

# How acids, bases and salts behave

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

The answers show the key chemistry behind each result. For equations, check the formulae first and then the balancing; for explanations, make sure you link your point to  $\text{H}^+$  ions or to ionisation.

**Level:** Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C4, IGCSE 7

## Problem 1 Sort the household liquids

1. Acids: **lemon juice, milk, stomach acid**. Neutral: **pure water**. Alkalis: **bleach, soapy water**.
2. The lowest pH is 1.5, so **stomach acid** is the most acidic.
3. At pH 2 universal indicator is **red**.

## Problem 2 Name the salt

1. **Sodium chloride**.
2. **Copper(II) sulfate**.
3. **Potassium nitrate**.
4. **Zinc chloride** (and hydrogen gas).

## Problem 3 Complete the word equations

1. **salt + water**.
2. **salt + water + carbon dioxide**.
3. **salt + hydrogen**.
4. **salt + water**.

## Problem 4 Ions in acids and alkalis

1. The **hydrogen ion,  $\text{H}^+$** .
2. The **hydroxide ion,  $\text{OH}^-$** .
3.  **$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$** .
4. **pH 7**.

## Problem 5 Reading indicator colours

1. **Alkaline**: all three colours are the alkaline colours.
2. **Blue or violet**.
3. The **hydroxide ion,  $\text{OH}^-$** .

**Problem 6 An ant sting**

1. The alkali **neutralises the acid** in the sting, so the pain eases.
2. Strong alkalis are corrosive and would burn the skin.
3. **Neutralisation.**

**Problem 7 Balance the equations**

1. Already balanced:  $\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$ .
2.  $\text{Mg}(\text{OH})_2 + 2\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + 2\text{H}_2\text{O}$ .
3. Already balanced:  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O} + \text{CO}_2$ .
4.  $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$  (2 Al, 6 Cl, 6 H and 3 O on each side).

**Problem 8 Ionic equations**

1. Full ionic:  $\text{Na}^+ + \text{OH}^- + \text{H}^+ + \text{Cl}^- \rightarrow \text{Na}^+ + \text{Cl}^- + \text{H}_2\text{O}$ . Cancelling gives  **$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$** .
2.  **$\text{Na}^+$  and  $\text{Cl}^-$ .**
3.  **$\text{CaCO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$** ; the  $\text{Cl}^-$  ions are spectators.

**Problem 9 Order the method**

1. **B, D, A, E, C.**
2. The excess guarantees that **all the acid has reacted**, so the crystals are not contaminated with acid.
3. Some zinc oxide **stays undissolved** however long you stir.

**Problem 10 Choose the method**

1. **(i)**: zinc oxide is an insoluble base, so the excess can be filtered off.
2. **(ii)**: potassium hydroxide is soluble, so exact volumes are needed.
3. **(iii)**: the insoluble barium sulfate forms at once and is filtered, washed and dried.

**Problem 11 Mass of zinc sulfate**

1.  $M(\text{ZnO}) = 81$ ;  $n = 4.05 \div 81 = \mathbf{0.0500 \text{ mol}}$ .
2. Ratio 1 : 1, so **0.0500 mol**.
3.  $M(\text{ZnSO}_4) = 65 + 32 + 64 = 161$ ;  $m = 0.0500 \times 161 = \mathbf{8.05 \text{ g}}$ .

**Problem 12 Fertiliser from ammonia**

1.  $M(\text{NH}_3) = 17 \text{ g/mol}$ ;  $8500 \div 17 = \mathbf{500 \text{ mol}}$ .
2.  $M(\text{NH}_4\text{NO}_3) = 80 \text{ g/mol}$ ;  $500 \times 80 = 40\,000 \text{ g} = \mathbf{40 \text{ kg}}$ .
3.  $0.92 \times 40 = \mathbf{36.8 \text{ kg}}$ .

**Problem 13 Comparing pH values**

1. **A**, with the lowest pH.
2.  $4 - 2 = 2$  units, so  $10 \times 10 =$  **100 times**.
3.  $6 - 2 = 4$  units, so  $10^4 =$  **10 000 times**.
4. The volume increases tenfold, so  $[H^+]$  falls tenfold and the pH rises by 1 to **pH 3** (for a strong acid).

**Problem 14 Strong or weak?**

1. **Acid X** is strong: it is fully split into ions and has no whole molecules.
2. **Acid X** has the lower pH because it has more  $H^+$  ions.
3. **Acid X** reacts faster, because more  $H^+$  ions are present to collide with the magnesium.

**Problem 15 Dilution data**

1. Each tenfold dilution raises the pH by **1 unit**.
2. **pH 4.0**.
3. Ethanoic acid is a **weak acid**: only a small fraction of molecules ionise, so  $[H^+]$  is lower and the pH is higher.

**Problem 16 Acid rain on a statue**

1.  $n(H^+) = 2400 \times 1.0 \times 10^{-4} =$  **0.24 mol**.
2. The ratio  $CaCO_3 : H^+$  is 1 : 2, so  $n =$  **0.12 mol**.
3.  $m = 0.12 \times 100 =$  **12 g**.
4. pH 3.0 has ten times more  $H^+$ , so the mass lost is **ten times larger** (120 g).

**Problem 17 Treating a fish pond**

1.  $50 \times 1000 =$  **50 000 dm<sup>3</sup>**.
2.  $n(H^+) = 50\,000 \times 1.0 \times 10^{-5} =$  **0.50 mol**.
3.  $n(Ca(OH)_2) = 0.50 \div 2 = 0.25$  mol;  $M = 74$ ;  $m =$  **18.5 g**.
4. Calcium hydroxide is only slightly soluble and a weak excess leaves a mildly alkaline pond, but a **large excess makes the water too alkaline** for fish.

**Problem 18 Spot the errors**

1. Strength is confused with concentration, in both statements: **strong means fully ionised, weak means partly ionised**.
2.  $1.0 \text{ mol/dm}^3$  ethanoic acid (weak) has pH 2.4, lower than  $0.001 \text{ mol/dm}^3$  hydrochloric acid (strong) at pH 3.0. So **a concentrated weak acid can be more acidic than a dilute strong acid**.
3. "Hydrochloric acid is strong because it ionises completely. Ethanoic acid is weak because it ionises only partly."

**Problem 19 Copper sulfate crystals**

1.  $n = 0.500 \times 0.0500 = \mathbf{0.0250 \text{ mol}}$ .
2.  $M(\text{CuO}) = 79.5$ ;  $0.0250 \times 79.5 = \mathbf{1.99 \text{ g}}$ .
3.  $M(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 159.5 + 90 = 249.5$ ;  $0.0250 \times 249.5 = \mathbf{6.24 \text{ g}}$ .
4.  $5.10 \div 6.2375 \times 100 = \mathbf{81.8\%}$ .

**Problem 20 Pure potassium chloride**

1. Potassium hydroxide is **soluble**, so the excess would dissolve and there would be nothing to filter off.
2. Find the exact volume of acid that neutralises the alkali using an indicator, then repeat **without the indicator** using that volume. Evaporate part of the water and crystallise.
3.  $n(\text{KOH}) = 0.200 \times 0.0250 = 0.00500 \text{ mol}$ ;  $n(\text{KCl}) = 0.00500 \text{ mol}$ ;  $M = 74.5$ ;  $m = \mathbf{0.373 \text{ g}}$ .