F6 Recording data and uncertainty

This is the sixth lesson in an introductory course for post-16 chemistry learners covering key ideas in order of scale. Find out more about the course and approach here: rsc.li/4kGyaoN

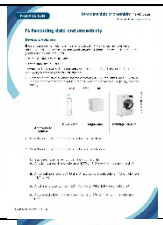
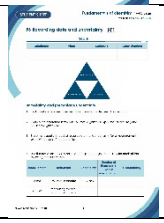
Before each lesson, ask learners to complete the preparation worksheet to revise knowledge from their 14–16 courses or previous lessons and introduce the topic for the lesson.

Then, get them to complete the student sheet during the lesson. It includes all key content and challenges misconceptions. Each student sheet has a scale and a Johnstone's triangle diagram at the top. Use these to help learners think about the relative scale of different aspects of chemistry and connect their understanding of sub-microscopic, macroscopic and symbolic representations.

This icon indicates that students will need access to learning materials e.g. textbook or online resources to support their learning, see rsc.li/4m4UObJ for links.

Begin each lesson by checking learners have completed the preparation work. Share the answers and ask learners to mark their own worksheets as part of their independent work.

Topics in this lesson

	Last lesson	F5 Light and electron energy levels
	**Preparation worksheet**	Revision: volumes New content: making measurements
	**Lesson worksheet**	Making measurements practise; uncertainty and percentage uncertainty; repeated measurements
	Next lesson	F7 Electronic structure: sub-shells and orbitals

This lesson provides an introduction to laboratory work as learners use a range of measuring equipment to make measurements to the appropriate precision. They are asked to draw a diagram to show the correct way to fill volumetric glassware with a solution before moving on to practise. Then they predict and compare the accuracy of different pieces of glassware to measure 25 cm^3 of water.

© 2025 Royal Society of Chemistry

Answers

Revision: volumes

1. Drinks bottle = 500 cm^3; sugar cube = 1 cm^3; washing machine = 1 m^3
2. Divide the volume in cm^3 by 1 x 10^{-6} to get the volume in m^3.
3. Multiply the volume in cm^3 by 1000 to get the volume in dm^3.

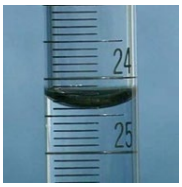
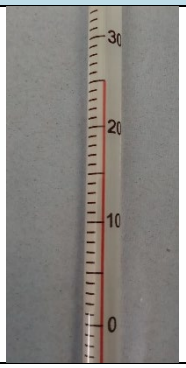
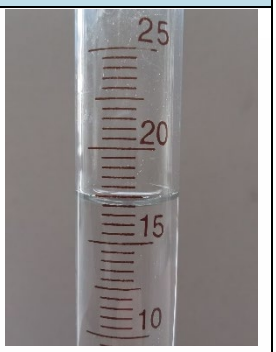
4.

(a)

$$\frac{1600}{1000} = 1.6\ dm^3$$

(b) 1.35 × 1000 = 1350 cm^3
(c) 375 × 1,000,000 = 375,000,000 cm^3
(d) 6.54 × 10^{-3} m^3

New content: making measurements

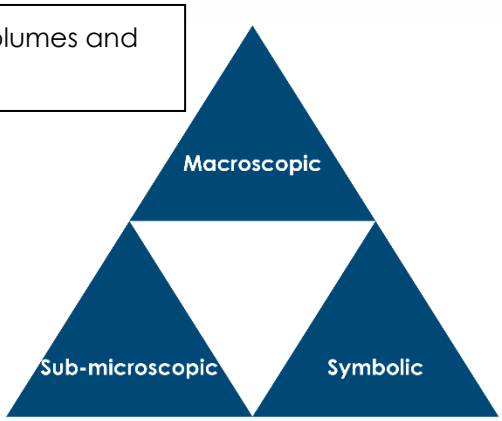
Equipment	Burette	Thermometer	Measuring cylinder (cm^3)	Measuring cylinder (cm^3)
Picture of scale				
Smallest division	0.1 cm^3	1°C	0.2 cm^3	0.5 cm^3
Half of the smallest division	0.05 cm^3	0.5°C	0.1 cm^3	0.25 cm^3
Reading shown in diagram	24.40 cm^3	25.0°C	2.4 cm^3	17 cm^3

All measured on the line. Therefore, e.g. the burette measurement is 24.40, whereas if the meniscus was between the lines, it would be 24.45.

© 2025 Royal Society of Chemistry

Worksheet

Measuring volumes and equipment



Uncertainty and percentage uncertainty

1. The instrument has a limitation; it's not a mistake.
2. Volumetric glassware measures one amount very precisely. Quantitative glassware measures an approximate amount.
3. $$\%\ \text{uncertainty} = 100 \times \frac{\text{uncertainty of scale} \times \text{number of times used}}{\text{amount measured}}$$
4.

Measurement	Instrument	Uncertainty	Number of times scale used in measurement	% Uncertainty
25 cm^3	volumetric pipette	0.06 cm^3	**1**	$\frac{0.06}{25} \times 100 = 0.24\%$
25 cm^3	measuring cylinder with 1 cm^3 division	**0.5cm^3**	**1**	$\frac{0.5}{25} \times 100 = 2\%$
25 cm^3	beaker, division 25 cm^3	**12.5cm^3**	**1**	$\frac{12.5}{25} \times 100 = 50\%$
25 cm^3	burette, division 0.1cm^3	**0.05**	**2**	$\frac{2 \times 0.05}{25} \times 100 = 0.4\%$
250cm^3	volumetric flask (250 cm^3)	0.24 cm^3	**1**	$\frac{0.24}{250} \times 100 = 0.096\%$
12.22 g	balance (2 decimal places) mass measured by difference	**0.01**	**2**	$\frac{0.01 \times 2}{12.22} \times 100 = 0.16\%$

© 2025 Royal Society of Chemistry

12.220 g	balance (3 decimal places) mass measured by difference	**0.001**	**2**	$\frac{0.001 \times 2}{12.220} \times 100 = 0.016\%$
temperature change of 22.5 °C	thermometer (1°C division)	**0.5**	**2**	$\frac{2 \times 0.5}{22.5} \times 100 = 4.44\%$

5.

$$\frac{0.06}{25} \times 100 = 0.24\%$$

6.

$$\frac{\text{uncertainty}}{12} \times 100 = 0.833\%$$

$$\frac{0.833}{100} \times 12 = \text{uncertainty}$$

$$= 0.09996$$

Smallest division on the scale is 2 x uncertainty

$$0.09996 \times 2 = 0.199$$

$$= 0.2 \text{ cm}^3$$

7.

(a) Note: scale = 1°C, therefore 0.5°C used for accuracy.

Experiment	Final temp. (°C)	Initial temp. (°C)	Temp. change (°C)
1	23.0	21.0	2.0
2	27.0	23.0	4.0
3	28.0	22.0	6.0
4	23.0	21.0	2.0

(b) Mean temperature change $= \frac{(2+4+6+2)}{4} = 3.5$°C

(c)

$$\frac{0.5 \times 2}{3.5} \times 100 = \frac{1}{3.5} \times 100 = 28.6\%$$

(d) Not necessarily, because one or more of the measured values could be an anomaly

8. Accuracy is the closeness of a measurement to the accepted reference value. Precision is when measurements taken are similar to one another.

9. To look for anomalies and to spot systematic errors.

© 2025 Royal Society of Chemistry