1 Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

\[ 2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \]

(a) Sulfuric acid is a strong acid.

What is meant by a strong acid?
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(2)

(b) Write the ionic equation for this neutralisation reaction. Include state symbols.
___________________________________________________________________
___________________________________________________________________
(2)

(c) A student used a pipette to add 25.0 cm\(^3\) 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\(^3\) 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)
The student carried out five titrations. Her results are shown in the table below.

<table>
<thead>
<tr>
<th>Volume of 0.100 mol / dm$^3$ sulfuric acid in cm$^3$</th>
<th>Titration 1</th>
<th>Titration 2</th>
<th>Titration 3</th>
<th>Titration 4</th>
<th>Titration 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.40</td>
<td>28.15</td>
<td>27.05</td>
<td>27.15</td>
<td>27.15</td>
<td></td>
</tr>
</tbody>
</table>

Concordant results are within 0.10 cm$^3$ of each other.

Use the student’s concordant results to work out the mean volume of 0.100 mol / dm$^3$ sulfuric acid added.

Mean volume = _____________________________ cm$^3$

(2)

The equation for the reaction is:

$$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$$

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

Concentration = _______________________ mol / dm$^3$

(4)
(f) The student did another experiment using 20 cm$^3$ of sodium hydroxide solution with a concentration of 0.18 mol / dm$^3$.

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

Calculate the mass of sodium hydroxide in 20 cm$^3$ of this solution.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Mass = ________________ g

(2) (Total 16 marks)
Dilute nitric acid reacts with potassium hydroxide solution.

The equation for the reaction is:

\[ \text{HNO}_3 + \text{KOH} \rightarrow \text{KNO}_3 + \text{H}_2\text{O} \]

A student investigated the temperature change in this reaction.

This is the method the student used.

Step 1 Put 25 cm\(^3\) of dilute nitric acid in a polystyrene cup.
Step 2 Use a thermometer to measure the temperature of the dilute nitric acid.
Step 3 Use a burette to add 4 cm\(^3\) of potassium hydroxide solution to the dilute nitric acid and stir the mixture.
Step 4 Use a thermometer to measure the highest temperature of the mixture.
Step 5 Repeat steps 3 and 4 until 40 cm\(^3\) of potassium hydroxide solution have been added.

The dilute nitric acid and the potassium hydroxide solution were both at room temperature.

(a) **Figure 1** shows part of the thermometer after some potassium hydroxide solution had been added to the dilute nitric acid.

![Figure 1]

What is the temperature shown on the thermometer?

The temperature shown is __________ °C

(1)

(b) Errors are possible in this experiment.

(i) Suggest **two** causes of random error in the experiment.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)
(ii) Another student used a glass beaker instead of a polystyrene cup.

This caused a systematic error.

Why does using a glass beaker instead of a polystyrene cup cause a systematic error?

______________________________________________________________

______________________________________________________________

______________________________________________________________

(1)

(c) The results of the student using the polystyrene cup are shown in Figure 2.

Figure 2

![Graph showing temperature vs. volume of potassium hydroxide added]

(i) How do the results in Figure 2 show that the reaction between dilute nitric acid and potassium hydroxide solution is exothermic?

______________________________________________________________

______________________________________________________________

______________________________________________________________

(1)

(ii) Explain why the temperature readings decrease between 28 cm$^3$ and 40 cm$^3$ of potassium hydroxide solution added.

______________________________________________________________

______________________________________________________________

______________________________________________________________

(2)
(iii) It is difficult to use the data in Figure 2 to find the exact volume of potassium hydroxide solution that would give the maximum temperature.

Suggest further experimental work that the student should do to make it easier to find the exact volume of potassium hydroxide solution that would give the maximum temperature

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2)

(d) The student did further experimental work and found that 31.0 cm$^3$ of potassium hydroxide solution neutralised 25.0 cm$^3$ of dilute nitric acid.

