Activity 5C: Complexometric and precipitation titrations

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1. A sample of hard water is known to contain the ions Mg^{2+} and Ca^{2+}. Both these ions form a complex with EDTA, so can be analysed using a complexometric titration.

a. 50.00 mL of a sample of hard water is titrated with an EDTA solution of concentration 0.0120 mol L^{-1} using Eriochrome T as the indicator and adding a buffer solution to keep the pH close to 10. The average titre used is 22.60 mL.

Calculate the combined concentration of the Ca^{2+} and Mg^{2+} ions.

b. The Mg^{2+} ions are selectively removed by precipitation with NaOH, leaving only the Ca^{2+} ions in the solution. A second set of titrations is then carried out to determine the Ca^{2+} concentration. 50.00 mL of the solution is used and this time, the volume of EDTA used is 15.26 mL.

Calculate the concentration of Ca^{2+} in the solution and use the result from **a.** to determine the Mg^{2+} concentration.

2. A silver nitrate solution is standardised by titrating 10.00 mL portions with 0.0350 mol L^{-1} NaCl solution. Potassium chromate was used as an indicator, and the average volume of NaCl solution needed to reach the equivalence point is 12.40 mL.

$$Ag^+ + Cl^- \rightarrow AgCl(s)$$

a. Calculate the mass of NaCl that would be needed to make 500 mL of the standard 0.0350 mol L^{-1} solution (M(NaCl) = 58.5 g mol^{-1}).

b. Calculate the concentration of the $AgNO_3$ solution.

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1. a. $M^{2+} + EDTA^{4-} \rightarrow [M(EDTA)]^{2-}$, where M represents Ca^{2+} and Mg^{2+}

$n(EDTA) = c(EDTA) \times V(EDTA) = 0.0120 \text{ mol L}^{-1} \times 0.02260 \text{ L} = 2.712 \times 10^{-4} \text{ mol}$

From the equation: $n(EDTA) = n(M^{2+}) = 2.712 \times 10^{-4}$ mol

$$c(M^{2+}) = \frac{n(M^{2+})}{V(M^{2+})} = \frac{2.712 \times 10^{-4} \text{ mol}}{0.05000 \text{ L}} = 0.00542 \text{ mol L}^{-1}$$

b. $n(EDTA) = c(EDTA) \times V(EDTA) = 0.0120 \text{ mol L}^{-1} \times 0.01526 \text{ L} = 1.831 \times 10^{-4} \text{ mol}$

From the equation:

$n(EDTA) = n(Ca^{2+}) = 1.831 \times 10^{-4}$ mol

$$c(Ca^{2+}) = \frac{n(M^{2+})}{V(M^{2+})} = \frac{1.831 \times 10^{-4} \text{ mol}}{0.05000 \text{ L}} = 0.00366 \text{ mol L}^{-1}$$

And, $c(Mg^{2+}) = 0.00542 - 0.00366 = 0.00176 \text{ mol L}^{-1}$

2. a. $n(NaCl) = c(NaCl) \times V(NaCl) = 0.0350 \text{ mol L}^{-1} \times 0.500 \text{ L} = 0.0175 \text{ mol}$

$m(NaCl) = n(NaCl) \times M(NaCl) = 0.0175 \text{ mol} \times 58.5 \text{ g mol}^{-1} = 1.02 \text{ g}$

b. $n(NaCl) = c(NaCl) \times V(NaCl) = 0.0350 \text{ mol L}^{-1} \times 0.01240 \text{ L} = 4.34 \times 10^{-4} \text{ mol}$

From the equation:

$n(Ag^{+}) = n(Cl^{-}) = 4.34 \times 10^{-4}$ mol

$$c(Ag^{+}) = \frac{n(Ag^{2+})}{V(Ag^{2+})} = \frac{4.34 \times 10^{-4} \text{ mol}}{0.01000 \text{ L}} = 0.0434 \text{ mol L}^{-1}$$

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