

# 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,  $\text{CH}_3\text{COOH}$ , 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	$K_a / \text{mol dm}^{-3}$
$\text{CH}_3\text{COOH}$	$1.70 \times 10^{-5}$
$\text{C}_2\text{H}_5\text{COOH}$	$1.30 \times 10^{-5}$

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

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

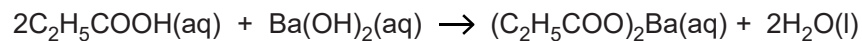
(ii) Calculate the mass of  $\text{Ba}(\text{OH})_2$  that the student would need to weigh on a **two** decimal place balance to prepare  $250.0 \text{ cm}^3$  of  $0.1250 \text{ mol dm}^{-3}$   $\text{Ba}(\text{OH})_2$ . [3]

(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 cm<sup>3</sup> of 0.324 mol dm<sup>-3</sup> C<sub>2</sub>H<sub>5</sub>COOH with 100 cm<sup>3</sup> of the 0.1250 mol dm<sup>-3</sup> Ba(OH)<sub>2</sub> 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, H<sub>2</sub>CO<sub>3</sub>, and hydrogencarbonate ions, HCO<sub>3</sub><sup>-</sup>.

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,  $\text{HNO}_2(\text{aq})$ .

$\text{HNO}_2$  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  $1 \text{ dm}^3$  of a buffer solution by mixing  $200 \text{ cm}^3$  of  $0.200 \text{ mol dm}^{-3} \text{ HNO}_2$  with  $800 \text{ cm}^3$  of  $0.0625 \text{ mol dm}^{-3}$  sodium nitrite,  $\text{NaNO}_2$ .

(i) Calculate the pH of the buffer solution.

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

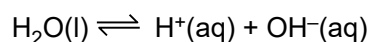
(ii) Explain how this buffer solution controls pH when:

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

At  $25^\circ\text{C}$ , 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 cm<sup>3</sup> of 0.0270 mol dm<sup>-3</sup> NaOH is diluted with water and the solution made up to 100 cm<sup>3</sup> 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]**