The concentration of the dilute nitric acid was 2.0 moles per dm$^3$.

\[ \text{HNO}_3 + \text{KOH} \rightarrow \text{KNO}_3 + \text{H}_2\text{O} \]

Calculate the concentration of the potassium hydroxide solution in moles per dm$^3$.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Concentration = ______________ moles per dm$^3$

(3)
(e) The student repeated the original experiment using 25 cm$^3$ of dilute nitric acid in a polystyrene cup and potassium hydroxide solution that was twice the original concentration.

She found that:

- a smaller volume of potassium hydroxide solution was required to reach the maximum temperature
- the maximum temperature recorded was higher.

Explain why the maximum temperature recorded was higher.

___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________

(2)
(Total 14 marks)

A student investigated the rate of reaction of magnesium and hydrochloric acid.

\[
\text{Mg(s) + 2HCl(aq) \rightarrow MgCl}_2(\text{aq}) + \text{H}_2(\text{g})
\]

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.

![Diagram of reaction setup with concentrations 0.5, 1.0, 1.5, and 2.0 moles per dm$^3$.]

(a) The student changed the concentration of the hydrochloric acid.

Give two variables that the student should control.

1. _________________________________________________________________
2. _________________________________________________________________

(2)
(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased. Explain why.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(ii) Explain why increasing the temperature would increase the rate of reaction.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)

(3)
(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm$^3$.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm$^3$ of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm$^3$ sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
(4)
(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

\[
\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}
\]

The student found that 27.20 cm\(^3\) of 0.100 moles per dm\(^3\) sodium hydroxide neutralised 5.00 cm\(^3\) of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per dm\(^3\).

Give your answer to three significant figures.

<table>
<thead>
<tr>
<th>Concentration of hydrochloric acid = __________________ moles per dm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3)</td>
</tr>
<tr>
<td>(Total 14 marks)</td>
</tr>
</tbody>
</table>
Ammonium sulfate is an artificial fertiliser.

(a) (i) When this fertiliser is warmed with sodium hydroxide solution, ammonia gas is given off. Describe and give the result of a test for ammonia gas.

Test: __________________________________________________________

_________________________________________________________________

Result: _______________________________________________________

_________________________________________________________________

(2)

(ii) Describe and give the result of a chemical test to show that this fertiliser contains sulfate ions (SO$_4^{2-}$).

Test: __________________________________________________________

_________________________________________________________________

Result: _______________________________________________________

_________________________________________________________________

(2)

(b) Ammonium sulfate is made by reacting sulfuric acid (a strong acid) with ammonia solution (a weak alkali).

(i) Explain the meaning of strong in terms of ionisation.

_________________________________________________________________
(ii) A student made some ammonium sulfate in a school laboratory.

The student carried out a titration, using a suitable indicator, to find the volumes of sulfuric acid and ammonia solution that should be reacted together.

Name a suitable indicator for strong acid-weak alkali titrations.

______________________________________________________________

(iii) The student found that 25.0 cm$^3$ of ammonia solution reacted completely with 32.0 cm$^3$ of sulfuric acid of concentration 0.050 moles per cubic decimetre.

The equation that represents this reaction is:

$$2\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NH}_3(\text{aq}) \rightarrow (\text{NH}_4)\text{}_2\text{SO}_4(\text{aq})$$

Calculate the concentration of this ammonia solution in moles per cubic decimetre.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Concentration = _________________ moles per cubic decimetre

(iv) Use your answer to (b)(iii) to calculate the concentration of ammonia in grams per cubic decimetre.

(If you did not answer part (b)(iii), assume that the concentration of the ammonia solution is 0.15 moles per cubic decimetre. This is not the correct answer to part (b)(iii).)

Relative formula mass of ammonia (NH$_3$) = 17.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Concentration = _________________ grams per cubic decimetre

(Total 11 marks)
In 1916, during the First World War, a German U-boat sank a Swedish ship which was carrying a cargo of champagne. The wreck was discovered in 1997 and the champagne was brought to the surface and analysed.

(a) 25.0 cm$^3$ of the champagne were placed in a conical flask.

Describe how the volume of sodium hydroxide solution needed to react completely with the weak acids in 25.0 cm$^3$ of this champagne can be found by titration, using phenolphthalein indicator.

