

## Taking it Further: Calculating Unknown Concentrations

Answer the questions below.

1. State the quantity that is measured with the unit mol/dm<sup>3</sup>.

**Concentration.**

2. Calculate the concentration (in mol/dm<sup>3</sup>) of a solution that has 2 moles of solute dissolved in 100 cm<sup>3</sup> of solution.

**20 mol/dm<sup>3</sup>**

3. Complete the following general equation: Acid + Alkali →

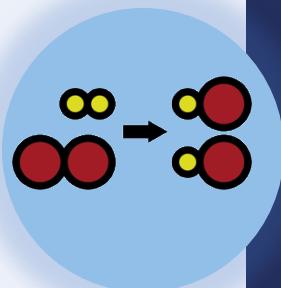
**Salt + water**

4. What type of reaction is described in question 3?

**A neutralisation reaction**

5. State the colour of universal indicator in an acidic solution.

**Red/Orange**



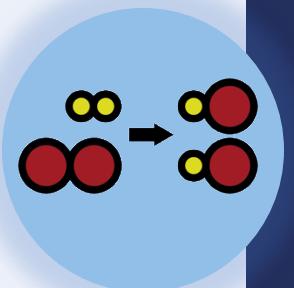
## Taking it Further: Calculating Unknown Concentrations

### **Do Now:**

1. State the quantity that is measured with the unit mol/dm<sup>3</sup>.
2. Calculate the concentration of a solution that has 2 moles of solute dissolved in 100 cm<sup>3</sup> of solution.
3. Complete the following general equation: Acid + Alkali →
4. What type of reaction is described in question 3?
5. State the colour of universal indicator in an acidic solution.

### **Drill:**

1. What type of solution would have a pH of 10?
2. What type of ions would be present in a solution with a pH of 10?
3. Which electrode would these ions travel towards in electrolysis?

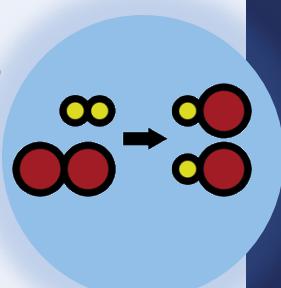


## Taking it Further: Calculating Concentration

### **Read Now:**

Depression is a serious risk to the mental health of people around the world. Low vitamin D levels in the blood are associated with a greater risk of depression. This is especially concerning for those of us living in the UK and Ireland. This is because humans naturally get our vitamin D from sunlight, which we don't get a lot of in our countries, especially in winter! Those of us who spend a lot of time indoors, or who wear clothes that cover up most of our skin, are at a greater risk of vitamin D deficiency. Doctors recommend that most people living here take a vitamin D supplement, especially during the winter months when we get the least amount of sunlight. Scientists recently carried out a study to investigate the blood concentration of vitamin D in 56 patients (aged 18-60 years), all of whom had mild to moderate depression. They found that following 8 weeks of vitamin D supplementation, a significant proportion of patients reported a reduction in the severity of their depression.

1. What is the relationship between vitamin D and depression?
2. Why is this relationship especially important for us to understand in the UK and Ireland?
3. Why do doctors recommend that people take vitamin D supplements in the winter months?
4. What did scientists find out in their study?



