M1. (a) (sulfuric acid is) completely / fully ionised

In aqueous solution or when dissolved in water

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

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)

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

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

27.12 cm³  
\textit{accept 27.12 with no working shown for 2 marks}  

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

(e) Moles \( H_2SO_4 \) = conc × vol = 0.00271  
\textit{allow ecf from 8.4}  

Ratio \( H_2SO_4:NaOH \) is 1:2  
\textbf{or}  
Moles NaOH = Moles \( H_2SO_4 \) × 2 = 0.00542  

Concentration NaOH = mol / vol = 0.00542 / 0.025 = 0.2168  

0.217 (mol / dm³)  
\textit{accept 0.217 with no working for 4 marks}  

\textit{accept 0.2168 with no working for 3 marks}  

(f) \[ \frac{20}{1000} \times 0.18 = \text{no of moles} \]  
\textbf{or}  
0.15 × 40 g
0.144 (g)

accept 0.144g with no working for 2 marks
(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

(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 = (2 × 25 / 1000) = 0.05 for 1 mark
moles KOH = (moles nitric acid) = 0.05 for 1 mark
concentration KOH = 0.05 / 0.031
(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

answer must be correctly rounded (1.62 is incorrect)
M3. (a) Hydrogen / H⁺

ignore state symbols
ignore proton / H

(b) it = weak acid

pH of weak acid is higher than the pH of a strong acid
allow converse for strong acids
allow correct numerical comparison

any one from:
allow converse for strong acids

• only partially dissociated (to form ions)
allow ionises less

• not as many hydrogen ions (in the solution)
allow fewer H⁺ released

(c) (i) (titration of) weak acid and strong base

(ii) 0.61

correct answer with or without working gains 2 marks
if the answer is incorrect:
moles of sodium hydroxide = (30.5 × 0.5)/1000 = 0.01525 moles
or
(0.5 × 30.5/25) gains 1 mark

(d) 12

correct answer with or without working gains 2 marks or even
with incorrect working.

if the answer is incorrect:

\[ 0.8 \times 60 = 48g \]

or

evidence of dividing 48g (or ecf) by 4

or

\[ \frac{0.8 \times 250}{1000} = \frac{0.8}{4} = 0.8 \times 0.25 = 0.2 \text{ mol} \]

or

evidence of multiplying 0.2mol (or ecf) by 60

would gain 1 mark
M4.  (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

   (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

(ii) methyl orange
accept correct spelling only
accept any strong acid-weak base indicator
do not allow phenolphthalein / litmus / universal indicator

(iii) $32 \times 0.05/1000$ or $0.0016$ (mole H$_2$SO$_4$)

accept $(0.05 \times 32) = (V \times 25)$ or $0.05 \times 32 / 25$

(reacts with) $2 \times 0.0016$ or $0.0032$ (mole NH$_3$ in 25 cm$^3$)
accept dividing rhs by 2 or multiplying lhs by 2

$(0.0032 \times 1000/25 =) 0.128$
allow ecf from previous stage
correct answer $0.128$ or $0.13$ with or without working gains all 3 marks

(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
$0.128 \times 17$ or $0.13 \times 17$
or their (b)(iii) $\times 17$
or $0.15 \times 17 \text{ gains 1 mark}$
M5.  (a)  (i)  sodium hydroxide / NaOH (solution)

*accept potassium hydroxide / KOH
accept ammonia (solution) / NH\(_{3}\) (aq) / \(\text{NH}_3\) \(\text{OH}\)
do **not** accept limewater / calcium hydroxide
*incorrect reagent
*or no reagent = 0 marks

(pale) **green precipitate / solid**

*allow iron(II) hydroxide / Fe(OH)\(_2\), (formed)
allow OH\(^-\) / hydroxide solution gives a green precipitate for 1 mark

(ii)  (acidified) barium chloride / BaCl\(_2\), barium nitrate / Ba(NO\(_3\))\(_2\),

do **not** accept sulphuric acid
incorrect reagent
*or no reagent = 0 marks

**white precipitate / solid**

*allow barium sulfate / BaSO\(_4\), (formed)
allow a solution of barium ions / Ba\(^+\) gives a white precipitate for 1 mark

(b)  (i)  credit can not be obtained for incorrect reactions

carbonate (ions) give (white) ppt (with silver nitrate)
*owtte

(nitric) acid reacts with / removes / displaces carbonate (ions)
*owtte
(ii) Hydrochloric acid is a chloride / contains chloride (ions) / Cl⁻

   accept hydrochloric acid reacts with silver nitrate
do not accept chlorine