

# Strong and weak acids, pH and buffer solutions

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

Model answers follow the sample data in the results tables. Your own readings will differ a little, so judge your work by the shape of the graph, the size of the intercept difference and the clear contrast between buffer and water.

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

## Question 1 Ratio logarithms

Ratios 0.111, 0.250, 0.667, 1.00, 1.50, 4.00, 9.00 give logs: **-0.954, -0.602, -0.176, 0, +0.176, +0.602, +0.954.**

## Question 2 Graph of pH against log ratio

The points lie on a straight line rising from left to right. The gradient is **0.96** (close to the theoretical 1) and the y-intercept, where log ratio = 0, is **4.75**.

## Question 3 Finding pKa

At log ratio 0, pH = pKa, so pKa  $\approx$  **4.75**. Difference =  $(4.75 - 4.74) \div 4.74 \times 100 =$  **0.2 %**, so the data support the equation.

## Question 4 Measured and calculated pH

Predicted:  $4.74 + \log(0.111) = 4.74 - 0.954 = 3.79$ ; measured 3.83, so the difference is **0.04 pH units**. Reasons: the activity of ions differs from concentration; the calibration uncertainty of the meter ( $\pm 0.02$ ); temperature of 20 °C instead of 25 °C where pKa is quoted; ethanoate sample slightly impure.

## Question 5 Buffer against water

Buffer:  $4.75 \rightarrow 4.68$ , change **-0.07**. Water:  $5.9 \rightarrow 2.42$ , change **-3.5**. Predictions: buffer,  $n(\text{HA}) = 2.5 \times 10^{-3} + 2.0 \times 10^{-4} = 2.7 \times 10^{-3} \text{ mol}$ ,  $n(\text{A}^-) = 2.3 \times 10^{-3} \text{ mol}$ ,  $\text{pH} = 4.74 + \log(2.3 \div 2.7) =$  **4.67**; water,  $[\text{H}^+] = 2.0 \times 10^{-4} \div 0.052 = 3.8 \times 10^{-3} \text{ mol/dm}^3$ ,  $\text{pH} =$  **2.41**. Both agree with the measurements.

## Question 6 Dilution of the buffer

The ratio is unchanged, so the calculated **pH stays about 4.74**. But the buffer now has ten

times fewer HA and A<sup>-</sup>, so it has a **much smaller buffer capacity**: the same 2.0 cm<sup>3</sup> of acid would change the pH far more.

### Question 7 Improving the lab

The smallest volume, 5.0 cm<sup>3</sup>, has the largest percentage uncertainty ( $\pm 0.1$  cm<sup>3</sup> is **2 %**), though this changes log ratio by only 0.009. A more important limit is the single-point calibration drift and the unstable reading; calibrate with two buffers at the working temperature, wait for a steady reading and repeat each trial to get a mean.