# pH & Buffers
# AS & A Level

## Question Paper 1

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|---|---|
| Level | A Level |
| Subject | Chemistry |
| Exam Board | OCR |
| Module | Physical Chemistry & Transition Elements |
| Topic | pH & Buffers |
| Paper | AS & A Level |
| Booklet | Question Paper 1 |

**Time allowed:** **66 minutes**

**Score:** **/49**

**Percentage:** **/100**

**Grade Boundaries:**

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

Butanoic acid, $CH_3(CH_2)_2COOH$, is the 'butter acid', formed when butter turns rancid and tastes sour. A student prepares an aqueous solution of butanoic acid with a concentration of $0.250\,mol\,dm^{-3}$.

The $K_a$ of butanoic acid is $1.51 \times 10^{-5}\,mol\,dm^{-3}$.

(a) (i) Write the expression for the acid dissociation constant of butanoic acid. [1]

(ii) Calculate the p$K_a$ of butanoic acid. [1]

(iii) Calculate the pH of the $0.250\,mol\,dm^{-3}$ butanoic acid.

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

(b) The student adds aqueous butanoic acid to magnesium.

The student then adds aqueous butanoic acid to aqueous sodium carbonate.

(i) Write the ionic equation for the reaction between aqueous butanoic acid and magnesium. [1]

(ii) Write the ionic equation for the reaction between aqueous butanoic acid and aqueous sodium carbonate. [1]

(c) The student adds 50.0 $cm^3$ of 0.250 mol $dm^{-3}$ butanoic acid to 50.0 $cm^3$ of 0.0500 mol $dm^{-3}$ sodium hydroxide. A buffer solution forms.

(i) Explain why a buffer solution forms. [2]

[5]

(ii) Calculate the pH of the buffer solution.

The $K_a$ of butanoic acid is $1.51 \times 10^{-5}$ mol $dm^{-3}$.

Give your answer to **two** decimal places.

(d) The student adds methanoic acid, HCOOH ($K_a = 1.82 \times 10^{-4}$ mol $dm^{-3}$), to butanoic acid. A reaction takes place to form an equilibrium mixture containing two acid–base pairs.

Complete the equilibrium below and label the conjugate acid–base pairs.

$HCOOH + CH_3(CH_2)_2COOH \rightleftharpoons$ ..... + .....

[2]

[Total16 Marks]

This question looks at acids, bases and buffer solutions.

(a) Nitric acid, $HNO_3$, is a strong Brønsted–Lowry acid.
Nitrous acid, $HNO_2$, is a weak Brønsted–Lowry acid with a $K_a$ value of $4.43 \times 10^{-4}$ mol$dm^{-3}$.

(i) What is the difference between a strong acid and a weak acid? [1]

(ii) What is the expression for the acid dissociation constant, $K_a$, of nitrous acid, $HNO_2$? [1]

(iii) Calculate the pH of 0.375 mol $dm^{-3}$ nitrous acid, $HNO_2$.

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

(iv) A student suggests that an acid–base equilibrium is set up when nitric acid is mixed with nitrous acid.

Complete the equation for the equilibrium that would be set up and label the conjugate acid–base pairs.

$HNO_3$ + $HNO_2$ $\rightleftharpoons$ ..... + .....

[2]

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

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

(ii) Calculate the pH of 0.0400 $mol dm^{-3}$ $Ca(OH)_2$.

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

(c) Aqueous calcium hydroxide is added to nitrous acid, $HNO_2$.

Write the overall equation and the ionic equation for the reaction that takes place. [2]

(d) Carbonic acid, $H_2CO_3$, is a weak Brønsted–Lowry acid formed when carbon dioxide dissolves in water. Healthy blood is buffered to a pH of 7.40. The most important buffer solution in blood is a mixture of carbonic acid and hydrogencarbonate ions, $HCO_3^-$.

(i) Explain how the carbonic acid–hydrogencarbonate mixture acts as a buffer in the control of blood pH.

*In your answer you should explain how equilibrium allows the buffer solution to control the pH.* [5]

(ii) Healthy blood at a pH of 7.40 has a hydrogencarbonate : carbonic acid ratio of 10.5 : 1.
A patient is admitted to hospital. The patient's blood pH is measured as 7.20.

Calculate the hydrogencarbonate : carbonic acid ratio in the patient's blood. [5]

[Total 22 Marks]

This question is about acids and bases found in the home.

(a) Ethanoic acid, $CH_3COOH$, is the acid present in vinegar.

A student carries out an experiment to determine the p$K_a$ value of $CH_3COOH$.

- The concentration of $CH_3COOH$ in the vinegar is $0.870\,mol\,dm^{-3}$.
- The pH of the vinegar is 2.41.

**(i)** Write the expression for the acid dissociation constant, $K_a$, of $CH_3COOH$.

**[1]**

**(ii)** Calculate the p$K_a$ value of $CH_3COOH$.

Give your answer to **two** decimal places.

**[3]**

**(iii)** Determine the percentage dissociation of ethanoic acid in the vinegar.

Give your answer to **three** significant figures.

**[1]**

(b) Many solid drain cleaners are based on sodium hydroxide, NaOH.

- A student dissolves 1.26 g of a drain cleaner in water and makes up the solution to 100.0 $cm^3$.
- The student measures the pH of this solution as 13.48.

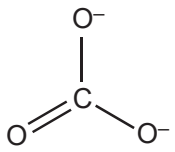
Determine the percentage, by mass, of NaOH in the drain cleaner.

Give your answer to **three** significant figures.

**[4]**

**(c)** Sodium carbonate, $Na_2CO_3$, is a base used in washing soda.

$Na_2CO_3$ contains the carbonate ion, $CO_3^{2-}$, shown below.




Draw the '*dot-and-cross*' diagram for the carbonate ion.

Show outer electrons only and use different symbols for electrons from C and O, and any 'extra' electrons.

**[2]**

**(Total 11 marks)**