Q1. The acid dissociation constant, K_a, for ethanoic acid is given by the expression

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

The value of K_a for ethanoic acid is 1.74×10^{-5} mol dm^{-3} at 25 °C.

(a) A buffer solution is prepared using ethanoic acid and sodium ethanoate. In the buffer solution, the concentration of ethanoic acid is 0.186 mol dm^{-3} and the concentration of sodium ethanoate is 0.105 mol dm^{-3}.

Calculate the pH of this buffer solution.
Give your answer to 2 decimal places.

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(3)

(b) In a different buffer solution, the concentration of ethanoic acid is 0.251 mol dm^{-3} and the concentration of sodium ethanoate is 0.140 mol dm^{-3}.

A sample of hydrochloric acid containing 0.015 mol of HCl is added to 1000 cm^3 of this buffer solution.

Calculate the pH of the buffer solution after the hydrochloric acid has been added.
You should ignore any change in total volume.
Give your answer to 2 decimal places.

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(5)
(Total 8 marks)

Q2. A solution of chlorine in water is acidic. Swimming pool managers maintain pool water at a constant pH by using a buffer. They do so by adding sodium hydrogencarbonate and sodium carbonate.

(a) Hydrogen carbonate ions (HCO_3^-) act as a weak acid in aqueous solution. Write an equation for this equilibrium.

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(b) Use the equation in part (a) to explain how a solution containing sodium hydrogencarbonate and sodium carbonate can act as a buffer when small amounts of acid or small amounts of alkali are added.

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(Total 4 marks)

Q3. When 1.00 mol dm^{-3} solutions of salicylic acid and sodium hydroxide are mixed a buffer solution can be formed. Salicylic acid is a monoprotic acid that can be represented by the formula HA.

(a) Select a mixture from the table below that would produce a buffer solution. Give a reason for your choice.

Mixture	Volume of 1.00 mol dm^{-3} salicylic acid solution / cm^3	Volume of 1.00 mol dm^{-3} sodium hydroxide solution / cm^3
X	25	75
Y	50	50
Z	75	25

Mixture .....

Reason .....

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(2)

(b) Another mixture, formed by adding 50 cm^3 of 1.00 mol dm^{-3} salicylic acid solution to 25 cm^3 of 1.00 mol dm^{-3} sodium hydroxide solution, can be used to determine the pK_a of salicylic acid. State **one** measurement that must be made for this mixture and explain how this measurement can be used to determine the pK_a of salicylic acid.

Measurement .....

Explanation .....

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(3)

(Total 5 marks)

Q4. This question is about alkalis and carboxylic acids.

In this question, all data are quoted at 25 °C.

(a) Carboxylic acids are weak acids.

State the meaning of the term **weak** as applied to carboxylic acids.

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(b) Write an equation for the reaction of propanoic acid with sodium carbonate.

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(c) Calculate the pH of a 0.0120 mol dm^{-3} solution of calcium hydroxide.
The ionic product of water $K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}.
Give your answer to 2 decimal places.

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(d) The value of the acid dissociation constant K_a for benzenecarboxylic acid (C_6H_5COOH) is 6.31×10^{-5} mol dm^{-3}.

(i) Write an expression for the acid dissociation constant K_a for benzenecarboxylic acid.

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(ii) Calculate the pH of a 0.0120 mol dm^{-3} solution of benzenecarboxylic acid. Give your answer to 2 decimal places.

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(iii) A buffer solution with a pH of 4.00 is made using benzenecarboxylic acid and sodium benzenecarboxylate.

Calculate the mass of sodium benzenecarboxylate (M_r = 144.0) that should be dissolved in 1.00 dm^3 of a 0.0120 mol dm^{-3} solution of benzenecarboxylic acid to produce a buffer solution with a pH of 4.00

The value of the acid dissociation constant K_a for benzenecarboxylic acid (C_6H_5COOH) is 6.31×10^{-5} mol dm^{-3}.

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(5)

(e) Two solutions, one with a pH of 4.00 and the other with a pH of 9.00, were left open to the air.

The pH of the pH 9.00 solution changed more than that of the other solution.

Suggest what substance might be present in the air to cause the pH to change. Explain how and why the pH of the pH 9.00 solution changes.

Substance present in air .....

Explanation .....

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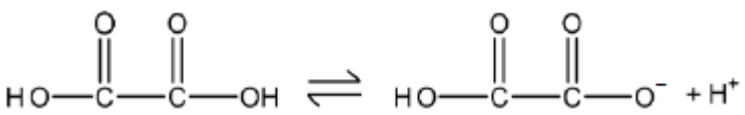
(3)
(Total 17 marks)

Q5. Ethanedioic acid is a weak acid.

Ethanedioic acid acts, initially, as a monoprotic acid.



(a) Use the concept of electronegativity to justify why the acid strengths of ethanedioic

acid and ethanoic acid are different.

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(6)

(b) A buffer solution is made by adding 6.00×10^{-2} mol of sodium hydroxide to a solution containing 1.00×10^{-1} mol of ethanedioic acid ($H_2C_2O_4$).
Assume that the sodium hydroxide reacts as shown in the following equation and that in this buffer solution, the ethanedioic acid behaves as a monoprotic acid.

$$H_2C_2O_4(aq) + OH^-(aq) \longrightarrow HC_2O_4^-(aq) + H_2O(l)$$

The dissociation constant K_a for ethanedioic acid is 5.89×10^{-2} mol dm^{-3}.

Calculate a value for the pH of the buffer solution.
Give your answer to the appropriate number of significant figures.

pH = ...

(5)

(c) In a titration, the end point was reached when 25.0 cm^3 of an acidified solution containing ethanedioic acid reacted with 20.20 cm^3 of 2.00×10^{-2} mol dm^{-3} potassium manganate(VII) solution.

Deduce an equation for the reaction that occurs and use it to calculate the original concentration of the ethanedioic acid solution.

Equation .....

Calculation

Original concentration = ... mol dm^{-3}

(4)
(Total 15 marks)