

Laboratory Equipment and Safety

How do you work safely and choose the right equipment in the lab?

●○○ Beginner

Foundations

Last reviewed 5 October 2026

Before you start: it helps to understand Significant Figures and Measurement.

What is it?

A chemistry lab is a safe place **when everyone follows the same rules**. Two skills go together:

- **Safety:** recognizing hazards, wearing the right protection and working in a way that prevents accidents.
- **Equipment:** knowing what each piece of apparatus is for and **how precisely** it measures, so that results are reliable.

Hazards are communicated worldwide with the **GHS** (Globally Harmonized System) pictograms: red-bordered diamonds printed on bottles and on **safety data sheets (SDS)**.

Pictogram	Meaning	Example
Flame	Flammable	Ethanol, propanone (acetone)
Flame over circle	Oxidizer: makes fires burn more fiercely	Concentrated hydrogen peroxide, potassium nitrate
Exploding bomb	Explosive or self-reacting	Some peroxides
Gas cylinder	Gas under pressure	Oxygen and nitrogen cylinders
Corrosion	Destroys skin, eyes or metal	Concentrated acids, sodium hydroxide
Skull and crossbones	Toxic: can kill in small amounts	Mercury compounds
Exclamation mark	Harmful or irritant	Dilute ammonia solution
Health hazard	Long-term harm (e.g. cancer, damage to organs)	Benzene
Environment	Toxic to aquatic life	Copper(II) sulfate

The **signal word** shows severity: **Danger** for the more serious hazards, **Warning** for the less serious ones.

KEY IDEA

Before any practical, ask three questions: **What are the hazards?** (read the label and the SDS), **How could I be harmed?** and **What will I do to reduce the risk?** This is a **risk assessment**, and every professional chemist does one.

Why does it matter?

- **Your safety and others'.** Most lab accidents come from a few avoidable causes: no eye protection, spills, heating carelessly and mixing up bottles.
- **Reliable results.** Using a beaker to measure 25.00 mL, or reading a burette from above, gives results that no calculation can rescue.
- **Every later practical depends on it**, from making solutions (molarity) to titrations.

How does it work?

1. Protective equipment and safe habits

- Wear **safety goggles** at all times while chemicals are in use; add a lab coat and, when needed, gloves. Tie back long hair; wear closed shoes.
- **No eating or drinking** in the lab, and never taste or directly sniff a chemical: waft the vapour gently towards your nose if told to smell it.
- Use a **fume cupboard** for toxic or smelly gases and volatile solvents.
- When heating a test tube, point it **away** from everyone. Keep flammable liquids away from flames; use a water bath or hot plate instead.
- To dilute a concentrated acid, **add acid to water**, slowly, never water to acid: the mixing releases heat, and adding water to acid can make it boil and spit.
- Never pipette by mouth; use a pipette filler.
- Report every spill, breakage and injury at once. Know where the eyewash, safety shower and fire blanket are. Dispose of waste as instructed, not down the sink by default.

2. Equipment and its precision

Apparatus	Use	Typical tolerance (class A)
Beaker	Holding, mixing, heating	Marks only approximate (about $\pm 5\%$)
Conical flask	Swirling, titrations	Marks only approximate
Measuring cylinder, 100 mL	Measuring volumes roughly	± 0.5 mL
Burette, 50 mL	Adding a variable, measured volume (titration)	± 0.05 mL
Volumetric pipette, 25 mL	Delivering one fixed volume	± 0.03 mL
Volumetric flask, 250 mL	Making a solution of exact volume	± 0.15 mL
Top-pan balance	Weighing	± 0.01 g
Analytical balance	Accurate weighing	± 0.0001 g

The **percent uncertainty** compares equipment fairly:

$$\begin{aligned} &\text{percent uncertainty} \\ &= \frac{\text{uncertainty}}{\text{measured value}} \times 100\% \end{aligned}$$

3. Reading a scale

- Liquids in narrow glassware form a curved surface, the **meniscus**. For water and most solutions, read the **bottom** of the meniscus.
- Your eye must be **level** with the meniscus. Reading from above or below gives a **parallax error**.
- Record one more digit than the smallest graduation by estimating between the lines: a burette marked every 0.1 mL is read to **two decimal places**, for example 23.35 mL.
- A burette reads **downwards** from 0.00 mL at the top. The volume delivered (the **titre**) is the final reading minus the initial reading.

THINK OF IT LIKE THIS

Using the right glassware is like choosing the right kitchen tool: you can measure a teaspoon of salt with a mug, but you wouldn't expect the cake to come out the same twice. A beaker is the mug; a volumetric pipette is the measuring spoon.