Name any other apparatus used.

___________________________________________________________________
___________________________________________________________________
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(b) The acid in 25.0 cm$^3$ of the champagne reacted completely with 13.5 cm$^3$ of sodium hydroxide of concentration 0.10 moles per cubic decimetre.

Calculate the concentration in moles per cubic decimetre of acid in the champagne.

Assume that 1 mole of sodium hydroxide reacts completely with 1 mole of acid.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Concentration = _____________ moles per cubic decimetre

(2)
(c) Is analysis by titration enough to decide whether this champagne is safe to drink?

Explain your answer.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

(1)

(d) The graph shows how the pH of the solution changes during this titration.

![Graph showing pH change during titration](image)

Phenolphthalein is the indicator used in this titration. It changes colour between pH 8.2 and pH 10.0.

Methyl orange is another indicator. It changes colour between pH 3.2 and pH 4.4.

Suggest why methyl orange is **not** a suitable indicator for this titration.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

(2)

(Total 9 marks)
Household ammonia is a dilute solution of ammonia in water. It is commonly used to remove grease from ovens and windows.

(a) The amount of ammonia in household ammonia can be found by titration.

25.0 cm$^3$ of household ammonia is placed in a conical flask. Describe how the volume of dilute nitric acid required to neutralise this amount of household ammonia can be found accurately by titration. Name any other apparatus and materials used.

*To gain full marks you should write down your ideas in good English. Put them into a sensible order and use correct scientific words.*
(b) In an experiment, it was found that 25.0 cm$^3$ of household ammonia was neutralised by 20.0 cm$^3$ of dilute nitric acid with a concentration of 0.25 moles per cubic decimetre.

The balanced symbol equation which represents this reaction is

$$\text{NH}_3(\text{aq}) + \text{HNO}_3(\text{aq}) \rightarrow \text{NH}_4\text{NO}_3(\text{aq})$$

Calculate the concentration of the ammonia in this household ammonia in moles per cubic decimetre.

Concentration = _______________ moles per cubic decimetre

(2)

(c) The salt, ammonium nitrate, is formed in this reaction.

Describe, and give the result of, a chemical test which shows that ammonium nitrate contains ammonium ions.

(2)

(Total 8 marks)

A student carried out a titration to find the concentration of a solution of sulphuric acid. 25.0 cm$^3$ of the sulphuric acid solution was neutralised exactly by 34.0 cm$^3$ of a potassium hydroxide solution of concentration 2.0 mol/dm$^3$. The equation for the reaction is:

$$2\text{KOH}(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{K}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(l)$$
(a) Describe the experimental procedure for the titration carried out by the student.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(4)

(b) Calculate the number of moles of potassium hydroxide used.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
Number of moles = ____________________

(2)

(c) Calculate the concentration of the sulphuric acid in mol/dm$^3$.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Concentration = ____________________ mol/dm$^3$

(3)

(Total 9 marks)
An oven cleaner solution contained sodium hydroxide. A 25.0 cm³ sample of the oven cleaner solution was placed in a flask. The sample was titrated with hydrochloric acid containing 73 g/dm³ of hydrogen chloride, HCl.

(a) Describe how this titration is carried out.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(b) Calculate the concentration of the hydrochloric acid in mol/dm³.

Relative atomic masses: H 1; Cl 35.5

___________________________________________________________________

Answer = __________________ mol/dm³

(2)

(c) 10.0 cm³ of hydrochloric acid were required to neutralise the 25.0 cm³ of oven cleaner solution.

(i) Calculate the number of moles of hydrochloric acid reacting.

___________________________________________________________________

Answer = _____________________ mol

(2)

(ii) Calculate the concentration of sodium hydroxide in the oven cleaner solution in mol/dm³.

___________________________________________________________________

Answer = _____________________ mol/dm³

(2)

(Total 9 marks)

A student carried out a titration to find the concentration of a solution of hydrochloric acid. The following paragraph was taken from the student’s notebook.

