

# TITRATIONS



Answer all the questions below then check your answers

1. A solution has a volume of 50ml.

What is its volume in  $\text{dm}^3$ ?

2. A solution has a volume of  $35.5\text{cm}^3$ .

What is its volume in  $\text{dm}^3$ ?

3. A solution has a volume of 75ml.

What is its volume in  $\text{dm}^3$ ?

4. A solution has a volume of 25ml.

What is its volume in litres?

5. Calculate the concentration of the

following solutions. Give your answer in  $\text{g}/\text{dm}^3$ :

a. solution has 25g of solute in 500ml of solution.

b. solution has 2.6g of solute in 350ml of solution.

c. solution has 7.5g of solute in  $100\text{cm}^3$  of solution.

Use the following formula to solve all the problems on this page

$c$  = concentration

$v$  = volume

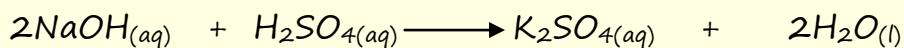
$n$  = number of moles

$$c = n/v$$

$$V = n/c$$

$$n = c \times V$$

6. Calculate the concentration of the following solutions. Give your answer in mol/dm<sup>3</sup>:
- solution has 2 moles of solute in 500 ml of solution.
  - solution has 0.5 moles of solute in 2000 ml of solution.
  - solution has 0.5 moles of solute in 75 ml of solution.
  - solution has 0.2 moles of solute in 125 cm<sup>3</sup> of solution.
7. How many moles of solute are in the following solutions?
- 0.5 dm<sup>3</sup> of a solution with concentration of 0.5 mol/dm<sup>3</sup>
  - 0.35 dm<sup>3</sup> of a solution with concentration of 1.5 mol/dm<sup>3</sup>
  - 0.5 dm<sup>3</sup> of a solution with concentration of 0.5 mol/dm<sup>3</sup>
  - 250 ml of a solution with concentration of 0.1 mol/dm<sup>3</sup>
8. A student carried out a titration to find the concentration of a sulfuric acid solution. 25 ml of the sulfuric acid was neutralised by 31.0 ml of a sodium hydroxide solution with a concentration of 1.5 mol/dm<sup>3</sup>. The equation for the neutralisation reaction is:



- From the equation above how many moles of sodium hydroxide are required to neutralise 1 mole of sulfuric acid?
- How many moles of sodium hydroxide were used in this titration experiment. Use the figures in the question to calculate your answer. (hint make sure your volumes are in dm<sup>3</sup>).

- c. Use your answer to part b to calculate the number of moles of sulfuric acid that neutralised the sodium hydroxide solution in the titration.
- d. Calculate the concentration of the sulfuric acid solution.
- e. Name a suitable indicator for this reaction.
- f. Describe the experimental procedure the student would have used to carry out this titration.
9. Use the table below to help you answer the following questions:

Substance	formula	Substance	formula
Hydrochloric acid	HCl	Sodium hydroxide	NaOH
Sulfuric acid	H <sub>2</sub> SO <sub>4</sub>	Potassium hydroxide	KOH
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	Sodium nitrate	NaNO <sub>3</sub>
Nitric acid	HNO <sub>3</sub>	Sodium sulfate	Na <sub>2</sub> SO <sub>4</sub>
Sodium phosphate	Na <sub>3</sub> PO <sub>4</sub>		

- a. In a titration, 20 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> HCl reacted with 25 cm<sup>3</sup> of NaOH. What was the concentration of the sodium hydroxide?
- b. In a titration, 25 cm<sup>3</sup> of 1.25 mol dm<sup>-3</sup> HCl reacted with 25 cm<sup>3</sup> of KOH. What was the concentration of the potassium hydroxide?
- c. In a titration, 25 cm<sup>3</sup> of 1.25 mol dm<sup>-3</sup> sulphuric acid, H<sub>2</sub>SO<sub>4</sub>, reacted with 25 ml of NaOH. What was the concentration of the sodium hydroxide?
- d. In a titration, 18 cm<sup>3</sup> of 1.5 mol dm<sup>-3</sup> nitric acid, HNO<sub>3</sub>, reacted with 25 cm<sup>3</sup> of KOH. What was the concentration of the sodium hydroxide?

