CHAPTER 21 ACIDS, BASES & BUFFERS

1 In this question give all values of pH to 2 decimal places.

The acid dissociation constant, K_a, for propanoic acid has the value 1.35×10^{-5} mol dm^{-3} at 25 °C.

$$K_a = \frac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$$

(a) Calculate the pH of a 0.169 mol dm^{-3} solution of propanoic acid.

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(3 marks)

(b) A buffer solution contains 0.250 mol of propanoic acid and 0.190 mol of sodium propanoate in 1000 cm^3 of solution.

A 0.015 mol sample of solid sodium hydroxide is then added to this buffer solution.

(i) Write an equation for the reaction of propanoic acid with sodium hydroxide.

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(ii) Calculate the number of moles of propanoic acid and of propanoate ions present in the buffer solution after the addition of the sodium hydroxide.

Moles of propanoic acid present .....

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Moles of propanoate ions present .....

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(iii) Hence, calculate the pH of the buffer solution after the addition of the sodium hydroxide.

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(6 marks)

2 In this question, give all values of pH to 2 decimal places.

(a) The ionic product of water has the symbol K_w

(i) Write an expression for the ionic product of water.

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(1 mark)

(ii) At 42 °C, the value of K_w is 3.46×10^{-14} mol^2 dm^{-6}.

Calculate the pH of pure water at this temperature.

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(2 marks)

(iii) At 75 °C, a 0.0470 mol dm^{-3} solution of sodium hydroxide has a pH of 11.36

Calculate a value for K_w at this temperature.

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(2 marks)

(b) Methanoic acid (HCOOH) dissociates slightly in aqueous solution.

(i) Write an equation for this dissociation.

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(1 mark)

(ii) Write an expression for the acid dissociation constant K_a for methanoic acid.

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(1 mark)

(iii) The value of K_a for methanoic acid is 1.78×10^{-4} mol dm^{-3} at 25 °C.

Calculate the pH of a 0.0560 mol dm^{-3} solution of methanoic acid.

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(3 marks)

(iv) The dissociation of methanoic acid in aqueous solution is endothermic.

Deduce whether the pH of a solution of methanoic acid will increase, decrease or stay the same if the solution is heated. Explain your answer.

Effect on pH .....

Explanation .....

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(3 marks)

(c) The value of K_a for methanoic acid is 1.78×10^{-4} mol dm^{-3} at 25 °C.
A buffer solution is prepared containing 2.35×10^{-2} mol of methanoic acid and 1.84×10^{-2} mol of sodium methanoate in 1.00 dm^3 of solution.

(i) Calculate the pH of this buffer solution at 25 °C.

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(ii) A 5.00 cm^3 sample of 0.100 mol dm^{-3} hydrochloric acid is added to the buffer solution in part **(c) (i)**.

Calculate the pH of the buffer solution after this addition.

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(4 marks)

3 In this question give all values of pH to 2 decimal places.

(a) The dissociation of water can be represented by the following equilibrium.

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

(i) Write an expression for the ionic product of water, K_w

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(ii) The pH of a sample of pure water is 6.63 at 50 °C.

Calculate the concentration in mol dm^{-3} of H^+ ions in this sample of pure water.

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(iii) Deduce the concentration in mol dm^{-3} of OH^- ions in this sample of pure water.

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(iv) Calculate the value of K_w at this temperature.

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(4 marks)

(b) At 25 °C the value of K_w is 1.00×10^{-14} mol^2 dm^{-6}.

Calculate the pH of a 0.136 mol dm^{-3} solution of KOH at 25 °C.

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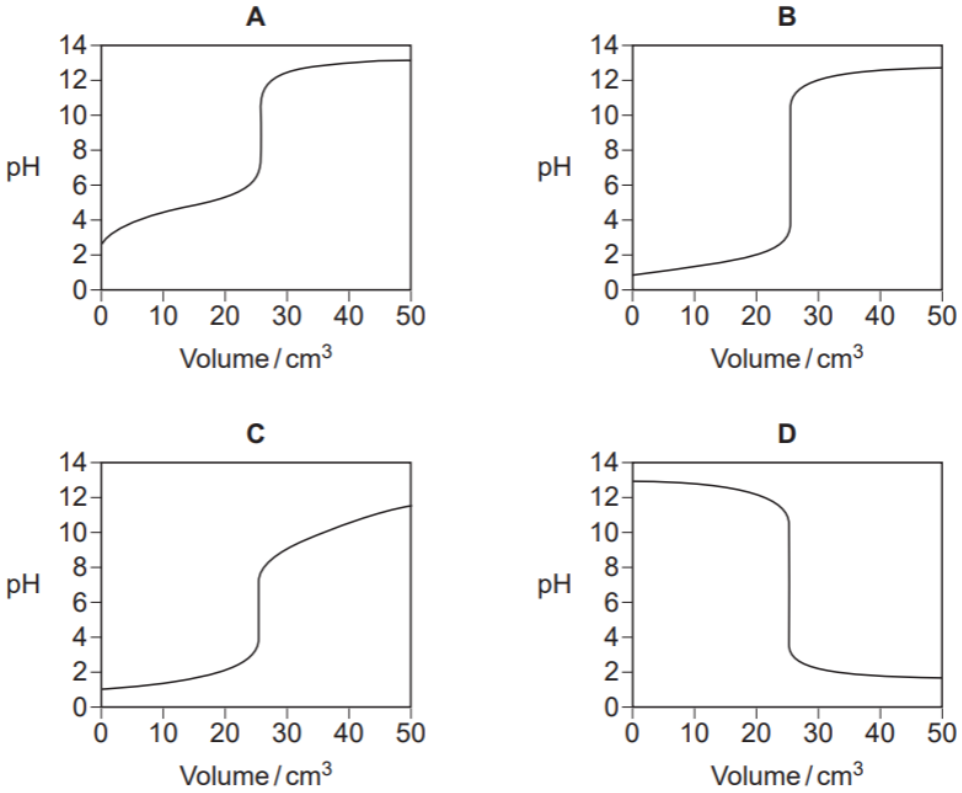
(2 marks)

4 Titration curves labelled **A**, **B**, **C** and **D** for combinations of different aqueous solutions of acids and bases are shown below.
All solutions have a concentration of 0.1 mol dm^{-3}.



(a) In this part of the question write the appropriate letter in each box.

From the curves **A**, **B**, **C** and **D**, choose the curve produced by the addition of

ammonia to 25 cm^3 of hydrochloric acid ☐

sodium hydroxide to 25 cm^3 of ethanoic acid ☐

nitric acid to 25 cm^3 of potassium hydroxide ☐

(3 marks)

(b) A table of acid–base indicators is shown below.
The pH ranges over which the indicators change colour and their colours in acid and alkali are also shown.

Indicator	pH range	Colour in acid	Colour in alkali
Trapaeolin	1.3 – 3.0	red	yellow
Bromocresol green	3.8 – 5.4	yellow	blue
Cresol purple	7.6 – 9.2	yellow	purple
Alizarin yellow	10.1 – 12.0	yellow	orange

(i) Select from the table an indicator that could be used in the titration that produces curve **B** but **not** in the titration that produces curve **A**.

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(1 mark)

(ii) Give the colour change at the end point of the titration that produces curve **D** when cresol purple is used as the indicator.

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(1 mark)