Worksheet 8.2: Solutions
A back titration

No.	Answer
1	**a** $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$ **b** $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
2	**a** $n(HCl)$ initially $= c \times V = 1.020 \times 40.00 \times 10^{-3} = 4.080 \times 10^{-2}$ mol **b** $n(NaOH) = c \times V = 0.275 \times 25.56 \times 10^{-3} = 7.029 \times 10^{-3}$ mol **c** $n(HCl)$ unreacted $= n(NaOH) = 0.275 \times 25.56 \times 10^{-3} = 7.029 \times 10^{-3}$ mol **d** $n(HCl)$reacting $= n(HCl)$ initially $- n(HCl)$unreacted $= 4.080 \times 10^{-2} - 7.029 \times 10^{-3} = 3.377 \times 10^{-2}$ mol **e** $n(CaCO_3) = \frac{1}{2} \times n(HCl)$ reacting $= \frac{1}{2} \times 3.377 \times 10^{-2} = 1.689$ mol **f** $m(CaCO_3) = n \times M = \frac{1}{2} \times 3.377 \times 10^{-2} \times 100.09 = 1.690$ g **g** % $CaCO_3$ in marble $= \frac{m(CaCO_3)}{m(\text{marble})} \times \frac{100}{1} = \frac{1.690}{1.740} \times \frac{100}{1} = 97.1\%$
3	Solid sodium hydroxide absorbs water from the atmosphere. Solid samples may therefore be damp and therefore impure. Sodium hydroxide solutions react with carbon dioxide in the atmosphere, decreasing the concentration of the solution: $2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(aq) + H_2O(l)$
4	CO_2 is an acidic oxide. It reacts with NaOH. If the CO_2 was not removed, more NaOH would be required for the titration, leading to an increased value for the unreacted HCl, and hence a decreased value for the $CaCO_3$ percentage.
5	Calcium carbonate is not soluble. The carbonate ion is a weak base that gives an indistinct endpoint in a direct titration.
6	**a** This would dilute the acid. More would be required to react with the marble, giving an increased percentage for the carbonate. **b** This would dilute the NaOH. More would be required to react with the HCl, giving an increased value for the unreacted HCl. This, in turn, would give a decreased value for the reacting HCl, and so a decreased percentage for the carbonate. **c** This has no effect. Flasks should be rinsed with water.
7	$n(CO_2) = \frac{pV}{RT} = \frac{765 \times 101.3 \times 95.0 \times 10^{-3}}{760 \times 8.314 \times 296} = 0.003\,936$ mol $n(CaCO_3) = n(CO_2) = 0.003\,936$ mol $m(CaCO_3) = n \times M = 0.003\,936 \times 100.09 = 0.3940$ g % $CaCO_3$ in marble $= \frac{m(CaCO_3)}{m(\text{marble})} \times \frac{100}{1} = \frac{0.3940}{0.411} \times \frac{100}{1} = 95.9\%$
8	Small amounts of gas may have been lost in the collection process. Some carbon dioxide may remain dissolved in the reaction solution.