10. A student carried out a titration and obtained the following results:

Burette reading/ml	Volume/ml	First trial/ml	second trial/ml	third trial/ml
Initial	1.0	1.5	1.0	1.0
Final	25.5	26.0	25.6	25.5
Titre (amount used)	24.5	24.5	24.6	24.5

- Calculate the mean titre for these titrations.
- How precise were the students results?
- Calculate the uncertainty in the mean titre.

## Answers

1. A solution has a volume of 50ml.

What is its volume in  $\text{dm}^3$ ?  $0.05\text{dm}^3$

2. A solution has a volume of  $35.5\text{cm}^3$ .

What is its volume in  $\text{dm}^3$ ?  $0.0355\text{dm}^3$

3. A solution has a volume of 75ml.

What is its volume in  $\text{dm}^3$ ?  $0.075\text{dm}^3$

4. A solution has a volume of 25ml.

What is its volume in litres?

$0.025$  litres

5. Calculate the concentration of the

following solutions. Give your answer in  $\text{g}/\text{dm}^3$ :

a. solution has 25g of solute in 500ml of solution.  $25/0.5 = 50\text{g}/\text{dm}^3$

b. solution has 2.6g of solute in 350ml of solution.  $2.6/0.35 = 7.42\text{g}/\text{dm}^3$

c. solution has 7.5g of solute in  $100\text{cm}^3$  of solution.  $7.5/0.1 = 75\text{g}/\text{dm}^3$

6. Calculate the concentration of the following solutions. Give your answer in  $\text{mol}/\text{dm}^3$ :

a. solution has 2moles of solute in 500ml of solution.  $2/0.5 = 4 \text{ mol}/\text{dm}^3$

b. solution has 0.5moles of solute in 2000ml of solution.  $0.5/2 = 0.25 \text{ mol}/\text{dm}^3$

Use the following formula to solve all the problems on this page

$c$  = concentration

$v$  = volume

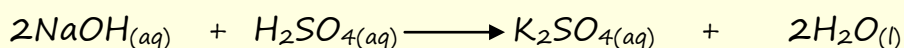
$n$  = number of moles

$$c = n/v$$

$$V = n/c$$

$$n = c \times V$$

- c. solution has 0.5 moles of solute in 75 ml of solution.  $0.5/0.075 = 6.6 \text{ mol/dm}^3$
- d. solution has 0.2 moles of solute in 125  $\text{cm}^3$  of solution.  $0.2/0.125 = 1.6 \text{ mol/dm}^3$
7. How many moles of solute are in the following solutions?
- a. 0.5  $\text{dm}^3$  of a solution with concentration of 0.5  $\text{mol/dm}^3$   $0.5 \times 0.5 = 0.25 \text{ mol}$
- b. 0.35  $\text{dm}^3$  of a solution with concentration of 1.5  $\text{mol/dm}^3$   $0.35/0.5 = 0.175 \text{ mol}$
- c. 0.5  $\text{dm}^3$  of a solution with concentration of 0.5  $\text{mol/dm}^3$   $0.5/0.5 = 1 \text{ mol}$
- d. 250 ml of a solution with concentration of 0.1  $\text{mol/dm}^3$   $0.1/0.25 = 0.4 \text{ mol}$
8. A student carried out a titration to find the concentration of a sulfuric acid solution. 25 ml of the sulfuric acid was neutralised by 31.0 ml of a sodium hydroxide solution with a concentration of 1.5  $\text{mol/dm}^3$ . The equation for the neutralisation reaction is:



- a. From the equation above how many moles of sodium hydroxide are required to neutralise 1 mole of sulfuric acid? 2 moles of sodium hydroxide, from the equation 1 mol of sulfuric acid will neutralise 2 moles of NaOH
- b. How many moles of sodium hydroxide were used in this titration experiment. Use the figures in the question to calculate your answer. (hint make sure your volumes are in  $\text{dm}^3$ ).  $n = c \times v$ ,  $n = 1.5 \times 0.031 = 0.0465 \text{ mol}$
- c. Use your answer to part b to calculate the number of moles of sulfuric acid that neutralised the sodium hydroxide solution in the titration. Divide answer to part b by 2,  $0.0465/2 = 0.02325 \text{ mol}$  of sulfuric acid.

