.

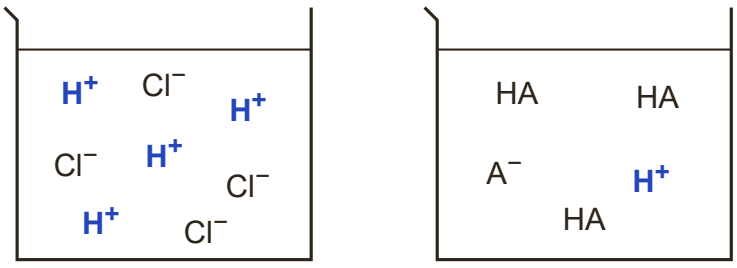
Key facts

- Strong acid: completely ionised in water (hydrochloric, nitric, sulfuric)
- Concentrated / dilute = amount of acid in a given volume
- pH down by 1 → H^+ concentration × 10
- $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
- Weak acid: partially ionised in water (ethanoic, citric, carbonic)
- Same concentration: stronger acid → more H^+ ions → lower pH
- pH down by 2 → × 100; pH down by 3 → × 1000

Notes

Strong and weak acids

- Acids ionise in water to release hydrogen ions, H^+.
- A **strong acid** is **completely ionised** in aqueous solution. Examples: hydrochloric, nitric and sulfuric acids. $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
- A **weak acid** is only **partially ionised** in aqueous solution: only a small fraction of its molecules release H^+ ions at any time, and the ionisation is reversible (⇌). Examples: ethanoic, citric and carbonic acids.



strong acid: completely ionised

weak acid: partially ionised

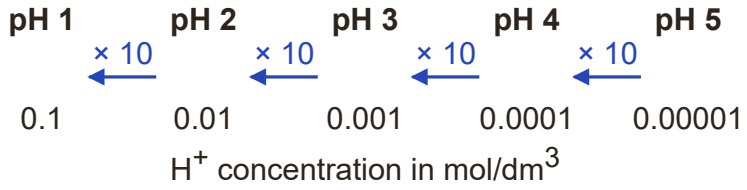
Same concentration, but the strong acid releases far more H^+ ions (HA is a weak acid molecule, A^- its negative ion).

Strength is not concentration

- **Strength** (strong or weak) is about the proportion of the acid that ionises.
- **Concentration** (concentrated or dilute) is about the amount of acid dissolved in a given volume of solution. A concentrated acid has a large amount of acid per dm^3; a dilute acid has a small amount per dm^3.
- So you can have a dilute strong acid or a concentrated weak acid.
- At the **same concentration**, a strong acid has a higher concentration of H^+ ions than a weak acid, so it has a **lower pH**. It also reacts faster, e.g. with magnesium or a carbonate, because its H^+ ions collide with the reactant more often.

pH and hydrogen ion concentration

- A neutral solution has pH 7. Below 7 is acidic: the lower the pH, the higher the concentration of H^+ ions.
- When the pH **decreases by 1**, the H^+ ion concentration **increases by a factor of 10**.



Each 1 unit lower in pH means 10 times more H^+ ions.

- pH 3 → pH 1 is a decrease of 2 units, so the H^+ concentration is 10 × 10 = **100 times** greater.
- pH 4 → pH 7 is an increase of 3 units, so the H^+ concentration is 1000 times smaller.
- Diluting any acid lowers its H^+ concentration, so its pH rises. Diluting a strong acid 10 times raises its pH by 1.

How to answer each type of question

Explain the difference between strong and weak (or dilute and concentrated)

2 to 4 marks | **Grade 6**

1. Strong or weak: use 'completely ionised' and 'partially ionised' in aqueous solution.
2. Concentrated or dilute: talk about the amount of acid in a given volume.
3. Never use 'strong' to mean concentrated.

Example. Hydrochloric acid is a strong acid. Ethanoic acid is a weak acid.
(a) Explain the difference between a strong acid and a weak acid.
(b) A student says 'a dilute acid is the same as a weak acid'. Explain why the student is wrong.

Model answer.

(a) A strong acid is completely ionised in aqueous solution	(1)
a weak acid is only partially ionised	(1)
(b) Dilute means there is a small amount of acid in a given volume of solution	(1)
weak describes how much the acid ionises, so a dilute acid can still be strong	(1)

Explain pH differences between acids of the same concentration

3 to 4 marks | Grade 7

1. Say which acid is strong (completely ionised) and which is weak (partially ionised).
2. Say which has the higher concentration of H^+ ions.
3. Link a higher H^+ concentration to a lower pH.

Example. Solutions of nitric acid and citric acid have the same concentration. The nitric acid has pH 1 and the citric acid has pH 2.
(a) Explain why the pH values are different.
(b) How many times greater is the hydrogen ion concentration in the nitric acid?

Model answer.

(a) Nitric acid is a strong acid, so it is completely ionised	(1)
Citric acid is a weak acid, so it is only partially ionised	(1)
So the nitric acid has a higher concentration of hydrogen ions, giving a lower pH	(1)
(b) 10 times	(1)

Work out the change in H^+ concentration from a pH change

1 to 2 marks | Grade 8

1. Find the change in pH (always whole numbers at GCSE).
2. Each unit is a factor of 10: 1 unit = 10, 2 units = 100, 3 units = 1000.
3. Say whether the H^+ concentration goes up (pH falls) or down (pH rises).

Example. The pH of a solution changes from 5 to 2.
Describe how the hydrogen ion concentration changes.

Model answer.

The pH decreases by 3 units	(1)
so the hydrogen ion concentration increases by a factor of 1000	(1)

Don’t lose marks

- Using 'strong' to mean concentrated or 'weak' to mean dilute.
- Saying a pH change of 2 means 2 times (or 20 times) more H^+: it is 100 times.
- Saying weak acids do not ionise: they do, but only partially.
- Saying strong acids always have a lower pH without adding 'at the same concentration'.
- Getting the direction wrong: a higher pH means fewer H^+ ions.
- Writing 'the hydrogen ions are ionised': it is the acid that ionises to release hydrogen ions.

More tips

Memory tricks

- Strong or weak = how much it splits up into ions. Concentrated or dilute = how much acid is in the water.
- Count the pH steps and write that many zeros after a 1: 3 steps → 1000.
- pH and H^+ concentration go in opposite directions: lower pH, more H^+.

Exam technique

- Use the exact phrases: 'completely ionised', 'partially ionised', 'in aqueous solution', 'hydrogen ions'.
- Only whole-number pH changes are asked, so answers are always 10, 100, 1000 and so on.
- When comparing two acids, say which has the higher H^+ concentration and link it to pH.

What each grade needs

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

Grade 5

Name examples of strong and weak acids

Strong: hydrochloric, nitric and sulfuric acids. Weak: ethanoic, citric and carbonic acids.

Grade 6

Define strong and weak acids

A strong acid is completely ionised in aqueous solution; a weak acid is only partially ionised.

Grade 6

Explain the terms dilute and concentrated

They describe the amount of acid in a given volume of solution, not how much it ionises.

Grade 7

Explain why a stronger acid has lower pH

At the same concentration, a strong acid releases more H^+ ions, so its pH is lower.

Grade 8

Relate pH changes to H^+ concentration

Each decrease of 1 pH unit means the H^+ concentration is 10 times greater.

Grade 9

Separate strength from concentration in unfamiliar data

For example, explain why a concentrated weak acid can have a lower pH than a very dilute strong acid.

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