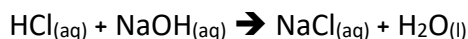


Titration Calculations & Answers

1. Use the information to determine the concentration of the hydrochloric acid.
- A 25 cm³ sample of hydrochloric acid is sucked into a pipette and transferred into a 250 cm³ volumetric flask. The solution is made up to the mark.
 - 25 cm³ 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:



- a. The average titre of the sodium hydroxide solution was 30.00 cm³. Calculate the number of moles in the average titre.

$$n = c \times (v/1000) = 0.100 \times (30.00/1000) = 0.003 \text{ mol (1)}$$

$$0.003 \text{ mol (1)}$$

- b. Determine the number of moles in the diluted sample of hydrochloric acid, and hence the concentration of the diluted acid.

$$\text{Moles in diluted sample} = 0.003 \text{ mol (1)}$$

$$c = n/(v/1000) = 0.003/(25/1000) = 0.12 \text{ mol dm}^{-3} \text{ (1)}$$

$$0.12 \text{ mol dm}^{-3} \text{ (2)}$$

- c. Calculate the concentration of the undiluted hydrochloric acid in mol dm⁻³.

$$\text{Dilution} = 250/25 = 10$$

$$10 \times 0.003 = 0.12 \text{ mol dm}^{-3} = 1.2 \text{ mol dm}^{-3} \text{ (1)}$$

$$1.2 \text{ mol dm}^{-3} \text{ (1)}$$

- d. Calculate the concentration of the hydrochloric acid in g dm⁻³.

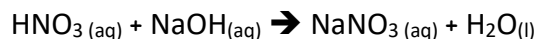
$$M_r = 1 + 35.5 = 36.5 \text{ (1)}$$

$$m = n \times M_r = 1.2 \times 36.5 = 43.8 \text{ g dm}^{-3} \text{ (1)}$$

$$43.8 \text{ g dm}^{-3} \text{ (2)}$$

2. Use the information to determine the concentration of the nitric acid.
- A 10 cm³ sample of nitric acid is sucked into a pipette and transferred into a 100 cm³ volumetric flask. The solution is made up to the mark.
 - 25 cm³ 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:



- a. The average titre of the sodium hydroxide solution was 23.33 cm³. Calculate the number of moles in the average titre.

$$n = c \times (v/1000) = 0.150 \times (23.33/1000) = 0.0034995 \text{ (1)}$$

$$0.0035 \text{ mol (1)}$$

- b. Determine the number of moles in the diluted sample of nitric acid, and hence the concentration of the diluted acid.

$$\text{Moles in diluted sample} = 0.0035 \text{ mol in } 25 \text{ cm}^3 \text{ (1)}$$

$$c = n/(v/1000) = 0.0035/(25/1000) = 0.14 \text{ mol dm}^{-3} \text{ (1)}$$

$$0.14 \text{ mol dm}^{-3} \text{ (2)}$$

- c. Calculate the concentration of the undiluted nitric acid in mol dm⁻³.

$$\text{Dilution} = 100/10 = 10$$

$$10 \times 0.14 = 1.4 \text{ mol dm}^{-3} \text{ (1)}$$

$$1.4 \text{ mol dm}^{-3} \text{ (1)}$$

- d. Calculate the concentration of the nitric acid in g dm⁻³.

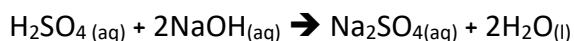
$$\text{Mr} = 1 + 14 + 48 = 63 \text{ (1)}$$

$$m = n \times \text{Mr} = 1.4 \times 63 = 88.2 \text{ g dm}^{-3} \text{ (1)}$$

$$88.2 \text{ g dm}^{-3} \text{ (2)}$$

3. Use the information to determine the concentration of the sulfuric acid.
- A 25 cm³ sample of sulfuric acid is sucked into a pipette and transferred into a 500 cm³ volumetric flask. The solution is made up to the mark.
 - 25 cm³ 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:



- a. The average titre of the sodium hydroxide solution was 25.00 cm³. Calculate the number of moles in the average titre.

$$n = c \times (v/1000) = 0.100 \times (25.00/1000) = 0.0025$$

$$0.0025 \text{ mol (1)}$$

- b. Determine the number of moles in the diluted sample of sulfuric acid, and hence the concentration of the diluted acid.

$$\text{Moles in diluted sample} = 0.0025/2 = 0.00125 \text{ mol (1)}$$

$$c = n/(v/1000) = 0.00125/(25/1000) = 0.05 \text{ mol dm}^{-3} \text{ (1)}$$

$$0.05 \text{ mol dm}^{-3} \text{ (2)}$$

- c. Calculate the concentration of the undiluted sulfuric acid in mol dm⁻³.

$$\text{Dilution} = 500/25 = 20$$

$$20 \times 0.05 = 1.0 \text{ mol dm}^{-3} \text{ (1)}$$

$$1.0 \text{ mol dm}^{-3} \text{ (1)}$$

- d. Calculate the concentration of the sulfuric acid in g dm⁻³.

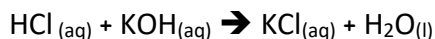
$$M_r = 2 + 32.1 + 64 = 98.1$$

$$m = n \times M_r = 1.0 \times 98.1 = 98.1 \text{ g dm}^{-3}$$

$$98.1 \text{ g dm}^{-3} \text{ (2)}$$

4. Use the information to determine the concentration of the hydrochloric acid.
- A 10 cm³ sample of hydrochloric acid is sucked into a pipette and transferred into a 500 cm³ volumetric flask. The solution is made up to the mark.
 - 25 cm³ 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:



- a. The average titre of the potassium hydroxide solution was 20.00 cm³. Calculate the number of moles in the average titre.

$$n = c \times (v/1000) = 0.050 \times (20.00/1000) = 0.001 \text{ (1)}$$

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.

$$\text{Moles in diluted sample} = 0.001 \text{ mol (1)}$$

$$c = n/(v/1000) = 0.001/(25/1000) = 0.04 \text{ mol dm}^{-3} \text{ (1)}$$

0.04 mol dm⁻³ (2)

- c. Calculate the concentration of the undiluted hydrochloric acid in mol dm⁻³.

$$\text{Dilution} = 500/10 = 50$$

$$50 \times 0.04 = 2.0 \text{ mol dm}^{-3} \text{ (1)}$$

2.0 mol dm⁻³ (1)

- d. Calculate the concentration of the hydrochloric acid in g dm⁻³.

$$\text{Mr} = 1 + 35.5 = 36.5$$

$$m = n \times \text{Mr} = 2.0 \times 36.5 = 73.0 \text{ g dm}^{-3}$$

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 cm³ volumetric flask with an uncertainty of 0.1 cm³. (1)
 $(0.1/100) \times 100 = 0.1\%$
 - b. A 250 cm³ volumetric flask with an uncertainty of 0.2 cm³. (1)
 $(0.2/250) \times 100 = 0.08\%$
 - c. A 500 cm³ volumetric flask with an uncertainty of 0.5 cm³. (1)
 $(0.5/500) \times 100 = 0.1\%$
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)