d. Calculate the concentration of the sulfuric acid solution.

$$C=n/v \quad 0.02325/0.025=0.93 \text{ mol/dm}^3$$

e. Name a suitable indicator for this reaction. *Methyl orange is suitable.*

f. Describe the experimental procedure the student would have used to carry out this titration.

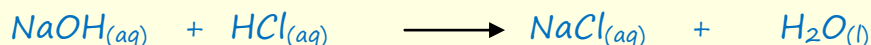
*Method is outlined on titration webpage, just swap the hydrochloric acid used in the example for sulfuric acid.*

9. Use the table below to help you answer the following questions:

Substance	formula	Substance	formula
Hydrochloric acid	HCl	Sodium hydroxide	NaOH
Sulfuric acid	H <sub>2</sub> SO <sub>4</sub>	Potassium hydroxide	KOH
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	Sodium nitrate	NaNO <sub>3</sub>
Nitric acid	HNO <sub>3</sub>	Sodium sulfate	Na <sub>2</sub> SO <sub>4</sub>
Sodium phosphate	Na <sub>3</sub> PO <sub>4</sub>		

a. In a titration, 20 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> HCl reacted with 25 cm<sup>3</sup> of NaOH.

What was the concentration of the sodium hydroxide?



*1 mole of acid neutralises 1 mole of alkali.*

*Number of moles of acid present  $n=c \times v = 2 \times 0.02=0.04$  moles, moles of acid present is same as moles of alkali present. Concentration of sodium hydroxide*

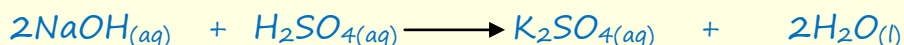
$$c = n/v \quad 0.04/0.31 = 1.29 \text{ mol dm}^3$$

b. In a titration,  $25 \text{ cm}^3$  of  $1.25 \text{ mol dm}^{-3}$  HCl reacted with  $25 \text{ cm}^3$  of KOH.

What was the concentration of the potassium hydroxide?

$$c = 1.25 \text{ mol/dm}^3$$

c. In a titration,  $25 \text{ cm}^3$  of  $1.25 \text{ mol dm}^{-3}$  sulphuric acid,  $\text{H}_2\text{SO}_4$ , reacted with  $25 \text{ ml}$  of NaOH. What was the concentration of the sodium hydroxide?



$$\text{Moles of sulfuric acid present} = 1.25 \times 0.025 = 0.03125 \text{ moles}$$

There will be twice as many moles of NaOH present,  $0.03125 \times 2 = 0.0625$  moles

$$c = n/v \quad 0.0625/0.025 = 2.5 \text{ mol/dm}^3$$

d. In a titration,  $18 \text{ cm}^3$  of  $1.5 \text{ mol dm}^{-3}$  nitric acid,  $\text{HNO}_3$ , reacted with  $25 \text{ cm}^3$  of KOH. What was the concentration of the sodium hydroxide?

$$c = 1.08 \text{ mol/dm}^3$$

10. A student carried out a titration and obtained the following results:

Burette reading/ml	Volume/ml	First trial/ml	second trial/ml	third trial/ml
Initial	1.0	1.5	1.0	1.0
Final	25.5	26.0	25.6	25.5
Titre (amount used)	24.5	24.5	24.6	24.5



- a. Calculate the mean titre for these titrations.  $(24.5 + 24.6 + 24.5) / 3 = 24.5 \text{ ml}$
- b. How precise were the students results? Results are precise, results are closely grouped together. All within 0.1ml
- c. calculate the uncertainty in the mean titre. Uncertainty is half the smallest scale division on the burette, burette reads to 0.1ml, so uncertainty is  $\pm 0.05 \text{ ml}$