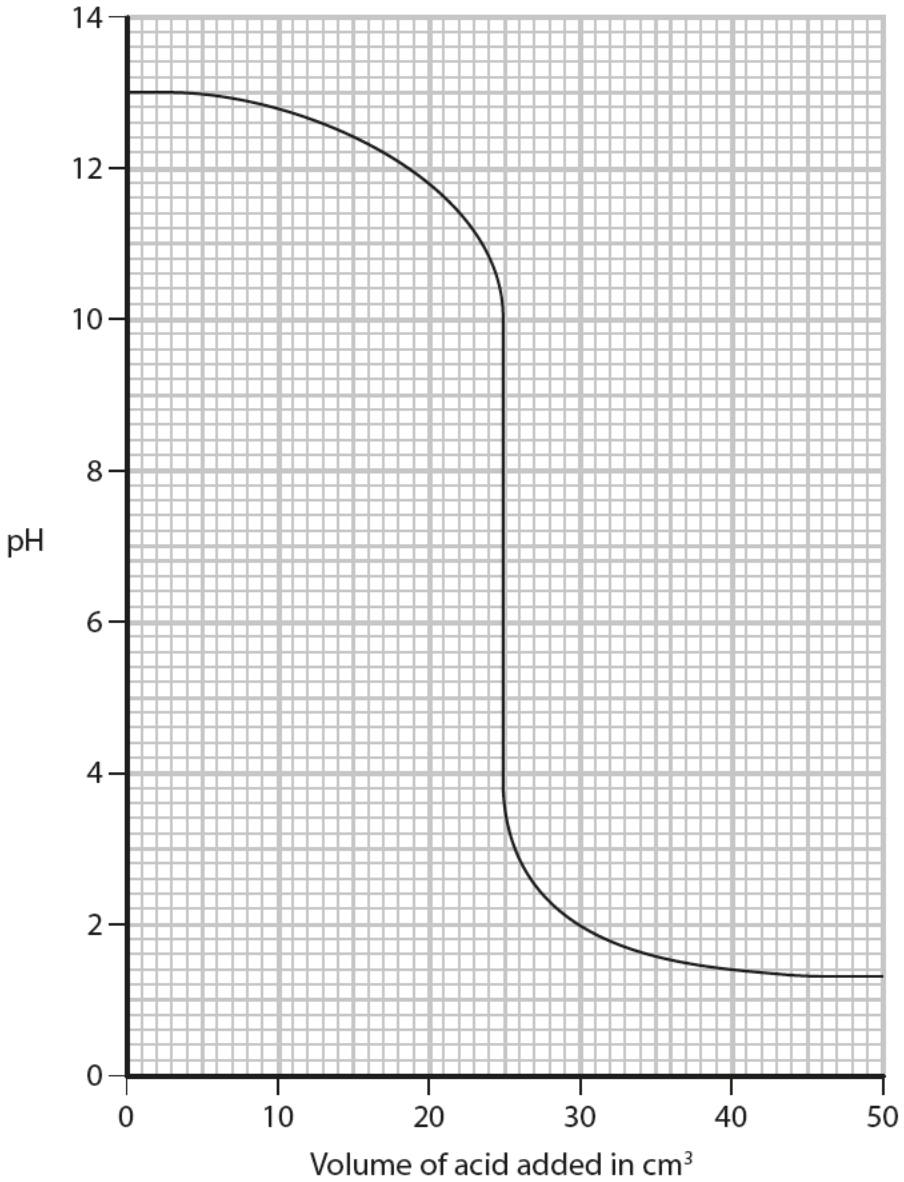
1 A total volume of 50 cm^3 of hydrochloric acid is added gradually to 50 cm^3 of sodium hydroxide solution containing some universal indicator.

The graph shows how the pH of the solution changes as the acid is added.



(a) Use the graph to answer these questions.

(i) What is the pH of the sodium hydroxide solution before any acid is added?

(1)

.....

(ii) What is the pH of the solution after 40 cm^3 of acid is added?

(1)

.....

(iii) What volume of acid is needed to completely neutralise the sodium hydroxide?

(1)

....

(b) The table shows the colour of universal indicator at different pH values.

pH	0–2	3–4	5–6	7	8–9	10–12	13–14
Colour	red	orange	yellow	green	blue	indigo	violet

Complete the table below to show the colour of the solution when the volume of hydrochloric acid added is 20 cm^3 and when the volume added is 35 cm^3.

(2)

Volume of hydrochloric acid added in cm^3	**Colour of solution**
20	
35	

(c) Write a chemical equation for the reaction between sodium hydroxide and hydrochloric acid.

(1)

.....

(Total for Question 1 = 6 marks)

2 (a) A student made a solution of sodium hydroxide by dissolving 10.0 g of solid sodium hydroxide in distilled water to make 250 cm^3 of solution.

(i) Calculate the amount, in moles, of NaOH in 10.0 g of sodium hydroxide.

(3)

amount = ... mol

(ii) Calculate the concentration, in mol/dm^3, of this solution of sodium hydroxide.

(2)

concentration = ... mol/dm^3

(b) (i) The student uses the sodium hydroxide solution to find the concentration of a solution of hydrochloric acid.

