1. (i) The H\(^+\) ion in an (nitric) acid has been replaced by a metal ion
   OR by a Ca\(^{2+}\) ion ✓
   **DO NOT ALLOW** it has been produced by the reaction of an acid and a base as this is stated in the question.
   **IGNORE** references to replacement by NH\(_4^+\) ions or positive ions.
   **ALLOW** H OR Hydrogen for H\(^+\);
   **DO NOT ALLOW** Hydrogen atoms
   **ALLOW** Ca OR Calcium for Ca\(^{2+}\).
   **DO NOT ALLOW** Calcium atoms
   **ALLOW** ‘metal’ for ‘metal ion

(ii) 2HNO\(_3\)(aq) + Ca(OH)\(_2\)(aq) → Ca(NO\(_3\))\(_2\) (aq)\(^+\) 2H\(_2\)O(l)
   Formulae ✓
   Balance AND states ✓
   **ALLOW** multiples
   **ALLOW** (aq) OR (s) for Ca(OH)\(_2\)

(iii) Accepts a proton OR accepts H\(^+\) ✓
   **ALLOW** H\(^+\) + OH\(^-\) → H\(_2\)O
   **ALLOW** OH\(^-\) reacts with H\(^+\) OR OH\(^-\) takes H\(^+\)
   **ALLOW** OH\(^-\) ‘attracts’ H\(^+\) if ‘to form water’ is seen
   **DO NOT ALLOW** OH\(^-\) neutralises H\(^+\) (‘neutralises’ is in the question)

2. (a) (i) Calculate correctly \(\frac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}\) mol
   OR 0.00220 mol ✓
   **ALLOW** 0.0022 OR 2.2 \(\times 10^{-3}\) mol

(ii) Calculates correctly \(\frac{0.00220}{2} = 1.10 \times 10^{-3}\) mol
   OR 0.00110 mol ✓
   **ALLOW** 0.0011 OR 1.1 \(\times 10^{-3}\) mol
   **ALLOW** ECF for answer (i)/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes
(iii) \[
\frac{0.00110 \times 1000}{17.60} = 0.0625 \text{ mol dm}^{-3}
\]
OR \(6.25 \times 10^{-2} \text{ mol dm}^{-3}\) ✓

ALLOW 0.063 OR \(6.3 \times 10^{-2} \text{ mol dm}^{-3}\)
ALLOW ECF for answer (ii) \(\times 1000/17.60\)
OR
ECF from (i) for answer (i)/2 \(\times 1000/17.60\) as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes

(b) (i) (The number of) Water(s) of crystallisation ✓

IGNORE hydrated OR hydrous

(ii) 142.1 ✓

ALLOW 142
ALLOW \(M_r\) expressed as a sum
ALLOW ECF from incorrect \(M_r\) and \(x\) is calculated correctly

\[x = \frac{322.1 - 142.1}{18.0} = 10\] ✓

ALLOW ECF values of \(x\) from nearest whole number to calculator value
ALLOW 2 marks if final answer is 10 without any working

3. (i) \(2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4\) ✓

ALLOW \(2\text{NH}_4\text{OH} + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4 + 2\text{H}_2\text{O}\)
ALLOW \(\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+\)
ALLOW any correct multiple
IGNORE state symbols

(ii) when the \(\text{H}^+\) in an acid is replaced by a metal ion OR an ammonium ion OR a + ion ✓

ALLOW \(H\) for \(\text{H}^+\);\nALLOW ‘metal’ for ‘metal ion’\ni.e.: \(H\) in an acid can be replaced by a metal

[6]
(iii) accepts a proton OR accepts H⁺ ✓
   ALLOW donates a lone pair
   ALLOW removes H⁺
   ALLOW forms OH⁻ ions

