Titration Calculations & Answers

1. Use the information to determine the concentration of the hydrochloric acid.
   - A 25 cm^3 sample of hydrochloric acid is sucked into a pipette and transferred into a 250 cm^3 volumetric flask. The solution is made up to the mark.
   - 25 cm^3 of the diluted acid is transferred into a conical flask using a pipette.
   - A burette is used to neutralise the acid with 0.1 mol dm^{-3} sodium hydroxide.

   Hydrochloric acid reacts with sodium hydroxide according to the equation:

   $$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

   a. The average titre of the sodium hydroxide solution was 30.00 cm^3. Calculate the number of moles in the average titre.
   n = c x (v/1000) = 0.100 x (30.00/1000) = 0.003 mol (1)

   0.003 mol (1)

   b. Determine the number of moles in the diluted sample of hydrochloric acid, and hence the concentration of the diluted acid.
   Moles in diluted sample = 0.003 mol (1)
   c = n/(v/1000) = 0.003/(25/1000) = 0.12 mol dm^{-3} (1)

   0.12 mol dm^{-3} (2)

   c. Calculate the concentration of the undiluted hydrochloric acid in mol dm^{-3}.
   Dilution = 250/25 = 10
   10 x 0.003 = 0.12 mol dm^{-3} = 1.2 mol dm^{-3} (1)

   1.2 mol dm^{-3} (1)

   d. Calculate the concentration of the hydrochloric acid in g dm^{-3}.
   Mr = 1 + 35.5 = 36.5 (1)
   m = n x Mr = 1.2 x 36.5 = 43.8 g dm^{-3} (1)

   43.8 g dm^{-3} (2)

2. Use the information to determine the concentration of the nitric acid.
   - A 10 cm^3 sample of nitric acid is sucked into a pipette and transferred into a 100 cm^3 volumetric flask. The solution is made up to the mark.
   - 25 cm^3 of the diluted acid is transferred into a conical flask using a pipette.
   - A burette is used to neutralise the acid with 0.15 mol dm^{-3} sodium hydroxide.

   Nitric acid reacts with sodium hydroxide according to the equation:

   $$HNO_{3\,(aq)} + NaOH_{(aq)} \rightarrow NaNO_{3\,(aq)} + H_2O_{(l)}$$

   a. The average titre of the sodium hydroxide solution was 23.33 cm^3. Calculate the number of moles in the average titre.
   n = c x (v/1000) = 0.150 x (23.33/1000) = 0.0034995 (1)

   0.0035 mol (1)

   b. Determine the number of moles in the diluted sample of nitric acid, and hence the concentration of the diluted acid.
   Moles in diluted sample = 0.0035 mol in 25 cm^3 (1)
   c = n/(v/1000) = 0.0035/(25/1000) = 0.14 mol dm^{-3} (1)

   0.14 mol dm^{-3} (2)

   c. Calculate the concentration of the undiluted nitric acid in mol dm^{-3}.
   Dilution = 100/10 = 10
   10 x 0.14 = 1.4 mol dm^{-3} (1)

   1.4 mol dm^{-3} (1)

   d. Calculate the concentration of the nitric acid in g dm^{-3}.
   Mr = 1 + 14 + 48 = 63 (1)
   m = n x Mr = 1.4 x 36.5 = 88.2 g dm^{-3} (1)

   88.2 g dm^{-3} (2)

3. Use the information to determine the concentration of the sulfuric acid.
   - A 25 cm^3 sample of sulfuric acid is sucked into a pipette and transferred into a 500 cm^3 volumetric flask. The solution is made up to the mark.
   - 25 cm^3 of the diluted acid is transferred into a conical flask using a pipette.
   - A burette is used to neutralise the acid with 0.1 mol dm^{-3} sodium hydroxide.

