

**Q1.**

This question is about acids.

Hydrogen chloride and ethanoic acid both dissolve in water.

All hydrogen chloride molecules ionise in water.

Approximately 1% of ethanoic acid molecules ionise in water.

- (a) A solution is made by dissolving 1 g of hydrogen chloride in 1 dm<sup>3</sup> of water.

Which is the correct description of this solution?

Tick (✓) **one** box.

A concentrated solution of a strong acid

A concentrated solution of a weak acid

A dilute solution of a strong acid

A dilute solution of a weak acid

(1)

- (b) Which solution would have the lowest pH?

Tick (✓) **one** box.

0.1 mol/dm<sup>3</sup> ethanoic acid solution

0.1 mol/dm<sup>3</sup> hydrogen chloride solution

1.0 mol/dm<sup>3</sup> ethanoic acid solution

1.0 mol/dm<sup>3</sup> hydrogen chloride solution

(1)

A student investigated the concentration of a solution of sodium hydroxide by titration with a 0.0480 mol/dm<sup>3</sup> ethanedioic acid solution.

This is the method used.

1. Measure 25.0 cm<sup>3</sup> of the sodium hydroxide solution into a conical flask using a 25.0 cm<sup>3</sup> pipette.
  2. Add two drops of indicator to the sodium hydroxide solution.
  3. Fill a burette with the 0.0480 mol/dm<sup>3</sup> ethanedioic acid solution to the 0.00 cm<sup>3</sup> mark.
  4. Add the ethanedioic acid solution to the sodium hydroxide solution until the indicator changes colour.
  5. Read the burette to find the volume of the ethanedioic acid solution used.
- (c) Suggest **two** improvements to the method that would increase the accuracy of the result.

1 \_\_\_\_\_  
\_\_\_\_\_

2 \_\_\_\_\_  
\_\_\_\_\_

(2)

- (d) Ethanedioic acid is a solid at room temperature.

Calculate the mass of ethanedioic acid (H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>) needed to make 250 cm<sup>3</sup> of a solution with concentration 0.0480 mol/dm<sup>3</sup>

Relative formula mass (*M<sub>r</sub>*): H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> = 90

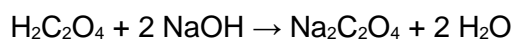
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Mass = \_\_\_\_\_g

(2)

- (e) The student found that 25.0 cm<sup>3</sup> of the sodium hydroxide solution was neutralised by 15.00 cm<sup>3</sup> of the 0.0480 mol/dm<sup>3</sup> ethanedioic acid solution.

The equation for the reaction is:



Calculate the concentration of the sodium hydroxide solution in mol/dm<sup>3</sup>

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Concentration = \_\_\_\_\_ mol/dm<sup>3</sup>

(3)

(Total 9 marks)

**Q2.**

This question is about citric acid (C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>).

Citric acid is a solid.

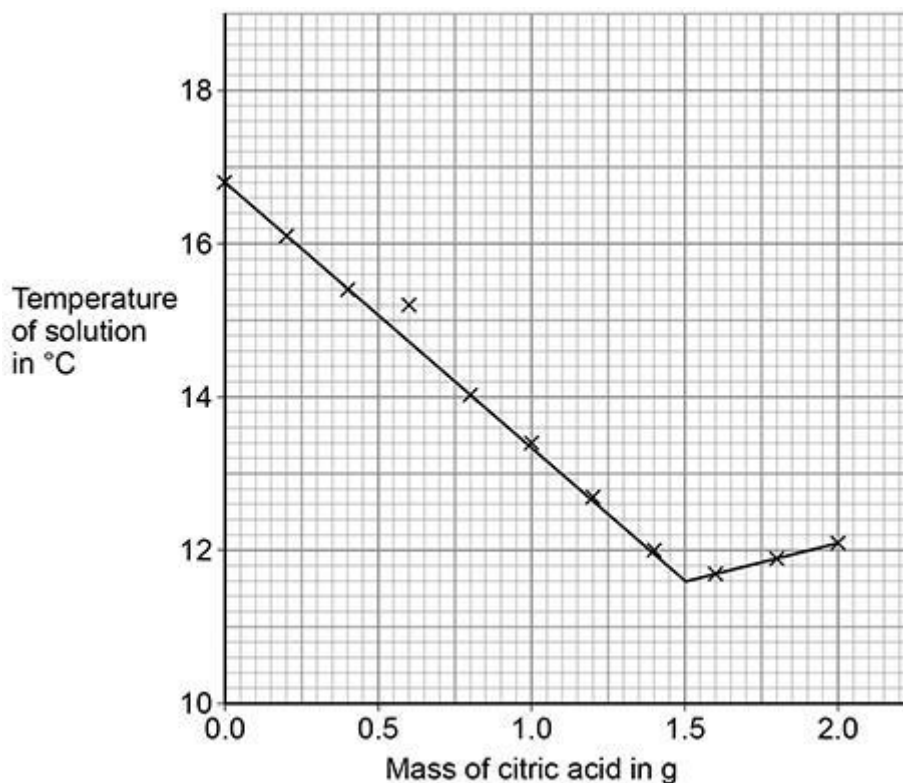
A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

