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%

This question is about acids, bases and buffer solutions.

(a) Ethanoic acid, CH_3COOH, and propanoic acid, C_2H_5COOH, are weak Brønsted–Lowry acids.

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

Acid	K_a / mol dm^{-3}
CH_3COOH	1.70×10^{-5}
C_2H_5COOH	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 2.85×10^{-2} mol dm^{-3} solution of C_2H_5COOH.

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**.

$C_2H_5COOH + CH_3COOH \rightleftharpoons$ [2]

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

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

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

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

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

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

(c) The student attempts to prepare a buffer solution by mixing 200 cm^3 of 0.324 mol dm^{-3} C_2H_5COOH with 100 cm^3 of the 0.1250 moldm^{-3} $Ba(OH)_2$ prepared in **(b)**.

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

$$2C_2H_5COOH(aq) + Ba(OH)_2(aq) \rightarrow (C_2H_5COO)_2Ba(aq) + 2H_2O(l)$$

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_2CO_3, and hydrogencarbonate ions, HCO_3^-.

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, $HNO_2(aq)$.

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

(a) Write the expression for K_a for $HNO_2(aq)$. [1]

(b) Calculate the pH of 0.120 mol dm^{-3} $HNO_2(aq)$.

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

(c) The chemist prepares 1dm^3 of a buffer solution by mixing 200 cm^3 of 0.200 mol dm^{-3} HNO_2 with 800 cm^3 of 0.0625 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 HCl (aq) is added
- a small amount of NaOH(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.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

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

At 25 °C, the ionic product of water, K_w, is 1.000×10^{-14} mol^2 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 , p*K*a and pH are logarithmic scales.

Calculate pK_w at 60 °C.

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

(iv) 20.0 cm^3 of 0.0270 mol dm^{-3} NaOH is diluted with water and the solution made up to 100 cm^3 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]