

Strong and weak acids, pH and buffer solutions

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Use these model answers and the marking notes to score yourself out of 20. Award method marks even when the final numerical value is slightly different because of rounding.

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

Question 1 Acids and bases (3 marks)

- a. A proton (H^+) donor.
b. Pair 1: **HSO_4^- (acid) / SO_4^{2-} (conjugate base)**. Pair 2: **NH_3 (base) / NH_4^+ (conjugate acid)**.

Marking: (a) 1 mark. (b) 1 mark for each correctly identified pair.

Question 2 pH of nitric acid (2 marks)

HNO_3 ionises completely, so $[\text{H}^+] = 0.0075 \text{ mol/dm}^3$. $\text{pH} = -\log(0.0075) = \mathbf{2.12}$.

Marking: 1 mark for $[\text{H}^+] = 0.0075 \text{ mol/dm}^3$; 1 mark for 2.12.

Question 3 pH of propanoic acid (3 marks)

- a. $K_a = [\text{H}^+][\text{CH}_3\text{CH}_2\text{COO}^-] / [\text{CH}_3\text{CH}_2\text{COOH}]$.
b. $[\text{H}^+] = \sqrt{(1.35 \times 10^{-5} \times 0.200)} = \sqrt{(2.70 \times 10^{-6})} = 1.64 \times 10^{-3} \text{ mol/dm}^3$; $\text{pH} = \mathbf{2.78}$.

Marking: (a) 1 mark. (b) 1 mark for $[\text{H}^+]$; 1 mark for pH. Allow 2.8.

Question 4 Hydrocyanic acid buffer (2 marks)

$\text{pH} = 9.31 + \log(0.10 \div 0.40) = 9.31 - 0.60 = \mathbf{8.71}$.

Marking: 1 mark for the correct ratio $[\text{A}^-]/[\text{HA}] = 0.25$; 1 mark for 8.71.

Question 5 Buffer response to alkali (3 marks)

The added OH^- reacts with the weak acid: $\text{CH}_3\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{COO}^- + \text{H}_2\text{O}$. The acid is plentiful so the OH^- is removed almost completely. $[\text{CH}_3\text{COOH}]$ falls and $[\text{CH}_3\text{COO}^-]$ rises only slightly, so the ratio $[\text{A}^-]/[\text{HA}]$ and therefore the pH change very little.

Marking: 1 mark for the equation; 1 mark for the acid removing OH^- ; 1 mark for the ratio changing only slightly.

Question 6 Titration of lactic acid (3 marks)

- a. Equivalence at 20.0 cm³: $n(\text{NaOH}) = 0.0200 \times 0.100 = 2.00 \times 10^{-3} \text{ mol}$, so $c = 2.00 \times 10^{-3} \div 0.0200 = \mathbf{0.100 \text{ mol/dm}^3}$.
- b. At 10.0 cm³ pH = 3.85, so pKa = **3.85** and $K_a = 10^{-3.85} = \mathbf{1.4 \times 10^{-4} \text{ mol/dm}^3}$.

Marking: (a) 1 mark. (b) 1 mark for pKa; 1 mark for Ka.

Question 7 pH at equivalence (2 marks)

At equivalence all the lactic acid has been converted to lactate ions. Lactate is a weak base: it accepts H⁺ from water, forming OH⁻, so the solution is slightly alkaline (pH about 8).

Marking: 1 mark for lactate (conjugate base) present; 1 mark for reaction with water giving OH⁻.

Question 8 Strong against weak acid (2 marks)

HCl is fully ionised so $[\text{H}^+] = 0.10 \text{ mol/dm}^3$. Ethanoic acid is only slightly ionised (about 1 %), so $[\text{H}^+]$ is much smaller ($1.3 \times 10^{-3} \text{ mol/dm}^3$) and its pH is higher.

Marking: 1 mark for complete against partial ionisation; 1 mark for the linked $[\text{H}^+]$ and pH comparison.