This is the method used.

1. Pour 25 cm<sup>3</sup> of sodium hydrogencarbonate solution into a polystyrene cup.
2. Measure the temperature of the sodium hydrogencarbonate solution.
3. Add 0.20 g of citric acid to the polystyrene cup.
4. Stir the solution.
5. Measure the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added.

The student plotted the results on a graph.

The student's graph is shown below.



- (a) The graph shows an anomalous point when 0.60 g of citric acid was added. This was caused by the student making an error.

The student correctly:

- measured the mass of the citric acid
- read the thermometer
- plotted the point.

Suggest **one** reason for the anomalous point.

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(1)

- (b) Explain the shape of the graph in terms of the energy transfers taking place.

You should use data from the graph above in your answer.

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(3)

- (c) A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were the same size and shape.

Sketch a line on above graph to show the second student's results until 1.00 g of citric acid had been added. The starting temperature of the solution was the same.

Explain your answer.

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(3)

The student used a solution of citric acid to determine the concentration of a solution of sodium hydroxide by titration.

- (d) The student made 250 cm<sup>3</sup> of a solution of citric acid of concentration 0.0500 mol/dm<sup>3</sup>

Calculate the mass of citric acid (C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>) required.

Relative atomic masses (*A<sub>r</sub>*): H = 1 C = 12 O = 16

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Mass = \_\_\_\_\_ g

(3)

This is part of the method the student used for the titration.

1. Measure 25.0 cm<sup>3</sup> of the sodium hydroxide solution into a conical flask using a pipette.
2. Add a few drops of indicator to the flask.
3. Fill a burette with citric acid solution.

- (e) Describe how the student would complete the titration.

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**(3)**

(f) Give **two** reasons why a burette is used for the citric acid solution.

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2 \_\_\_\_\_

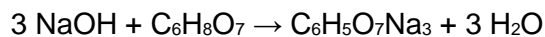
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**(2)**

(g) 13.3 cm<sup>3</sup> of 0.0500 mol/dm<sup>3</sup> citric acid solution was needed to neutralise 25.0 cm<sup>3</sup> of sodium hydroxide solution.

The equation for the reaction is:



Calculate the concentration of the sodium hydroxide solution in mol/dm<sup>3</sup>

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Concentration = \_\_\_\_\_ mol/dm<sup>3</sup>

**(3)****(Total 18 marks)****Q3.**

A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm<sup>3</sup> potassium hydroxide solution into a polystyrene cup.
2. Record the temperature of the solution.
3. Add 2.0 cm<sup>3</sup> dilute sulfuric acid.
4. Stir the solution.
5. Record the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 20.0 cm<sup>3</sup> dilute sulfuric acid has been added.