I filled a burette with hydrochloric acid. 25.0 cm³ of 0.40 mol/dm³ potassium hydroxide was added to a flask. 5 drops of indicator were added. I added the acid to the flask until the indicator changed colour. The volume of acid used was 35.0 cm³.
(a) What piece of apparatus would be used to measure 25.0 cm\(^3\) of the potassium hydroxide solution?

___________________________________________________________________

(1)

(b) Name a suitable indicator that could be used.

___________________________________________________________________

(1)

(c) Calculate the number of moles of potassium hydroxide used.

___________________________________________________________________

___________________________________________________________________

Moles of potassium hydroxide = ______________________ mol

(2)

(d) Calculate the concentration of the hydrochloric acid. The equation for the reaction is:

KOH + HCl → KCl + H\(_2\)O

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

Concentration of hydrochloric acid = ____________________ mol/dm\(^3\)

(2)

(Total 6 marks)
Mark schemes

(a)  (sulfuric acid is) completely / fully ionised

In aqueous solution or when dissolved in water

(b)  \[ \text{H}^+ (\text{aq}) + \text{OH}^- (\text{aq}) \rightarrow \text{H}_2\text{O}(\ell) \]

\textit{allow multiples}

1 mark for equation

1 mark for state symbols

(c)  adds indicator, eg phenolphthalein / methyl orange / litmus added to the sodium hydroxide (in the conical flask)

\textit{do not accept universal indicator}

(adds the acid from a) burette

with swirling or dropwise towards the end point or until the indicator just changes colour

until the indicator changes from pink to colourless (for phenolphthalein) or yellow to red (for methyl orange) or blue to red (for litmus)

(d)  titrations 3, 4 and 5

\textit{or}

\[
\frac{27.05 + 27.15 + 27.15}{3}
\]

27.12 cm\(^3\)

\textit{accept 27.12 with no working shown for 2 marks}

\textit{allow 27.1166 with no working shown for 2 marks}

(e)  \[ \text{Moles H}_2\text{SO}_4 = \text{conc} \times \text{vol} = 0.00271 \]

\textit{allow ecf from 8.4}

\[
\text{Ratio H}_2\text{SO}_4:\text{NaOH is 1:2}
\]

\textit{or}

\[ \text{Moles NaOH} = \text{Moles H}_2\text{SO}_4 \times 2 = 0.00542 \]

\[ \text{Concentration NaOH} = \text{mol} / \text{vol} = 0.00542 / 0.025 = 0.2168 \]
0.217 (mol / dm³)

accept 0.217 with no working for 4 marks

accept 0.2168 with no working for 3 marks

(f) \( \frac{20}{1000} \times 0.18 = \text{no of moles} \)

or

0.15 \times 40 \text{ g}

0.144 (g)

accept 0.144g with no working for 2 marks

(a) 31

(b) (i) any two from:

- incorrect reading of thermometer / temperature
- incorrect measurement of volume of acid
- incorrect measurement of volume of alkali ( burette).

(ii) glass is a (heat) conductor or polystyrene is a (heat) insulator

answer needs to convey idea that heat lost using glass or not lost using polystyrene

accept answers based on greater thermal capacity of glass (such as “glass absorbs more heat than polystyrene”)

(c) (i) temperature increases

(ii) no reaction takes place or all acid used up or potassium hydroxide in excess

cool / colder potassium hydroxide absorbs energy or lowers temperature

ignore idea of heat energy being lost to surroundings

(iii) take more readings

ignore just “repeat”

around the turning point or between 20 cm³ and 32 cm³

accept smaller ranges as long as no lower than 20 cm³ and no higher than 32 cm³

[16]
(d) **1.61 or 1.6(12903)**  
Correct answer with or without working scores **3**  
If answer incorrect, allow a maximum of **two** from:  
- Moles nitric acid = \( \frac{2 \times 25 \text{ mol}}{1000 \text{ g}} = 0.05 \) for **1** mark  
- Moles KOH = (moles nitric acid) = 0.05 for **1** mark  
- Concentration KOH = \( \frac{0.05 \text{ mol}}{0.031 \text{ L}} \)  
Answer must be correctly rounded (1.62 is incorrect)  

(e) Same amount of energy given out  
Which is used to heat a smaller total volume or mixture has lower thermal capacity  
or  
Number of moles reacting is the same  
But the total volume / thermal capacity is less  
If no other marks awarded award **1** mark for idea of reacting faster  

(a) Any **two** from:  
- Temperature (of the HCl)  
- Mass or length of the magnesium  
- Surface area of the magnesium  
- Volume of HCl  

(b) (i) A greater concentration has more particles per unit volume  
Allow particles are closer together  
Therefore more collisions per unit time or more frequent collisions.  