# Taking it Further: Calculating Unknown Concentrations

C4.3.6

Science  
**Mastery**

C4.3.1 Prior Knowledge Review

C4.3.2 (HT) Introducing the Mole

C4.3.3 (HT) Mole Calculations

C4.3.4 PKR: Concentration

C4.3.5 TIF: Calculating Concentration

➤ **C4.3.6 TIF: Calculating Unknown Concentrations**

C4.3.7 (HT) Amounts of Substances in Equations

C4.3.8 (HT) Limiting Reactants

C4.3.9 PKR: Reactions of Acids

C4.3.10 Acids, Alkalies and Neutralisation

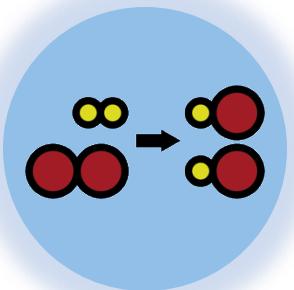
C4.3.11 TIF: Acid-Alkali Titration

C4.3.12 TIF: Acid-Alkali Titration Analysis

C4.3.13 TIF: Titration Calculations

C4.3.14 (HT) Strong and Weak Acids

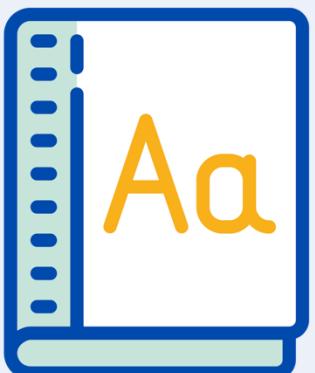
C4.3.15 TIF: Volumes of Gases



## Following this lesson, students will be able to:

- Deduce the molar ratio of acid: alkali in a neutralisation reaction
- Use molar ratio to calculate the number of moles of acid that react with a known number of moles of alkali
- Calculate the concentration of one reactant in a neutralisation reaction, when the concentration and volume of the other reactant is known.

### Key Words:



mass      volume      concentration  
moles      molar ratio

# This is the fix-it portion of the lesson

The **fix-it** is an opportunity to respond to gaps in knowledge, especially those identified by the **pre-unit quiz**.

- The teacher should customise this slide as needed, to facilitate
  - **reteach, explanation, demonstration or modelling** of ideas and concepts that students have not yet grasped or have misunderstood.
  - **practise** answering specific questions or of key skills.
  - **redrafting** or **improving** previous work.

## Answer the questions below.

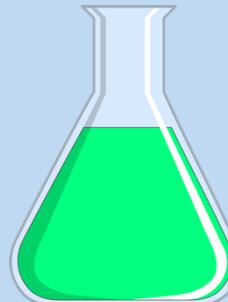
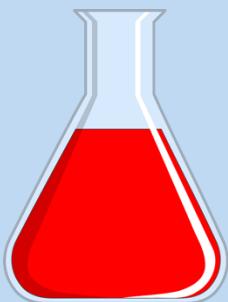
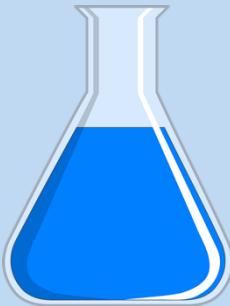
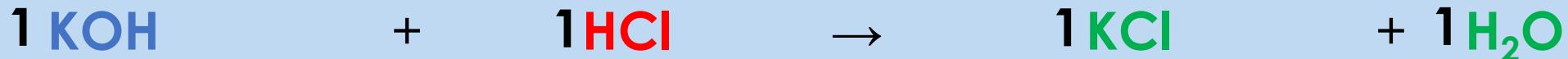
1. Calculate the concentration of a 750 cm<sup>3</sup> solution that contains 1.5 mol of solute.
  - A. 1.5 mol/dm<sup>3</sup>
  - B. 0.02 g/dm<sup>3</sup>
  - C. 2 mol/dm<sup>3</sup>
2. Calculate the number of moles in 2 dm<sup>3</sup> of 0.5 mol/dm<sup>3</sup> solution.
  - A. 4 mol
  - B. 1 mol
  - C. 0.25 mol
3. 80 g of sodium hydroxide ( $M_r = 40$ ) is dissolved in solution. How many moles of solute are in the solution?
  - A. 2 mol
  - B. 0.5 mol
  - C. 3200 mol

# Linking an equation to the number of moles

Let's take the example of a neutralisation reaction,

**Higher Tier only**

Potassium hydroxide + hydrochloric acid → Potassium chloride + water



This equation tells us that **1 mole of potassium hydroxide** reacts with **1 mole of hydrochloric acid**, to make **1 mole of potassium chloride** and **1 mole of water**.