- (a) Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

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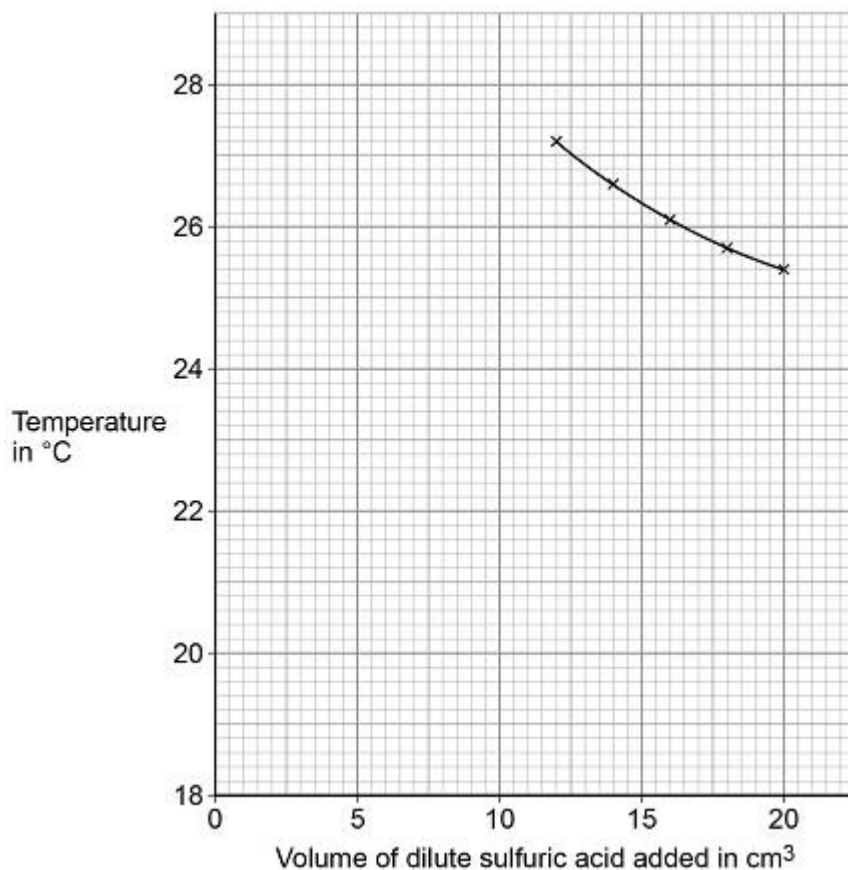
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(2)

The following table shows some of the student's results.

Volume of dilute sulfuric acid added in cm <sup>3</sup>	Temperature in °C
0.0	18.9
2.0	21.7
4.0	23.6
6.0	25.0
8.0	26.1
10.0	27.1

The figure below shows some of the data from the investigation.



(b) Complete the figure:

- plot the data from the table
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

(4)

(c) Determine the volume of dilute sulfuric acid needed to react completely with 25.0 cm<sup>3</sup> of the potassium hydroxide solution.

Use the figure above.

Volume of dilute sulfuric acid to react completely =  
\_\_\_\_\_ cm<sup>3</sup>

(1)

(d) Determine the overall temperature change when the reaction is complete.

Use the figure above.

\_\_\_\_\_

\_\_\_\_\_

Overall temperature change = \_\_\_\_\_ °C

(1)

(e) The student repeated the investigation.





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(2)

(b) A  $1.0 \times 10^{-3}$  mol/dm<sup>3</sup> solution of hydrochloric acid has a pH of 3.0

What is the pH of a  $1.0 \times 10^{-5}$  mol/dm<sup>3</sup> solution of hydrochloric acid?

pH = \_\_\_\_\_

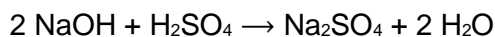
(1)

A student titrated 25.0 cm<sup>3</sup> portions of dilute sulfuric acid with a 0.105 mol/dm<sup>3</sup> sodium hydroxide solution.

(c) The table below shows the student's results.