(ii) Particles move faster  
Allow particles have more (kinetic) energy  
Therefore more collisions per unit time or more frequent collisions  
Collisions more energetic (therefore more collisions have energy greater than the activation energy) or more productive collisions  

(c) (i) Add (a few drops) of indicator to the acid in the conical flask  
Allow any named indicator
add NaOH (from the burette) until the indicator changes colour or add the NaOH dropwise

*candidate does not have to state a colour change but penalise an incorrect colour change.*

repeat the titration

calculate the **average** volume of NaOH or repeat until concordant results are obtained

(ii) **moles of NaOH**

\[0.10 \times 0.0272 = 0.00272 \text{ moles}\]

*correct answer with or without working gains 3 marks*

**Concentration of HCl**

\[0.00272 / 0.005 = 0.544\]

*allow ecf from mp1 to mp2*

**correct number of significant figures**

4

(a) (i) **incorrect test or no test = 0 mark**

*testing the solution or using blue litmus = 0 mark*

(test ammonia / gas with red) litmus

*accept any acid-base indicator with correct result*

(goes) blue

**OR**

(conc.) HCl (1)

white fumes / smoke / solid (1)

*allow white gas / vapour*

**OR**

(test ammonia / gas with) Universal Indicator (1)

blue / purple (1)
(ii) **incorrect test or no test = 0 marks**

add barium chloride / BaCl₂ (solution)

*do not* accept H₂SO₄ added

or add barium nitrate / Ba(NO₃)₂ (solution)

*allow* Ba²⁺ solution / aqueous added

white precipitate / solid (formed)

*allow* white barium sulfate / BaSO₄

ignore barium sulfate / BaSO₄ alone

1

(b) (i) **fully / completely ionised / dissociated**

or hydrogen ions fully dissociated

accept has more ions than weaker acid / alkali of same concentration

ignore strongly ionised

*do not* accept ions are fully ionised

ignore concentrated or reference to concentrations of ions

1

(ii) methyl orange

*accept* correct spelling only

*accept* any strong acid-weak base indicator

*do not* allow phenolphthalein / litmus / universal indicator

1

(iii) 32 × 0.05/1000 or 0.0016 (mole H₂SO₄)

*accept* (0.05 x 32) = (V x 25) or 0.05 x 32 / 25

(reacts with) 2 × 0.0016 or 0.0032 (mole NH₃ in 25 cm³)

*accept* dividing rhs by 2 or multiplying lhs by 2

(0.0032 × 1000/25 =) 0.128

*allow* ecf from previous stage

**correct answer** 0.128 or 0.13 with or without working gains all 3 marks

1
(iv) 2.176 or 2.18
    correct answer with or without working
    or ecf from candidate’s answer to (b)(iii)
    or 2.55 if 0.15 moles used
        if answer incorrect or no answer
        0.128 \times 17 \text{ or } 0.13 \times 17
        or their (b)(iii) \times 17
        or 0.15 \times 17 gains 1 mark