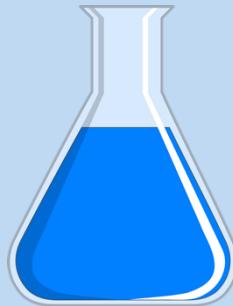
A student carried out the neutralisation reaction of potassium hydroxide and hydrochloric acid. The equation for the reaction is  $\text{KOH} + \text{HCl} \rightarrow \text{KCl} + \text{H}_2\text{O}$ . The student reacted 5 moles of potassium hydroxide. How many moles of hydrochloric acid reacted? **5 moles**

# Linking an equation to the number of moles

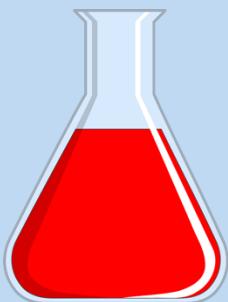
Let's take the example of a neutralisation reaction,

**Higher Tier only**

Sodium hydroxide + sulfuric acid → sodium sulfate + water



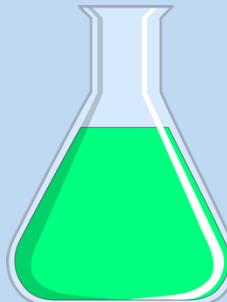
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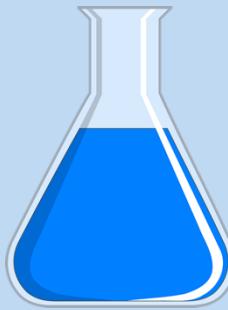


This equation tells us that **2 moles of sodium hydroxide** reacts with **1 mole of sulfuric acid**, to make **1 mole of sodium sulfate** and **2 moles of water**.

A student carried out the neutralisation reaction of sodium hydroxide and sulfuric acid. The equation for the reaction is  $2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$ . The student reacted 6 moles of sodium hydroxide. How many moles of sulfuric acid reacted? **3 moles**

# Calculating an Unknown Concentration

**Higher Tier only**



**Volume = 0.15 dm<sup>3</sup>**

**Concentration = 0.5 mol/dm<sup>3</sup>**

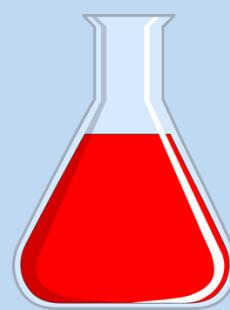
$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

**number of moles**

*= concentration × volume*

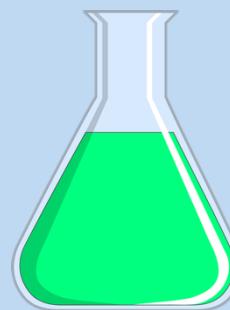
$$\text{number of moles} = 0.5 \times 0.15$$

$$= \underline{\underline{0.075 \text{ moles}}}$$



**Volume = 0.05 dm<sup>3</sup>**

**Concentration = ?**



**The mole ratio of alkali : acid is 1 : 1, or 0.075 : 0.075**

$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

$$\text{Concentration} = \frac{0.075}{0.05} = \underline{\underline{1.5 \text{ mol/dm}^3}}$$

# Calculating an Unknown Concentration

**Higher Tier only**

Sodium hydroxide + sulfuric acid → sodium sulfate + water



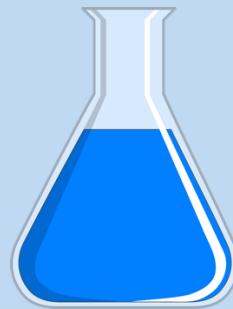
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**Volume = 25 cm<sup>3</sup>**

**Concentration = 0.2 mol/dm<sup>3</sup>**

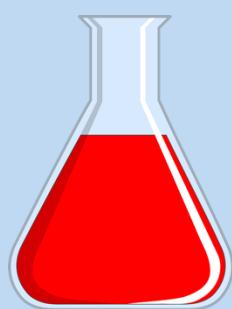
$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

**number of moles**

$$= \text{concentration} \times \text{volume}$$

$$\text{number of moles} = 0.2 \times 0.025$$

$$\equiv 0.005 \text{ moles}$$



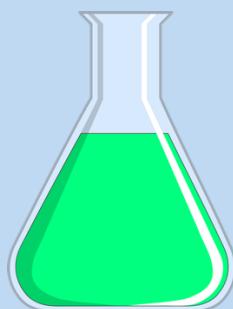
**Volume = 15 cm<sup>3</sup>**

**Concentration = ?**

**The mole ratio of alkali : acid is 2 : 1, or 0.005 : 0.0025**

$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

$$\text{Concentration} = \frac{0.0025}{0.015} \equiv 0.167 \text{ mol/dm}^3$$



**Discuss the answer to these questions with your partner.**

A student carried out a neutralisation reaction.

