3 This question is about Brønsted–Lowry acids of different strengths.

3 (a) State the meaning of the term *Brønsted–Lowry acid*.

.....

(1 mark)

3 (b) (i) Write an expression for the acid dissociation constant K_a for ethanoic acid.

.....

.....

(1 mark)

3 (b) (ii) The value of K_a for ethanoic acid is 1.75×10^{-5} mol dm^{-3} at 25 °C.

Calculate the concentration of ethanoic acid in a solution of the acid that has a pH of 2.69

.....

.....

.....

.....

.....

.....

(4 marks)

3 (c) The value of K_a for chloroethanoic acid ($ClCH_2COOH$) is 1.38×10^{-3} mol dm^{-3} at 25 °C.

3 (c) (i) Write an equation for the dissociation of chloroethanoic acid in aqueous solution.

.....

(1 mark)

3 (c) (ii) Suggest why chloroethanoic acid is a stronger acid than ethanoic acid.

.....

.....

.....

.....

.....

(2 marks)

3 (d) **P** and **Q** are acids. **X** and **Y** are bases. The table shows the strength of each acid and base.

Acids		Bases	
strong	weak	strong	weak
P	**Q**	**X**	**Y**

The two acids were titrated separately with the two bases using methyl orange as indicator.
The titrations were then repeated using phenolphthalein as indicator.
The pH range for methyl orange is 3.1–4.4
The pH range for phenolphthalein is 8.3–10.0

For each of the following titrations, select the letter, **A**, **B**, **C**, or **D**, for the correct statement about the indicator(s) that would give a precise end-point.
Write your answer in the box provided.

A Both indicators give a precise end-point.

B **Only** methyl orange gives a precise end-point.

C **Only** phenolphthalein gives a precise end-point.

D Neither indicator gives a precise end-point.

3 (d) (i) Acid **P** with base **X**

(1 mark)

3 (d) (ii) Acid **Q** with base **X**

(1 mark)

3 (d) (iii) Acid **Q** with base **Y**

(1 mark)

Question 3 continues on the next page

3 (e) Using a burette, 26.40 cm^3 of 0.550 mol dm^{-3} sulfuric acid were added to a conical flask containing 19.60 cm^3 of 0.720 mol dm^{-3} aqueous sodium hydroxide.
Assume that the sulfuric acid is fully dissociated.

Calculate the pH of the solution formed.

Give your answer to 2 decimal places.

.....

.....

.....

.....

.....

.....

.....

.....

(6 marks)

(Extra space) .....

.....

.....

18

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

4 (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.

.....

.....

.....

.....

(2 marks)

(Extra space) .....

.....

4 (b) HX is a weak monobasic acid.

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

.....

.....

(1 mark)

4 (b) (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.

.....

.....

.....

.....

.....

.....

(3 marks)

(Extra space) .....

.....

.....

4 (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.

(6 marks)

(Extra space)

12