Solutions and Concentrations

Indicates a Flash activity.
Indicates an accompanying worksheet.
Indicates that there are teacher’s notes.
Indicates that 'How Science Works' skills are covered.

For more detailed instructions, see the Getting Started presentation.
Solutions and Concentrations

- Solutions
  - Calculating concentrations
  - Dilutions
  - Summary activities
What is a solution?

A **solution** is a homogeneous mixture of two or more substances.

In a **homogeneous** mixture, the components are distributed uniformly.

Instant coffee is an example of a solution. The liquid is a uniform brown, and the components will not spontaneously separate. A stable mixture has been formed.

How many other examples of solutions can you think of?
At the molecular level, mixing occurs between the components of a solution.

A substance that dissolves other substances is called a **solvent**. The solvent is usually the primary component of a solution. Water is a common solvent.

A substance that dissolves in a solvent is called a **solute**. Coffee granules are the solute in instant coffee.
The concentration of a solution determines the number of particles of solute in a particular volume.

The greater the concentration the more solute particles there are in the same amount of space.
Solutions and Concentrations

Solutions

Calculating concentrations

Dilutions

Summary activities
Measuring concentrations

It is rarely sufficient to say that one concentration is higher or lower than another. Concentrations usually need to be measured accurately.

There are two ways of measuring concentration:

- **mass** per unit volume, e.g. grams per decimetre cubed
- **moles** per unit volume, e.g. moles per decimetre cubed.

A **cubic decimetre** (dm$^3$) is a unit of volume. One decimetre is equivalent to 1000 cm$^3$.

\[
1 \text{ cm}^3 \quad \text{divide by 1000} \quad 1 \text{ dm}^3
\]

\[
1 \text{ cm}^3 \quad \text{multiply by 1000} \quad 1 \text{ dm}^3
\]
Volume unit conversions

Do you know your centimetres from your decimetres?

Press "start" to begin.

start
Concentrations in g/dm³

The following equation gives concentration in g/dm³:

\[
\text{concentration} = \frac{\text{mass dissolved (g)}}{\text{volume of solution (dm}^3\text{)}}
\]

If 1.0 g of solid sodium hydroxide is dissolved in 250 cm³ of water, what is the concentration in g/dm³?

\[
\text{concentration} = \frac{1 \text{ g}}{250 \text{ cm}^3} = \frac{1 \text{ g}}{0.25 \text{ dm}^3} = \frac{1}{0.25} \frac{\text{g}}{\text{dm}^3} = 4 \text{ g/dm}^3
\]

convert the units
Calculating concentrations in g/dm³

You will need this equation to answer the following questions about chemical concentrations:

\[
\text{concentration} = \frac{\text{mass dissolved}}{\text{volume of solution}}
\]

Press "start" to begin.
Concentrations in mol/dm$^3$

To calculate concentration in mol/dm$^3$:

$$\text{concentration} = \frac{\text{number of moles (mol)}}{\text{volume of solution (dm}^3\text{)}}$$

This equation can be added to a formula triangle to rearrange the formula:

$$c = \frac{n}{v}$$

$$n = c \times v$$

$$v = \frac{n}{c}$$
Concentrations in mol/dm$^3$ – example

If 1.0 g of solid sodium hydroxide (NaOH) is dissolved in 250 cm$^3$ of water, what is the concentration in mol/dm$^3$?

The information in the question provides the volume but not the number of moles. The following formula is required:

$$c = \frac{\text{number of moles}}{0.25 \text{ dm}^3}$$

The number of moles can be calculated as follows:

$$\text{number of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{1}{40} = 0.025 \text{ mol}$$

Now substitute 0.025 mol into the original formula:

$$c = \frac{0.025 \text{ mol}}{0.25 \text{ dm}^3} = 0.1 \text{ mol/dm}^3$$
Calculating concentrations in mol/dm$^3$

You will need this equation to answer the following questions about chemical concentrations:

$$\text{concentration} = \frac{\text{moles dissolved}}{\text{volume of solution}}$$

Press "start" to begin.
What volume of 0.80 mol/dm$^3$ potassium bromide solution contains 1.6 moles of potassium bromide?

This calculation is simply a matter of substituting the values into the rearranged formula:

$$v = \frac{n}{c} = \frac{1.6}{0.8} = 2 \text{ dm}^3$$
Rearranging formulae – example 2

How many moles of copper sulfate are there in 250 cm$^3$ of 0.2 mol/dm$^3$ copper sulfate solution?

Step 1: convert the units

$250 \text{ cm}^3 = 0.25 \text{ dm}^3$

Step 2: substitute into the formula

$n = c \times v$

$n = 0.2 \times 0.25$

$= 0.05 \text{ mol}$
Calculating mass of solute

What mass of copper sulfate (CuSO$_4$) was used to make 250 cm$^3$ of 0.02 mol/dm$^3$ copper sulfate solution?

**Step 1:** Calculate the number of moles of copper sulfate

**Step 2:** Rearrange the moles formula to give the mass value

This is simply an extension of the previous calculation, from which the moles of copper sulfate was found to be 0.05 mol.

mass of copper sulfate = number of moles × molar mass

= 0.05 × 159.6

= 8.0 g
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Stock solutions

In a laboratory, substances are often stored as **stock solutions**.

These solutions are prepared using calculations similar to the ones you have just used.

Stock solutions are frequently made to concentrations greater than would be required in an experiment. Why do you think this is?

In order for the solutions to be used in an experiment they frequently need to be diluted.
Performing a dilution

Prepare a 0.1 mol/dm³ solution of sulfuric acid from a stock solution which has a concentration of 1.0 mol/dm³.

The stock solution requires diluting by a factor of 10.

The required solution can be made from:
- 9 parts distilled water
- 1 part stock solution
A standard solution is a solution of a **known concentration**.

Press "**play**" to see how a standard solution of sodium hydroxide is prepared.

4 g/dm$^3$
Common uses of dilutions

Dilutions have important uses outside laboratories. In fact, you will probably come into contact with dilutions in your everyday lives.

- Orange squash and fruit cordials are sold as concentrates. They might be prepared with one part concentrate to four or five parts water.

- Baby milk formulas are often sold as powders or liquid concentrates which require diluting before use.

Can you think of any other examples?
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**Glossary of keywords: solutions and concentrations**

**concentration** – A measure of how much solute is dissolved in a solution.

**cubic decimetre** – A unit of volume. One decimetre is equivalent to 1000 cm³.
Can you find the solution to these questions?

Press "start" to begin.