   Sulfuric acid reacts with sodium hydroxide according to the equation:

   $$H_2SO_{4\,(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

   a. The average titre of the sodium hydroxide solution was 25.00 cm^3. Calculate the number of moles in the average titre.
   n = c x (v/1000) = 0.100 x (25.00/1000) = 0.0025

   0.0025 mol (1)

   b. Determine the number of moles in the diluted sample of sulfuric acid, and hence the concentration of the diluted acid.
   Moles in diluted sample = 0.0025/2 = 0.00125mol (1)
   c = n/(v/1000) = 0.00125/(25/1000) = 0.05 mol dm^{-3} (1)

   0.05 mol dm^{-3} (2)

   c. Calculate the concentration of the undiluted sulfuric acid in mol dm^{-3}.
   Dilution = 500/25 = 20
   20 x 0.05 = 1.0 mol dm^{-3} (1)

   1.0 mol dm^{-3} (1)

   d. Calculate the concentration of the sulfuric acid in g dm^{-3}.
   Mr = 2 + 32.1 + 64 = 98.1
   m = n x Mr = 1.0 x 98.1 = 98.1 g dm^{-3}

   98.1 g dm^{-3} (2)

4. Use the information to determine the concentration of the hydrochloric acid.
   - A 10 cm^3 sample of hydrochloric acid is sucked into a pipette and transferred into a 500 cm^3 volumetric flask. The solution is made up to the mark.
   - 25 cm^3 of the diluted acid is transferred into a conical flask using a pipette.
   - A burette is used to neutralise the acid with 0.050 mol dm^{-3} potassium hydroxide.

   Hydrochloric acid reacts with potassium hydroxide according to the equation:

   $$HCl_{(aq)} + KOH_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)}$$

   a. The average titre of the potassium hydroxide solution was 20.00 cm^3. Calculate the number of moles in the average titre.
   n = c x (v/1000) = 0.050 x (20.00/1000) = 0.001 (1)

   0.001 mol (1)

   b. Determine the number of moles in the diluted sample of hydrochloric acid, and hence the concentration of the diluted acid.
   Moles in diluted sample = 0.001 mol (1)
   c = n/(v/1000) = 0.001/(25/1000) = 0.04 mol dm^{-3} (1)

   0.04 mol dm^{-3} (2)

   c. Calculate the concentration of the undiluted hydrochloric acid in mol dm^{-3}.
   Dilution = 500/10 = 50
   50 x 0.04 =2.0 mol dm^{-3} (1)

   2.0 mol dm^{-3} (1)

   d. Calculate the concentration of the hydrochloric acid in g dm^{-3}.
   Mr = 1 + 35.5 = 36.5
   m = n x Mr = 2.0 x 36.5 = 73.0 g dm^{-3}

   73.0 g dm^{-3} (2)

Questions

1. *Explain* what the effect on the titre would be if:
   a. The pipette used to transfer the acid solution was filled to slightly above the mark. (2)
      Increased/greater/too high titre (1)
      More *moles* of acid transferred to conical flask / more *moles* of acid in the pipette (1)
   b. The pipette used to transfer the acid solution was filled to slightly below the mark. (2)
      Decreased/lower/too low titre (1)
      Fewer *moles* of acid transferred to conical flask / fewer *moles* of acid in the pipette (1)
   c. The volumetric flask was filled to slightly above the mark. (2)
      Decreased/lower/too low titre (1)
      Concentration of acid lower (1)
   d. The volumetric flask was filled to slightly below the mark. (2)
      Increased/higher /too high titre (1)
      Concentration of acid higher (1)

2. Calculate the percentage uncertainty of:
   a. A 100 cm^3 volumetric flask with an uncertainty of 0.1 cm^3. (1)
      (0.1/100) x 100 = 0.1%
   b. A 250 cm^3 volumetric flask with an uncertainty of 0.2 cm^3. (1)
      (0.2/250) x 100 = 0.08%
   c. A 500 cm^3 volumetric flask with an uncertainty of 0.5 cm^3. (1)
      (0.5/500) x 100 = 0.1%

3. A student suggests washing out the pipette with water before filling it with acid solution. Explain why this is not a good idea. (2)
   Water left in the pipette would dilute the acid / reduce the concentration (1)
   Acid washes out contaminants (1)