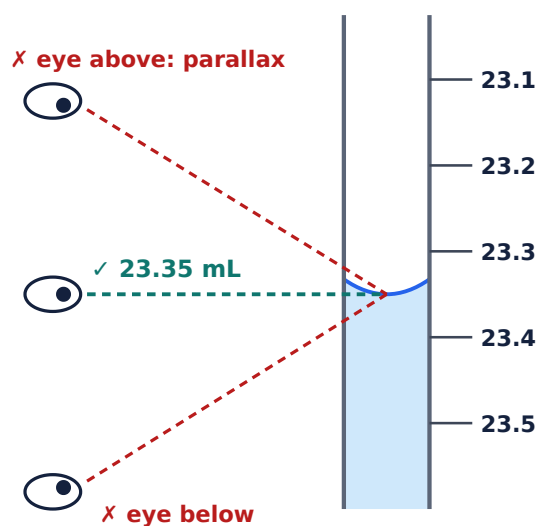
🔍 MORE PRECISELY

Glassware is made to two standards: **class A** (tighter tolerances, for accurate analysis) and **class B** (about twice the tolerance). The tolerance is printed on the glass. Pipettes and flasks are calibrated at a stated temperature, usually 20 °C, and are marked “Ex” (calibrated to deliver) or “In” (calibrated to contain). The tolerance is a limit on the **systematic error** of the item; replicate measurements show the **random error** of your technique.

Visualise it

Reading a burette

Bottom of the meniscus, eye level with it.



Read the bottom of the meniscus with your eye level with it.

Worked example

WORKED EXAMPLE: Choosing equipment by percent uncertainty

Question: You need 25.0 mL of a solution. Compare the percent uncertainty using a 100 mL measuring cylinder (± 0.5 mL) and a 25 mL volumetric pipette (± 0.03 mL).

Step 1 Measuring cylinder:

$$\frac{0.5 \text{ mL}}{25.0 \text{ mL}} \times 100\% \\ = 2\%$$

Step 2 Volumetric pipette:

$$\frac{0.03 \text{ mL}}{25.0 \text{ mL}} \times 100\% \\ = 0.12\%$$

Step 3 The pipette is far more precise. Use it whenever an **exact** volume matters, for example in a titration.

WORKED EXAMPLE: Finding a titre

Question: A burette reads 0.50 mL at the start of a titration and 23.35 mL at the end. What volume was delivered?

$$\text{titre} = 23.35 \text{ mL} - 0.50 \text{ mL} \\ = 22.85 \text{ mL}$$

Both readings are recorded to two decimal places, so the titre is also given to two decimal places.

WORKED EXAMPLE: Planning a safe method

Question: A student plans to warm ethanol over a Bunsen burner and to dilute concentrated sulfuric acid by pouring water into it. Identify the hazards and improve the plan.

Step 1 Ethanol carries the **flame** pictogram: its vapour catches fire easily. Warm it in a **water bath** (hot water from a kettle, or a beaker of water on a hot plate), with no flames nearby.

Step 2 Concentrated sulfuric acid carries the **corrosion** pictogram, and mixing it with water releases a lot of heat. **Add the acid slowly to the water**, stirring, wearing goggles and gloves.

Common mistake

COMMON MISTAKE: Measuring with a beaker

The marks on a beaker are only a rough guide. “50 mL” in a beaker could be several millilitres out. Use a measuring cylinder for rough volumes and a pipette or burette for accurate ones.

COMMON MISTAKE: Reading the top of the meniscus, or from an angle

For water-based solutions, read the **bottom** of the curve, with your eye **level** with it. Looking from above or below shifts the reading (parallax).

COMMON MISTAKE: Adding water to concentrated acid

The heat released can make the water boil instantly and spray acid. Always add **acid to water**, slowly.

NOTATION NOTE

- Record a burette reading to two decimal places even when the last digit is zero: 24.00 mL, not 24 mL.
- “ ± 0.05 mL” is the tolerance of the item; a result is reported as mean $\pm$ standard deviation of replicates.

Remember this

REMEMBER THIS

- Read the label and the SDS; know the GHS pictograms; **Danger** is more severe than **Warning**.
- Goggles on; no eating or drinking; fume cupboard for harmful vapours; add acid to water.
- Beakers and flasks are for holding; cylinders for rough volumes; pipettes, burettes and volumetric flasks for accurate ones.
- Percent uncertainty = $\text{uncertainty} \div \text{measured value} \times 100 \%$.
- Read the bottom of the meniscus at eye level; a burette is read to two decimal places; titre = final – initial.

References

1. United Nations. Globally Harmonized System of Classification and Labelling of Chemicals (GHS), 10th revised ed.; United Nations: New York and Geneva, 2023. [Link](#)
2. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

Practise this topic with flashcards and a quiz at chemistryclarity.com/chemistry/laboratory-equipment-and-safety/