Topic 8.8: Properties of Buffers

Revision Notes · AP Chemistry

UNIT 8 · ACIDS AND BASES

On ExamFitter.com: Topic 8.8 Quiz · Topic 8.8 Worksheet · Unit 8: All Topics · AP Chemistry Home

A Short Recap: The Pair and the Ratio

Topic 8.4 built the buffer: appreciable amounts of a weak acid with its conjugate base, or a weak base with its conjugate acid.

Both members, in real quantity. A buffer defends in two directions, so both members must stand by in quantity. A trace of one member, such as the trace conjugate base a weak acid makes by ionizing, defends nothing.

The ratio sets the pH. Everything here hangs off one line and one question: how much of each member is there?

$pH = pKa + \log([A^-] \div [HA])$

The Effective Range: Within One Unit of pKa

A buffer works well only while both members make up a serious share of the pair: pH within one unit of pKa.

At the edges the ratio is 10 or 0.10. $pH = pKa + 1$ requires $[A^-] \div [HA] = 10$, so the acid member is only about 9% of the pair; $pH = pKa - 1$ leaves the base member at about 9%. Beyond the edge, a modest addition aimed at the scarce member exhausts it.

Dominance is the quick read. At $pH = pKa$ the two forms are equal. One unit away, the dominant form is about 91% of the pair; two units away, about 99%.

© 2026 ExamFitter.com · Free AP Chemistry revision notes

Additions and Their Limits: Moles First

An addition to a buffer is a stoichiometry problem first: the added ion converts one member into the other completely, and only then is the pH recalculated.

Added strong acid attacks A^-:

$A^- + H_3O^+ \rightarrow HA + H_2O$

Added strong base attacks HA:

$HA + OH^- \rightarrow A^- + H_2O$

Each stock moves by the moles added, one up and one down.

Why the pH barely moves. pH answers to the logarithm of the ratio, so a small percentage change in the ratio moves it only a little. Both members must still stand at the end: a stock driven to zero means the buffer is gone and the leftover strong acid or base sets the pH alone.

Capacity is the stock, per direction. Defence against acid spends A^-, so the base member's stock caps that direction; defence against base spends HA. A buffer rich in A^- but poor in HA shields well against acid and weakly against base.

Concentration scales it. Two buffers at the same pH and ratio can differ tenfold in what they absorb: 0.50 mol L^{-1} of each member absorbs ten times the attack of 0.050 mol L^{-1} of each, because ten times the moles stand ready. Equal members, at pH = pKa, stock both directions evenly.

Choosing and Preparing a Buffer

Pick the weak acid whose pKa is closest to the target pH.

Target pH 4.0: CH_3COOH / CH_3COO^- (pKa 4.74) is the pick, needing a ratio of $10^{(4.00-4.74)}$ = 0.18. HCl / Cl^- is never a candidate: Cl^- is not a base in water at all. **Target pH 9.3:** NH_4^+ / NH_3 (pKa 9.26) wins, ratio about 1.1.

The blood exception. Blood holds pH 7.4 with H_2CO_3 / HCO_3^- (pKa 6.37), one unit below target, ratio about 10.7. It works because the system is open: breathing regulates CO_2.

$CO_2 + H_2O \rightleftharpoons H_2CO_3$

Three routes to make one. Mix the pair directly, in amounts that give the target ratio. Or partly neutralize a weak acid: 0.20 mol of CH_3COOH with 0.10 mol of NaOH leaves 0.10 mol of CH_3COOH

© 2026 ExamFitter.com · Free AP Chemistry revision notes

alongside 0.10 mol of CH_3COO^- formed in place, a buffer at pH = pKa = 4.74. Or partly neutralize a weak base with strong acid.

The stop rule. The strong reagent must run out first. Add a full equivalent or more and one member is never formed; the product is a salt solution, or excess strong acid or base.

Dilution: The Same pH behind a Thinner Shield

Dilute a buffer and both members fall by the same factor, so their ratio, and therefore the pH, stays put: a 0.20 ÷ 0.20 acetate buffer diluted tenfold to 0.020 ÷ 0.020 still reads pH 4.74 (the exact solve agrees within 0.01).

What dilution takes away is staying power. Each litre of the diluted buffer holds a tenth of the A^- stock, so a tenth of the added acid exhausts it. The pH reading hides the loss. Pushed far enough, the members end up so dilute that water's own ions are no longer negligible beside them.

