

pH & Buffers

AS & A Level

Question Paper 2

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	pH & Buffers
Paper	AS & A Level
Booklet	Question Paper 2

Time allowed: 54 minutes

Score: /40

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Question 1

This question is about acids, bases and buffer solutions.

(a) Ethanoic acid, CH_3COOH , and propanoic acid, $\text{C}_2\text{H}_5\text{COOH}$, are weak Brønsted–Lowry acids.

The acid dissociation constants, K_a , of the two acids are shown below.

Acid	$K_a / \text{mol dm}^{-3}$
CH_3COOH	1.70×10^{-5}
$\text{C}_2\text{H}_5\text{COOH}$	1.30×10^{-5}

(i) Explain the term *weak acid*. [1]

(ii) Write the expression for the acid dissociation constant, K_a , of ethanoic acid. [1]

(iii) Calculate the pH of a $2.85 \times 10^{-2} \text{ mol dm}^{-3}$ solution of $\text{C}_2\text{H}_5\text{COOH}$.

Give your answer to **two** decimal places. [2]

(iv) Ethanoic acid is mixed with propanoic acid. An acid–base equilibrium is set up.

Complete the equation for the equilibrium.

Label the conjugate acid–base pairs using the labels **acid 1**, **base 1**, **acid 2**, **base 2**.



(b) Barium hydroxide, $\text{Ba}(\text{OH})_2$, is a strong Brønsted–Lowry base.

A student prepares 250.0 cm^3 of $0.1250 \text{ mol dm}^{-3}$ barium hydroxide.

(i) Explain what is meant by the term *Brønsted–Lowry base*. [1]

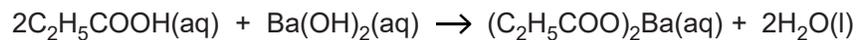
(ii) Calculate the mass of $\text{Ba}(\text{OH})_2$ that the student would need to weigh on a **two** decimal place balance to prepare 250.0 cm^3 of $0.1250 \text{ mol dm}^{-3}$ $\text{Ba}(\text{OH})_2$. [3]

(iii) Calculate the pH of a $0.1250 \text{ mol dm}^{-3}$ solution of $\text{Ba}(\text{OH})_2$.

Give your answer to **two** decimal places. [3]

- (c) The student attempts to prepare a buffer solution by mixing 200 cm³ of 0.324 mol dm⁻³ C₂H₅COOH with 100 cm³ of the 0.1250 mol dm⁻³ Ba(OH)₂ prepared in (b).

The equation for the reaction that takes place is shown below.



Explain whether the student was successful in preparing a buffer solution.

Include all reasoning and any relevant calculations.

[4]

- (d) Blood contains a mixture of carbonic acid, H₂CO₃, and hydrogencarbonate ions, HCO₃⁻.

Explain how the carbonic acid–hydrogencarbonate mixture acts as a buffer.



In your answer include the equation for the equilibrium in this buffer solution and explain how this equilibrium system is able to control blood pH.

[5]

[Total: 22 Marks]

A chemist carries out some experiments using nitrous acid, $\text{HNO}_2(\text{aq})$.

HNO_2 is a weak acid with a K_a value of $4.69 \times 10^{-4} \text{ mol dm}^{-3}$ at the temperature of the chemist's experiments.

(a) Write the expression for K_a for $\text{HNO}_2(\text{aq})$. [1]

(b) Calculate the pH of $0.120 \text{ mol dm}^{-3} \text{ HNO}_2(\text{aq})$.

Give your answer to **two** decimal places. [2]

(c) The chemist prepares 1 dm^3 of a buffer solution by mixing 200 cm^3 of $0.200 \text{ mol dm}^{-3} \text{ HNO}_2$ with 800 cm^3 of $0.0625 \text{ mol dm}^{-3}$ sodium nitrite, NaNO_2 .

(i) Calculate the pH of the buffer solution.

Give your answer to **two** decimal places. [4]

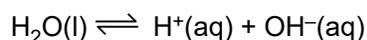
(ii) Explain how this buffer solution controls pH when:

- a small amount of $\text{HCl}(\text{aq})$ is added
- a small amount of $\text{NaOH}(\text{aq})$ is added.



*In your answer, include the equation for the equilibrium in the buffer solution and explain how **this** equilibrium system controls the pH.* [4]

(d) The dissociation of water is shown below.



At 60°C , the ionic product of water, K_w , is $9.311 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$.

At 25°C , the ionic product of water, K_w , is $1.000 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$.

(i) Explain whether the dissociation of water is an exothermic or endothermic process. [1]

(ii) Predict, using a calculation, whether a pH of 7 at 60 °C is neutral, acidic or alkaline. [2]

(iii) pK_w , pK_a and pH are logarithmic scales.

Calculate pK_w at 60 °C.

Give your answer to **two** decimal places. [1]

(iv) 20.0 cm³ of 0.0270 mol dm⁻³ NaOH is diluted with water and the solution made up to 100 cm³ at 60 °C.

Calculate the pH of the diluted solution of NaOH at 60 °C.

Give your answer to **two** decimal places. [3]

[Total: 18 Marks]