He uses this method

- use a pipette to put 25.0 cm^3 of the sodium hydroxide solution into a conical flask
- add a few drops of methyl orange indicator to the solution
- gradually add the hydrochloric acid from a burette until the solution in the flask just changes colour

The diagram shows his burette readings.



Complete the table, giving all values to the nearest 0.05 cm^3.

(3)

burette reading at end in cm^3	
burette reading at start in cm^3	
volume of acid added in cm^3	

(ii) State the colour of the methyl orange at the start and at the end of the experiment.

(2)

colour at start .....

colour at end .....

(iii) Why is a burette used instead of a pipette for adding the acid?

(1)

.....

.....

(c) Sodium hydroxide reacts with carbon dioxide.

The equation for this reaction is

$$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

A solution of sodium hydroxide of concentration 2.00 mol/dm^3 is used.

(i) Calculate the amount, in moles, of sodium hydroxide in 200 cm^3 of this solution.

(2)

amount of sodium hydroxide = ... mol

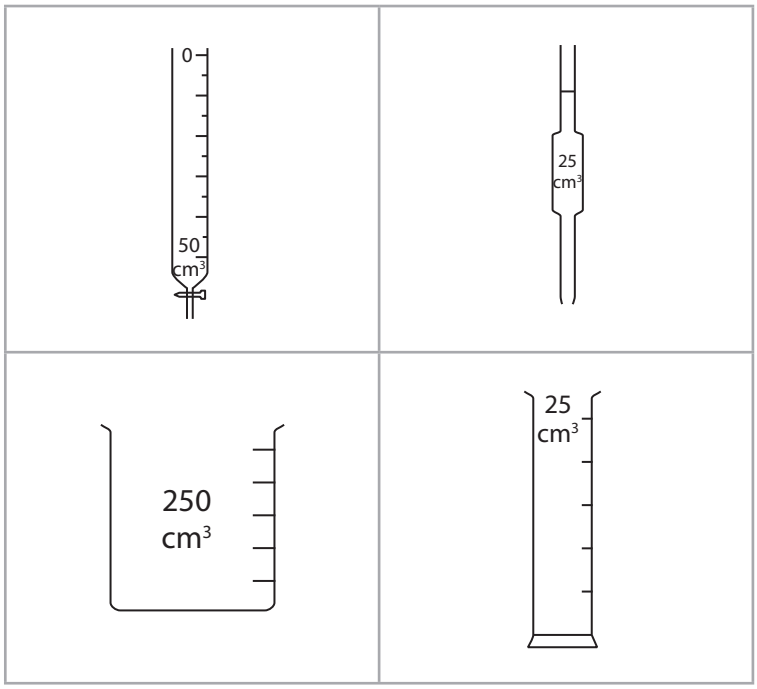
(ii) Deduce the maximum mass, in grams, of carbon dioxide that can react with this solution of sodium hydroxide.

(2)

mass of carbon dioxide = ... g

(Total for Question 2 = 15 marks)

3 The diagram shows some pieces of apparatus used to measure volumes.



A student was given a large bottle containing sodium hydroxide solution and a supply of dilute sulfuric acid of known concentration.

He was allowed to use normal laboratory apparatus, including the pieces of apparatus shown in the diagram.

He was told to plan an experiment to find the concentration of the sodium hydroxide solution.

This is his plan.

Step 1 Obtain about 150 cm^3 of each solution.

Step 2 Use a measuring cylinder to add exactly 25.0 cm^3 of sodium hydroxide solution to a conical flask.

Step 3 Add a few drops of universal indicator to the conical flask.

Step 4 Use a burette to add the sulfuric acid to the conical flask until the indicator changes colour.

(a) (i) Give the name of the most suitable piece of apparatus in the diagram that should be used in Step 1.

(1)

.....

(ii) Give the name of the piece of apparatus in the diagram that should be used instead of a measuring cylinder in Step 2.

(1)

.....

(iii) State why universal indicator is **not** a good choice for this experiment and suggest an indicator that would be more suitable.

(2)

.....

.....

.....

.....

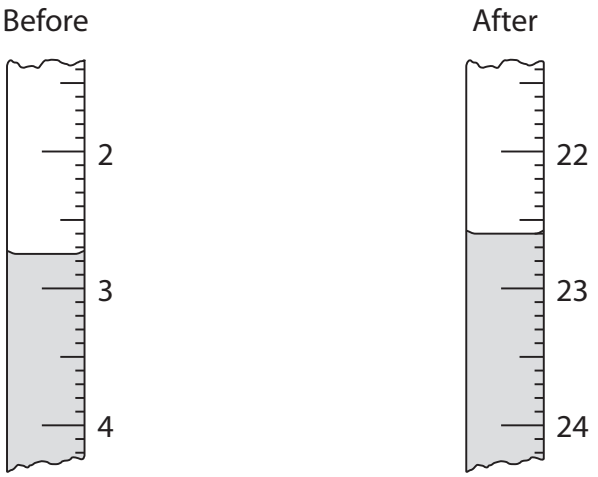
(iv) Why is a pipette not suitable for adding the acid in Step 4?