The equation for the reaction is  $\text{Ca}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$ .

The student reacted  $25 \text{ cm}^3$  of calcium hydroxide. The calcium hydroxide had a concentration of  $0.05 \text{ mol/dm}^3$ .  $10 \text{ cm}^3$  of acid reacted.

1. Name the acid  
and the alkali in  
this reaction.

2. How many  
moles of the  
alkali reacted?

3. How many  
moles of the acid  
reacted?

4. What was the  
concentration of  
the acid?

## Drill

1. State the equation that links concentration, mass and volume.
2. State the equation that links concentration, number of moles and volume.
3. State the equation that links number of moles, mass and relative formula mass.
4. Write a unit of volume.
5. Write a unit of concentration.
6. State the mole ratio of acid to alkali for the equation  $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
7. Calculate the number of moles for a solution with a volume of  $50 \text{ cm}^3$  and a concentration of  $0.5 \text{ mol/dm}^3$ .
8. Calculate the volume of a solution that contains 0.5 moles of solvent in a solution of concentration  $1.5 \text{ mol/dm}^3$

## Drill answers

1. Concentration =  $\frac{\text{mass}}{\text{volume}}$
2. Concentration =  $\frac{\text{number of moles}}{\text{volume}}$
3. Number of moles =  $\frac{\text{mass}}{M_r}$
4. dm<sup>3</sup> (or cm<sup>3</sup>)
5. Mol/dm<sup>3</sup> (or g/dm<sup>3</sup>)
6. The mole ratio of acid: alkali is 1:1
7. 0.025 moles
8. 0.33 dm<sup>3</sup>

# Calculating an Unknown Concentration

**Higher Tier only**

Sodium hydroxide + sulfuric acid → sodium sulfate + water



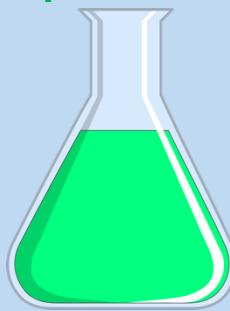
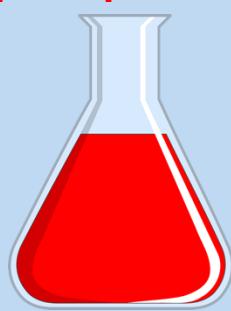
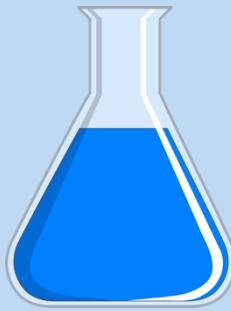
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**Volume = 25 cm<sup>3</sup>**

**Concentration = 0.02 mol/dm<sup>3</sup>**

$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

$$\text{number of moles} = \text{concentration} \times \text{volume}$$

$$\text{number of moles} = 0.02 \times 0.025$$

$$\equiv 0.0005 \text{ moles}$$

**Volume = 15 cm<sup>3</sup>**

**Concentration = ?**

**The mole ratio of alkali : acid is 2 : 1, or 0.0005 : 0.00025**

$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

$$\text{Concentration} = \frac{0.00025}{0.015} \equiv 0.0167 \text{ mol/dm}^3$$

## Answer the questions below.

1. What is the equation that links concentration, number of moles and volume?

- A. Concentration =  $\frac{\text{number of moles}}{\text{volume}}$
  - B. Number of moles =  $\frac{\text{concentration}}{\text{volume}}$
  - C. Concentration = number of moles  $\times$  volume
2. Calculate the number of moles in 100 cm<sup>3</sup> of 0.2 mol/dm<sup>3</sup> solution.
- A. 20 mol
  - B. 2 mol
  - C. 0.02 mol

Sodium hydroxide reacts with hydrochloric acid:



3. What is the mole ratio of alkali to acid in this reaction?

- A. 1:1
- B. 4:2
- C. Need more information

## Lesson C4.3.6

What was good about this lesson?

What can we do to improve this lesson?

[Send us your feedback by clicking this link](#)  
or by emailing [sciencemastery@arkonline.org](mailto:sciencemastery@arkonline.org)  
Thank you!