	<b>Titration 1</b>	<b>Titration 2</b>	<b>Titration 3</b>	<b>Titration 4</b>	<b>Titration 5</b>
Volume of sodium hydroxide solution in cm <sup>3</sup>	23.50	21.10	22.10	22.15	22.15

The equation for the reaction is:



Calculate the concentration of the sulfuric acid in mol/dm<sup>3</sup>

Use only the student's concordant results.

Concordant results are those within 0.10 cm<sup>3</sup> of each other.

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Concentration of sulfuric acid = \_\_\_\_\_ mol/dm<sup>3</sup>

(5)

- (d) Explain why the student should use a pipette to measure the dilute sulfuric acid and a burette to measure the sodium hydroxide solution.

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(2)

- (e) Calculate the mass of sodium hydroxide in 30.0 cm<sup>3</sup> of a 0.105 mol/dm<sup>3</sup> solution.

Relative formula mass ( $M_r$ ): NaOH = 40

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Mass of sodium hydroxide = \_\_\_\_\_ g

(2)

(Total 12 marks)

### Q5.

Citric acid is a weak acid.

- (a) Explain what is meant by a weak acid.

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(2)

A student titrated citric acid with sodium hydroxide solution.

This is the method used.

1. Pipette 25.0 cm<sup>3</sup> of sodium hydroxide solution into a conical flask.

2. Add a few drops of thymol blue indicator to the sodium hydroxide solution.

Thymol blue is blue in alkali and yellow in acid.

3. Add citric acid solution from a burette until the end-point was reached.

(b) Explain what would happen at the end-point of this titration.

Refer to the acid, the alkali and the indicator in your answer.

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(3)

(c) Explain why a pipette is used to measure the sodium hydroxide solution but a burette is used to measure the citric acid solution

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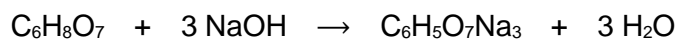
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(2)

(d) The table shows the student's results.

	<b>Titration 1</b>	<b>Titration 2</b>	<b>Titration 3</b>	<b>Titration 4</b>	<b>Titration 5</b>
Volume of citric acid solution in cm <sup>3</sup>	13.50	12.10	11.10	12.15	12.15

The equation for the reaction is:



The concentration of the sodium hydroxide was 0.102 mol / dm<sup>3</sup>

Concordant results are those within 0.10 cm<sup>3</sup> of each other.

Calculate the concentration of the citric acid in mol / dm<sup>3</sup>

Use only the concordant results from the table in your calculation.

You must show your working.

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Concentration = \_\_\_\_\_ mol / dm<sup>3</sup>

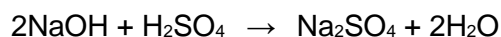
(5)

(Total 12 marks)

**Q6.**

Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:



- (a) Sulfuric acid is a strong acid.

What is meant by a strong acid?

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(2)

- (b) Write the ionic equation for this neutralisation reaction. Include state symbols.

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(2)

- (c) A student used a pipette to add 25.0 cm<sup>3</sup> of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol / dm<sup>3</sup> sulfuric acid needed to neutralise the sodium hydroxide.

Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen.

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**(4)**

- (d) The student carried out five titrations. Her results are shown in the table below.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of 0.100 mol / dm <sup>3</sup> sulfuric acid in cm <sup>3</sup>	27.40	28.15	27.05	27.15	27.15

Concordant results are within 0.10 cm<sup>3</sup> of each other.

Use the student's concordant results to work out the mean volume of 0.100 mol / dm<sup>3</sup> sulfuric acid added.

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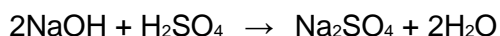
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Mean volume = \_\_\_\_\_ cm<sup>3</sup>

**(2)**

- (e) The equation for the reaction is:



Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

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Concentration = \_\_\_\_\_ mol / dm<sup>3</sup>

(4)

- (f) The student did another experiment using 20 cm<sup>3</sup> of sodium hydroxide solution with a concentration of 0.18 mol / dm<sup>3</sup>.

Relative formula mass ( $M_r$ ) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm<sup>3</sup> of this solution.

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Mass = \_\_\_\_\_ g

(2)

(Total 16 marks)