(1)

.....

.....

(b) The diagram shows the burette readings in one experiment before and after adding the acid.



Use the readings to complete the table, entering all values to the nearest 0.05 cm^3.

(3)

Burette reading after adding acid in cm^3	
Burette reading before adding acid in cm^3	
Volume of acid added in cm^3	

(c) The student repeated the experiment using a different concentration of sodium hydroxide solution and recorded these results.

Burette reading after adding acid in cm^3	24.90	25.85	24.85	25.55
Burette reading before adding acid in cm^3	1.20	2.75	1.50	2.10
Volume of acid added in cm^3	23.70	23.10	23.35	23.45
Titration results to be used (✓)				

The volumes of acid added during these titrations are not all the same. The average (mean) volume of acid should be calculated using only concordant results.

Concordant results are those volumes that differ from each other by 0.20 cm^3 or less.

(i) Identify the concordant results by placing ticks (✓) in the table where appropriate.

(1)

(ii) Use your ticked results to calculate the average (mean) volume of acid added.

(2)

Average (mean) volume of acid = ... cm^3

(d) The student used the same method to find the concentration of a solution of potassium hydroxide. The equation for the reaction is

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

These are his results.

Volume of potassium hydroxide solution	25.0 cm^3
Volume of sulfuric acid	23.60 cm^3
Concentration of sulfuric acid	0.0500 mol/dm^3

He used these results to calculate the concentration of the potassium hydroxide solution.

Step 1 amount of $H_2SO_4 = \frac{0.0500 \times 23.60}{100} = 0.0118$ mol

Step 2 amount of $KOH = \frac{0.0118}{2} = 0.00590$ mol

Step 3 concentration of $KOH = \frac{0.00590}{23.60} \times 1000 = 0.250$ mol/dm^3

There is one mistake in each step of the calculation.

What correction should the student make in each step?

(i) Step 1

(1)

.....

.....

(ii) Step 2

(1)

.....

.....

(iii) Step 3

(1)

.....

.....

(Total for Question 3 = 14 marks)

4 A student uses the neutralisation method to make a sample of the soluble salt, sodium sulfate.

The equation for the reaction he uses is

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(a) He does a titration using these steps to find the ratio of the volumes of reactants needed.

- add 25.0 cm^3 solution of dilute sodium hydroxide solution to a conical flask
- add a few drops of phenolphthalein indicator to the conical flask
- add dilute sulfuric acid from a burette until the indicator just changes colour
- repeat the experiment until concordant results are obtained

(i) Which piece of apparatus should the student use to add the sodium hydroxide solution?

(1)

.....

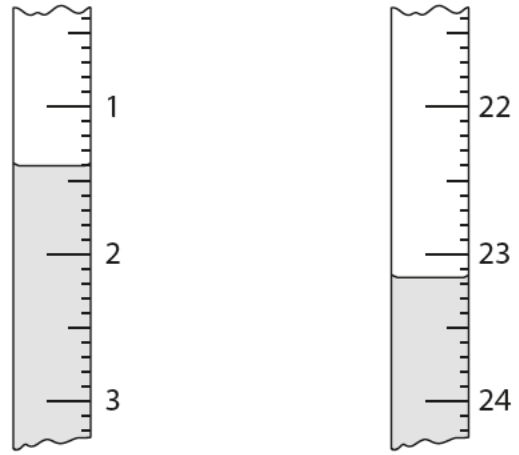
(ii) What colour change would the student see when he neutralises the sodium hydroxide solution?

(2)

colour before neutralisation .....

colour after neutralisation .....

(b) The diagram shows the burette readings in one experiment before and after adding the acid.



Use the readings to calculate the volume of acid added, entering all values to the nearest 0.05 cm^3.

(3)

burette reading after adding acid ..... cm^3

burette reading before adding acid ..... cm^3

volume of acid added ..... cm^3

(c) The student repeats the experiment and records these results.

burette reading in cm^3 after adding acid	25.20	25.05	23.65	23.50
burette reading in cm^3 before adding acid	2.90	3.10	2.55	2.30
volume of acid added in cm^3	22.30	21.95	21.10	21.20
titration results to be used (✓)				

The average (mean) volume of acid added should be calculated using only concordant results (those that differ from each other by 0.20 cm^3 or less).

(i) Identify the concordant results by placing ticks (✓) in the table where appropriate.

(1)

(ii) Use your ticked results to calculate the average volume of acid added.

(2)

average volume = ... cm^3

(d) The student uses 200 cm^3 of sodium hydroxide solution of concentration 0.300 mol/dm^3 to prepare a sample of sodium sulfate solution.

(i) Calculate the amount, in moles, of NaOH in the sodium hydroxide solution.

(2)

amount of NaOH = ... mol

(ii) Calculate the amount, in moles, of H_2SO_4 needed to neutralise this amount of NaOH.

(1)

amount of H_2SO_4 = ... mol

(iii) Calculate the mass, in grams, of this amount of H_2SO_4

(2)

mass of H_2SO_4 = ... g

(Total for Question 4 = 14 marks)