All questions are for separate science students only

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 dm3 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/dm3 ethanoic acid solution	☐
0.1 mol/dm3 hydrogen chloride solution	☐
1.0 mol/dm3 ethanoic acid solution	☐
1.0 mol/dm3 hydrogen chloride solution	☐

(1)

A student investigated the concentration of a solution of sodium hydroxide by titration with a 0.0480 mol/dm3 ethanedioic acid solution.

This is the method used.

1. Measure 25.0 cm3 of the sodium hydroxide solution into a conical flask using a 25.0 cm3 pipette.

2. Add two drops of indicator to the sodium hydroxide solution.

3. Fill a burette with the 0.0480 mol/dm3 ethanedioic acid solution to the 0.00 cm3 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 _____

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_____

(2)

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

Calculate the mass of ethanedioic acid ($H_2C_2O_4$) needed to make 250 cm3 of a solution with concentration 0.0480 mol/dm3

Relative formula mass (*M*r): $H_2C_2O_4$ = 90

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_____

_____

_____

Mass = _____g

(2)

(e) The student found that 25.0 cm3 of the sodium hydroxide solution was neutralised by 15.00 cm3 of the 0.0480 mol/dm3 ethanedioic acid solution.

The equation for the reaction is:

$$H_2C_2O_4 + 2\ NaOH \rightarrow Na_2C_2O_4 + 2\ H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm3

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_____

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_____

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_____

Concentration = _____ mol/dm3

(3)

(Total 9 marks)

Q2.

This question is about citric acid ($C_6H_8O_7$).

Citric acid is a solid.

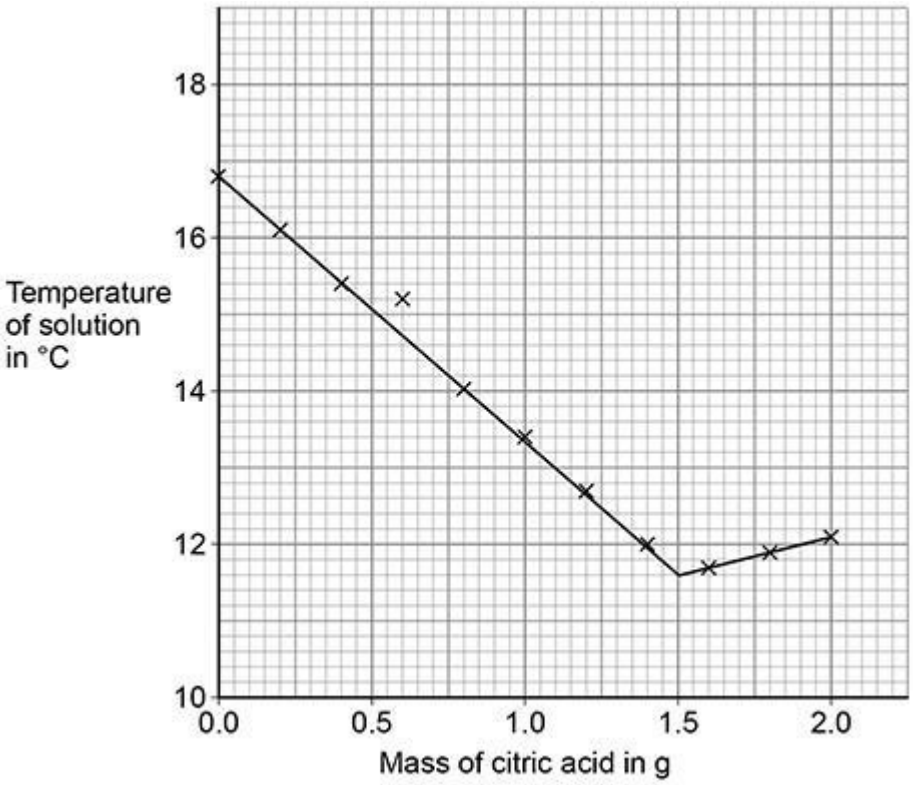
A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

This is the method used.

1. Pour 25 cm3 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.

_____

_____

(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 cm3 of a solution of citric acid of concentration 0.0500 mol/dm3

Calculate the mass of citric acid ($C_6H_8O_7$) required.

Relative atomic masses (*Ar*): H = 1 C = 12 O = 16

_____

_____

_____

_____

_____

Mass = _____ g

(3)

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

1. Measure 25.0 cm3 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.

1 _____

_____ 2

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_____

(2)

(g) 13.3 cm3 of 0.0500 mol/dm3 citric acid solution was needed to neutralise 25.0 cm3 of sodium hydroxide solution.

The equation for the reaction is:

$$3\ NaOH + C_6H_8O_7 \rightarrow C_6H_5O_7Na_3 + 3\ H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm3

_____

_____

_____

_____

_____

_____ Concentration = _____ mol/dm3

(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 cm3 potassium hydroxide solution into a polystyrene cup.