(a) must be description of a titration no titration = no marks
    NaOH in burette
        do not accept biuret etc
    add NaOH until (indicator) changes colour
        if specific colour change mentioned, must be correct – colourless to
        pink / red or ‘goes pink / red’
        do not accept ‘clear’ for colourless
    note (burette) volume used or final reading
        accept ‘work out the volume’
    one other point: eg repeat
        accept:
        (white) tile or add dropwise / slowly or white background or swirling
        / mix or read meniscus at eye level or wash apparatus
(b) 0.054

for 2 marks

\((0.1 \times 13.5)/25\) for 1 mark

(c) don't know – insufficient evidence to decide

owtte

any sensible answer

or

depends on whether acid level is considered safe or unsafe

yes, safe – acid level low / weak acids / low compared with stomach acid

owtte

any sensible answer

no, unsafe – acid level (too) high / other substances or bacteria may be present / insufficient evidence to decide

owtte

any sensible answer

(d) (methyl orange) would have changed colour (well) before the end-point / pH7 / neutral

owtte

weak acid present

weak acid-strong base (titration)

allow methyl orange used for strong acid-weak base titration
(a)  

must be a description of a titration no titration = 0 marks

Quality of written communication
for correct sequencing of 2 of first 3 bullet points i.e. 1 + 2
or 2 + 3 or 1 + 3

any three from:

- nitric acid in burette
do not accept biuret
can be inferred from 3rd point

- add nitric acid until indicator changes (colour)
can be named acid-base indicator
colour change does not have to be correct

- note (burette) volume used or final reading

- accuracy: e.g. repeat
accept white tile or dropwise near end or white background or
swirling the flask or read meniscus at eye level

(b)  
e.g. formula method:

\[ 25 \times M_{NH_3} = 0.25 \times 20 \]

\[ M_{NH_3} = 0.2 \]
correct answer alone = 2

OR

moles NH\(_3\) = moles HNO\(_3\)

\[ \frac{20}{1000} \times 0.25 = 0.005 \text{ moles} \]

concentration NH\(_3\)

\[ \frac{0.005 \times 1000}{25} = 0.2 \]

1
(c) sodium hydroxide or potassium hydroxide or lithium hydroxide or calcium hydroxide

*ignore mention of alkali*

ammonia produced

*accept gas produced turns (damp) (red) litmus blue (not blue litmus)*

*or alkaline gas produced*

*any suitable named indicator e.g. UI with consequential marking*

*white fumes / smoke with (concentrated) HCl*

*do not accept white gas wrong test = 0 marks*

1

(a) any four from:

- sulphuric acid measure by pipette
  *or diagram*

- potassium hydroxide in burette
  *or diagram*

- if solutions reversed, award

- note initial reading

- use of indicator

- note final reading or amount used

4

(b) \[
\frac{34 \times 2}{1000} = 0.068
\]

1

(c) \( \frac{1}{2} \) or 0.5 moles \( \text{H}_2\text{SO}_4 \) react with 1 mole KOH

moles \( \text{H}_2\text{SO}_4 \) in 25.0 cm\(^3\) = 0.068 \times 0.5

1

\[ \therefore \text{moles } \text{H}_2\text{SO}_4 \text{ in } 1 \text{ dm}^3 = \frac{0.068 \times 0.5 \times 1000}{25} = 1.36 \text{ mol/dm}^3 \]

1
(a) hydrochloric acid in burette

indicator

note volume at end / neutralisation point

titre must be HCl

(b) 1 mole HCl = 36.5g / 36.5

:. \[ \frac{73}{36.5} = 2 \text{ moles / dm}^3 \]

2 for correct answer

(c) (i) \[ \frac{10 \times 2}{1000} \]

allow e.c.f. ie their (b) \[ \frac{10}{1000} \]

2 for correct answer

= 0.02 moles

(ii) \[ 0.02 \times \frac{1000}{25} = 0.8 \text{ mol / dm} \]

allow e.c.f. ie their (c)(i) \[ \frac{1000}{25} \]

2 for correct answer

(a) pipette / burette

(b) named indicator eg methyl orange / phenolphthalein

not universal

accept litmus but not litmus paper

(c) \[ \frac{25 \times 0.4}{1000} \]

2 for correct answer

= 0.01
(d) \[ \text{1KOH} \equiv \text{1 HCl} \]

\[ \therefore \text{0.01 moles HCl in 35 cm}^3 \]

\[ \therefore \frac{0.01 \times 1000}{35} = 0.29 \]

2 for correct answer
0.3 = (1) (with correct working = (2))