Worked Examples

Example 1: An acetate buffer under acid attack. One litre holds 0.30 mol of CH_3COOH and 0.30 mol of CH_3COO^-, Ka = 1.8×10^{-5}. Equal members, so pH = pKa = 4.74. Add 0.020 mol of HCl: its H_3O^+ converts CH_3COO^- into CH_3COOH mole for mole, leaving 0.32 mol of CH_3COOH and 0.28 mol of CH_3COO^-. The ratio route gives pH = 4.74 + log(0.28 ÷ 0.32) = 4.69, a fall of 0.06. The full equilibrium returns $[H_3O^+] = 2.1 \times 10^{-5}$ mol L^{-1} and pH 4.69.

Example 2: An ammonia buffer under base attack. One litre holds 0.20 mol of NH_3 and 0.20 mol of NH_4Cl, Kb of NH_3 = 1.8×10^{-5}. Equal members, so pH 9.26. Add 0.020 mol of NaOH: its OH^- converts NH_4^+ into NH_3, leaving 0.22 mol of NH_3 and 0.18 mol of NH_4^+. Then $[OH^-] = Kb \times [NH_3] \div [NH_4^+] = 1.8 \times 10^{-5} \times 0.22 \div 0.18 = 2.2 \times 10^{-5}$ mol L^{-1}, so pOH = 4.66 and pH = 9.34. The exact solve agrees.

Example 3: An HF buffer under base attack. One litre holds 0.30 mol of HF and 0.10 mol of F^-, pKa = 3.17. The starting pH = 3.17 + log(0.10 ÷ 0.30) = 3.17 − 0.48 = 2.69. Add 0.050 mol of NaOH: its OH^- converts HF into F^-, leaving 0.25 mol of HF and 0.15 mol of F^-. Then pH = 3.17 + log(0.15 ÷ 0.25) = 3.17 − 0.22 = 2.95, a rise of 0.26. The exact solve agrees.

© 2026 ExamFitter.com · Free AP Chemistry revision notes

> **Example 4: Dilution counts moles, not litres. A 250 mL acetate buffer at 0.20 mol L^{-1} of each member holds 0.050 mol of each and absorbs 0.050 mol of HCl before its CH_3COO^- runs out. Diluted to 1.0 L, it still holds 0.050 mol of each member, still reads pH 4.74, and still absorbs the same 0.050 mol. What fell is the capacity per litre, from 0.20 mol to 0.050 mol.**

Traps That Cost Marks in Topic 8.8

"Any conjugate pair in solution is a working buffer." A pair with one member at trace level, or both extremely dilute, has the right names and no defence.

"HCl / Cl^- buffers because they are conjugates." Cl^- never accepts a proton in water.

"Diluting a buffer changes its pH." Dilution divides both members by the same factor; ratio and pH stand still.

"A buffer at pH = pKa + 1.5 is fine because its pH is right." At that distance the ratio is about 32 and one member is about 3% of the pair; the first push in its direction ends it.

"More A^- always means a better buffer." Only against acid: defence against base spends HA, and a lopsided buffer can be formidable one way and defenceless the other. The ratio sets the pH; amounts set the absorbable attack.

© 2026 ExamFitter.com · Free AP Chemistry revision notes

Key Relationships to Remember

- A working buffer needs both members of a weak conjugate pair, in appreciable and comparable amounts
- Effective range: pH within about 1 unit of pKa, where $[A^-] \div [HA]$ stays between 0.10 and 10 and neither member falls below about 9% of the pair
- At pH = pKa the members are equal and the buffer is most balanced; one unit away the dominant form is about 91% of the pair
- Added H_3O^+ converts A^- into HA; added OH^- converts HA into A^-; recount the moles first, then use the new ratio
- Defence against acid is capped by the A^- stock, against base by the HA stock; once a member is exhausted, the excess sets the pH
- Capacity grows with the absolute amounts of the members, not with the ratio; the ratio sets the pH
- Choose the pair whose pKa lies closest to the target pH; prepare by mixing the pair, or by partial neutralization
- Dilution leaves ratio and pH unchanged but shrinks both stocks

Continue Revising

Topic 8.8 Quiz: Properties of Buffers

Topic 8.8 Worksheet

Unit 8: All Topics

© 2026 ExamFitter.com · Free AP Chemistry revision notes