

Strong and weak acids, pH and buffer solutions

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

Does the pH of a buffer really follow the logarithm of the base-to-acid ratio? You mix ethanoic acid and sodium ethanoate in seven proportions, measure each pH and use a graph to extract pKa, then test how well a buffer and plain water cope with a little added acid.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R3.1

Aim

To measure the pH of mixtures of ethanoic acid and sodium ethanoate in different ratios, to test the Henderson-Hasselbalch equation, and to compare how a buffer and water respond to added acid.

Equipment

- 0.100 mol/dm³ ethanoic acid and 0.100 mol/dm³ sodium ethanoate
- 0.100 mol/dm³ hydrochloric acid and distilled water
- pH meter or data-logger pH probe, with pH 4.00 and pH 7.00 calibration solutions
- Two 50 cm³ burettes (or syringes), 100 cm³ beakers, magnetic stirrer or glass rod

Safety

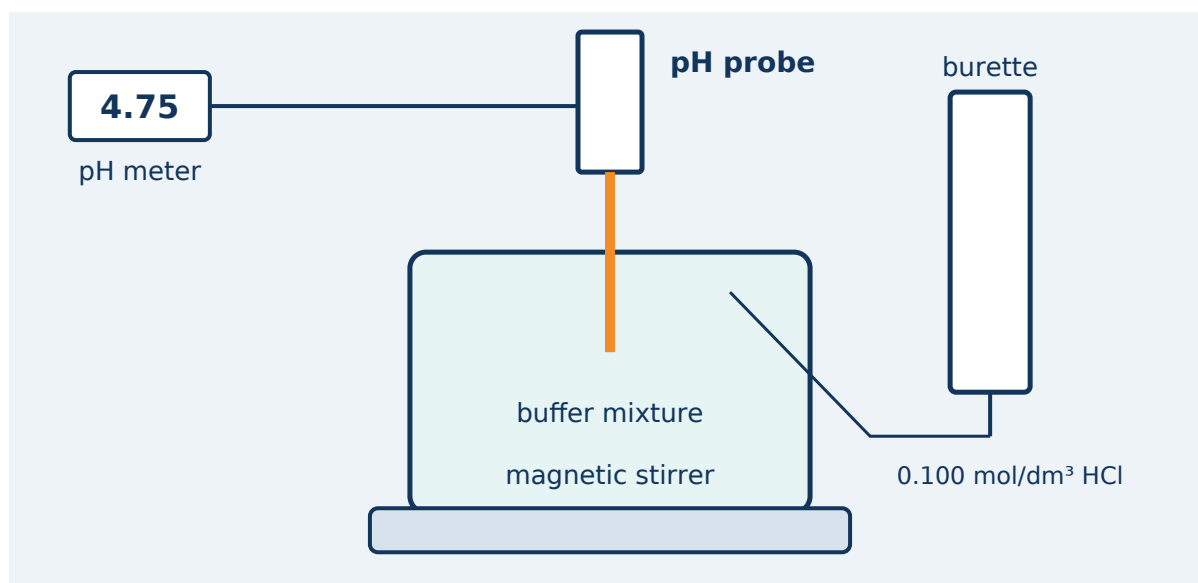
Safety

Wear eye protection. 0.1 mol/dm³ acids are low hazard but can irritate eyes. Wash spills with plenty of water and keep the probe in storage solution when not in use.

Method

1. Calibrate the pH meter with the pH 7.00 and pH 4.00 solutions, rinsing the probe with distilled water between solutions.
2. Run 25.0 cm³ of ethanoic acid into a beaker and 25.0 cm³ of sodium ethanoate into it. Stir and record the pH once the reading is steady.
3. Repeat for the other volume ratios in the table, always making 50.0 cm³ in total.
4. Place 50.0 cm³ of the 25.0 : 25.0 buffer in a clean beaker. Add 2.0 cm³ of the hydrochloric acid, stir and record the pH.

5. Do the same with 50.0 cm³ of distilled water and record both pH values.



Set-up for measuring the pH of ethanoic acid and sodium ethanoate mixtures.

Results

Sample measurements from a class in Nairobi (20 °C):

Trial	Ethanoic acid (cm ³)	Ethanoate (cm ³)	Ratio [A ⁻]/[HA]	Measured pH
1	45.0	5.0	0.111	3.83
2	40.0	10.0	0.250	4.16
3	30.0	20.0	0.667	4.58
4	25.0	25.0	1.00	4.75
5	20.0	30.0	1.50	4.93
6	10.0	40.0	4.00	5.33
7	5.0	45.0	9.00	5.66

Acid test (2.0 cm³ of 0.100 mol/dm³ HCl added to 50.0 cm³):

Solution	pH before	pH after
Buffer (trial 4)	4.75	4.68
Distilled water	5.9	2.42

Analysis questions

Question 1 Ratio logarithms

Calculate log₁₀ of the ratio [A⁻]/[HA] for each trial.

Question 2 Graph of pH against log ratio

Plot pH (y-axis) against $\log_{10}([A^-]/[HA])$ (x-axis) and draw the best-fit line. State the gradient and the y-intercept.

Question 3 Finding pKa

Compare your intercept with the accepted pKa of 4.74. Calculate the percentage difference.

Question 4 Measured and calculated pH

For trial 1, calculate the pH predicted by the Henderson-Hasselbalch equation and compare it with the measured value. Suggest two reasons for the difference.

Question 5 Buffer against water

Calculate the change in pH for the buffer and for the water when acid is added. Calculate the pH predicted for the water and for the buffer after adding the acid.

Question 6 Dilution of the buffer

Predict, with a reason, what happens to the pH and to the buffer's ability to resist change if both stock solutions are diluted ten times before mixing 25.0 : 25.0.

Question 7 Improving the lab

Identify the main source of uncertainty in the volumes used and suggest one improvement to the method.