(iv) 132.1 ✓
   IGNORE units
   NO OTHER ACCEPTABLE ANSWER

4. (i) \( M(\text{MgSO}_4) = 120.4 \) OR 120 (g mol\(^{-1}\)) ✓

   \[
   \text{mol MgSO}_4 = \frac{1.51}{120.4} = 0.0125 \text{ mol} ✓
   \]
   ALLOW 0.013 up to calculator value of 0.012541528 correctly rounded (from \( M = 120.4 \text{ g mol}^{-1} \))
   ALLOW 0.013 up to calculator value of 0.012583333 correctly rounded (from \( M = 120 \text{ g mol}^{-1} \))
   ALLOW ecf from incorrect \( M \) i.e. 1.51 ÷ \( M \)

(ii) \( \frac{1.57}{18.0} = 0.0872(2) \) (mol) ✓

   ALLOW 0.09 up to calculator value of 0.08722222

(iii) \( \times = 7 \) ✓

   ALLOW ecf i.e. answer to (ii) ÷ answer to (i)
   ALLOW correctly calculated answer from 1 significant figure up to calculator value, ie, \( \times \) does not have to be a whole number. Likely response = 6.95 ✓

5. (i) Ca(OH)\(_2\) ✓

   IGNORE charges, even if wrong
6. (i) Molar mass of CaCO$_3$ = 100.1 g mol$^{-1}$ (1)
\[
\frac{2.68}{100.1} = 0.0268/0.027 \quad (1)
\]
(ii) 0.0268 mol $\times 24,000 = 643$ cm$^3$ (1)
(iii) moles HNO$_3$ = 2 $\times$ 0.0268
\[
= 0.0536/0.054 \text{ mol} \quad (1)
\]
\[\text{(i.e. answer to (i) } \times 2)\]
volume of HNO$_3$ = 0.0536 $\times 1000/2.50 = 21.4$ cm$^3$ (1)

7. (i) MgO has reacted with CO$_2$ ✓ 1
(ii) Solid dissolves / disappears ✓
Fizzing / bubbles ✓
MgO + 2HCl $\rightarrow$ MgCl$_2$ + H$_2$O ✓
MgCO$_3$ + 2HCl $\rightarrow$ MgCl$_2$ + CO$_2$ + H$_2$O ✓
both reactions form magnesium chloride/MgCl$_2$ ✓ 3

8. (i) CaCO$_3$ (s) + 2HCl(aq) $\rightarrow$ CaCl$_2$(aq) + CO$_2$(g) + H$_2$O (l)
CaO(s) + 2HCl(aq) $\rightarrow$ CaCl$_2$(aq) + H$_2$O (l)
each balanced equation 1 mark (2)
all state symbols (1) 3
(ii) CaCO$_3$ fizzes/ gas given off/ gas evolved / carbon dioxide evolved (1)

9. (i) a proton donor ✓ 1
(ii) MgO + 2HCl $\rightarrow$ MgCl$_2$ + H$_2$O ✓ 1
10. CaCO₃ reacts with (or neutralises) HCl ✓
(or CaCO₃ + HCl in an equation)
CaCO₃ + 2HCl → CaCl₂ + H₂O + CO₂ ✓
(correct equation would score both marks) [2]

11. (i) as a base (1) ………… accepts a proton/H⁺/neutralises an acid/
reacts with acid to form salt/ has a lone pair of electrons (1) 2
(ii) fertiliser (1) 1
(iii) manufacture of explosives/ dyes/ nitric acid/ fibres/ ammonium
nitrate/ urea/ refrigeration/ cleaning agents/ fertiliser
(if not allowed in (ii) (1) 1 [4]

12. (i) fizzing/gas/hydrogen evolved or Mg dissolves/disappears ✓
[an incorrect observation negates this mark] 1
(ii) 2HCl + Mg → MgCl₂ + H₂
[correct formula for MgCl₂. Allow equation with HI/MgI₂ instead of HCl] ✓
[balancing: e.g. 2HCl + 2Mg → 2MgCl + H₂ will get this mark but
not the 1st] ✓ 2 [3]

13. No mark scheme available

14. No mark scheme available