Q1. This question involves calculations about two strong acids and one weak acid.
All measurements were carried out at 25 °C.

(a) A 25.0 cm^3 sample of 0.0850 mol dm^{-3} hydrochloric acid was placed in a beaker and 100 cm^3 of distilled water were added.
Calculate the pH of the new solution formed.
Give your answer to 2 decimal places.

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(2)

(b) HX is a weak monobasic acid.

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

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(ii) The pH of a 0.0850 mol dm^{-3} solution of HX is 2.79
Calculate a value for the acid dissociation constant, K_a, of this acid.
Give your answer to 3 significant figures.

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(c) A 25.0 cm^3 sample of 0.620 mol dm^{-3} nitric acid was placed in a beaker and 38.2 cm^3 of 0.550 mol dm^{-3} aqueous sodium hydroxide were added.
Calculate the pH of the solution formed.
Give your answer to 2 decimal places.

The ionic product of water $K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C.

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(Total 12 marks)

Q2. This question is about the pH of some solutions containing potassium hydroxide and ethanoic acid.

Give all values of pH to 2 decimal places.

(a) (i) Write an expression for pH.

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(1)

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

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(1)

(iii) At 10 °C, a 0.154 mol dm^{-3} solution of potassium hydroxide has a pH of 13.72. Calculate the value of K_w at 10 °C.

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(b) At 25 °C, the acid dissociation constant K_a for ethanoic acid has the value 1.75×10^{-5} mol dm^{-3}.

(i) Write an expression for K_a for ethanoic acid.

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(ii) Calculate the pH of a 0.154 mol dm^{-3} solution of ethanoic acid at 25 °C.

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(3)

(c) At 25 °C, the acid dissociation constant K_a for ethanoic acid has the value 1.75×10^{-5} mol dm^{-3}.

(i) Calculate the pH of the solution formed when 10.0 cm^3 of 0.154 mol dm^{-3} potassium hydroxide are added to 20.0 cm^3 of 0.154 mol dm^{-3} ethanoic acid at 25 °C.

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(ii) Calculate the pH of the solution formed when 40.0 cm^3 of 0.154 mol dm^{-3} potassium hydroxide are added to 20.0 cm^3 of 0.154 mol dm^{-3} ethanoic acid at 25 °C.

At 25 °C, K_w has the value 1.00×10^{-14} mol^2 dm^{-6}.

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(Total 16 marks)

Q3. Iron(II) sulfate is used to kill weeds in garden lawns. It is a by-product of the manufacture of steel.
When a lawn is treated with iron(II) sulfate, the iron(II) ions are oxidised to form iron(III) ions.

Iron(III) ions are acidic in aqueous solution as shown by the following equation.

$$[Fe(H_2O)_6]^{3+}(aq) \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+}(aq) + H^+(aq)$$

In an experiment, a calibrated pH meter was used to measure the pH of an iron(III) salt in solution. At 20 °C the pH of a 0.100 mol dm^{-3} solution of iron(III) sulfate was found to be 1.62.

(a) Explain briefly why a pH meter should be calibrated before use.

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(b) Write an expression for the equilibrium constant, K_a, for the dissociation of iron(III) ions in aqueous solution.

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(1)

(c) Use your answer from part (b) to calculate the value of K_a for this reaction at 20 °C. Give your answer to the appropriate precision. Show your working.

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(d) Name the substance that is most likely to oxidise the iron(II) ions when iron(II) sulfate is used as a weed killer.

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(1)

(e) Suggest a value for the pH of a 0.100 mol dm^{-3} solution of iron(II) sulfate.

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(1)

(Total 8 marks)

Q4. This question is about the pH of several solutions.

Give all values of pH to 2 decimal places.

(a) (i) Write an expression for pH.

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(1)

(ii) Calculate the pH of 0.154 mol dm^{-3} hydrochloric acid.

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(1)

(iii) Calculate the pH of the solution formed when 10.0 cm^3 of 0.154 mol dm^{-3} hydrochloric acid are added to 990 cm^3 of water.

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(b) The acid dissociation constant, K_a, for the weak acid HX has the value 4.83×10^{-5} mol dm^{-3} at 25 °C.
A solution of HX has a pH of 2.48

Calculate the concentration of HX in the solution.

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(c) Explain why the pH of an acidic buffer solution remains almost constant despite the

addition of a small amount of sodium hydroxide.

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

A buffer solution was prepared by dissolving 0.0236 mol of the salt NaY in 50.0 cm^3 of a 0.428 mol dm^{-3} solution of the weak acid HY

(i) Calculate the pH of this buffer solution.

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(ii) A 5.00×10^{-4} mol sample of sodium hydroxide was added to this buffer solution.

Calculate the pH of the buffer solution after the sodium hydroxide was added.

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(Total 18 marks)