2. Record the temperature of the solution.

3. Add 2.0 cm3 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 cm3 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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_____

_____

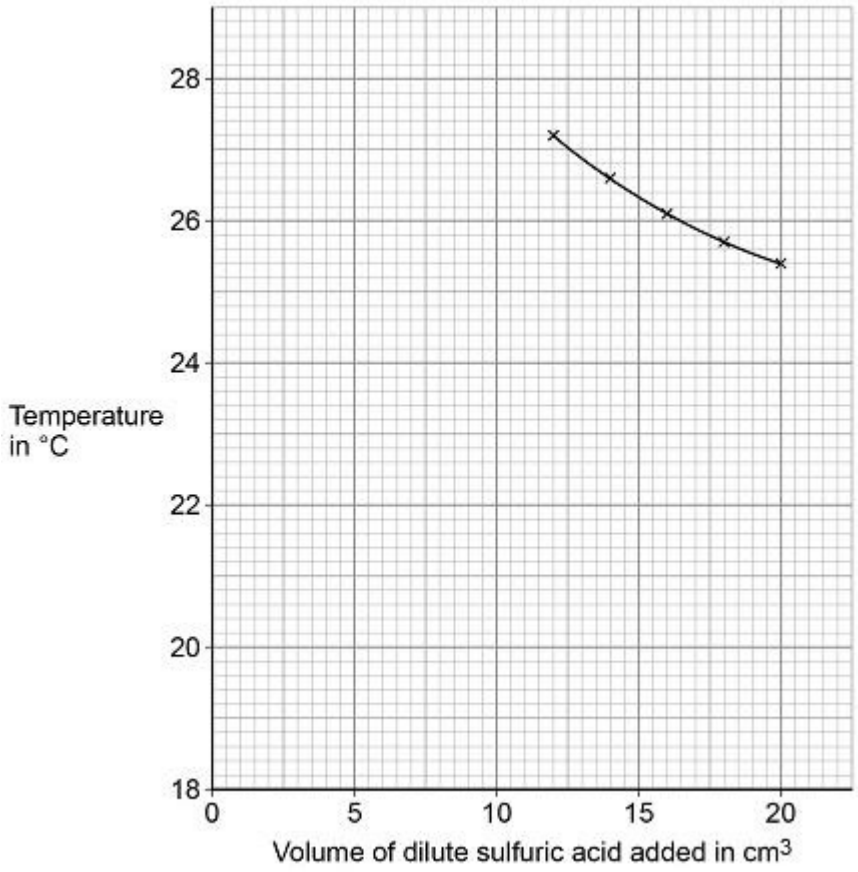
_____

(2)

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

Volume of dilute sulfuric acid added in cm3	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 cm3 of the potassium hydroxide solution.

Use the figure above.

Volume of dilute sulfuric acid to react completely = _____ cm3

(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.

The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm3 of 0.500 mol/dm3 dilute sulfuric acid completely reacted with 25.0 cm3 of potassium hydroxide solution.

The equation for the reaction is:

$$2\ KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\ H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm3 and in g/dm3

Relative atomic masses (*Ar*): H = 1 O = 16 K = 39

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Concentration in mol/dm3 = _____ mol/dm3

Concentration in g/dm3 = _____ g/dm3

(6)

(Total 14 marks)

Q4.

This question is about acids and alkalis.

(a) Dilute hydrochloric acid is a strong acid.

Explain why an acid can be described as both strong and dilute.

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_____

_____

_____

(2)

(b) A 1.0 × 10−3 mol/dm3 solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0 × 10−5 mol/dm3 solution of hydrochloric acid?

pH = _____

(1)

A student titrated 25.0 cm3 portions of dilute sulfuric acid with a 0.105 mol/dm3 sodium hydroxide solution.

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

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of sodium hydroxide solution in cm3	23.50	21.10	22.10	22.15	22.15

The equation for the reaction is:

$$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$$

Calculate the concentration of the sulfuric acid in mol/dm3 Use only the student's concordant results. Concordant results are those within 0.10 cm3 of each other.

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Concentration of sulfuric acid = _____ mol/dm3

(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.

_____

_____

_____

_____

(2)

(e) Calculate the mass of sodium hydroxide in 30.0 cm3 of a 0.105 mol/dm3 solution.

Relative formula mass (*Mr*): NaOH = 40

_____

_____

_____

_____

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 cm3 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.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of citric acid solution in cm3	13.50	12.10	11.10	12.15	12.15

The equation for the reaction is:

$$C_6H_8O_7 + 3\,NaOH \rightarrow C_6H_5O_7Na_3 + 3\,H_2O$$

The concentration of the sodium hydroxide was 0.102 mol / dm3

Concordant results are those within 0.10 cm3 of each other.

Calculate the concentration of the citric acid in mol / dm3
Use only the concordant results from the table in your calculation.
You must show your working.

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Concentration = _____ mol / dm3

(5)

(Total 12 marks)

Q6.

Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(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.

_____

(2)

(c) A student used a pipette to add 25.0 cm3 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 / dm3 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 / dm3 sulfuric acid in cm3	27.40	28.15	27.05	27.15	27.15

Concordant results are within 0.10 cm3 of each other.

Use the student's concordant results to work out the mean volume of 0.100 mol / dm3 sulfuric acid added.

_____

_____

_____

_____

Mean volume = _____ cm3

(2)

(e) The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

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_____

_____

_____

_____

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_____

Concentration = _____ mol / dm3

(4)

(f) The student did another experiment using 20 cm3 of sodium hydroxide solution with a concentration of 0.18 mol / dm3.

Relative formula mass (*Mr*) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm3 of this solution.

_____

_____

_____

_____

Mass = _____ g

(2)

(Total 16 marks)