Accuracy and Precision

Grade 9 – 10 science · measurement and lab skills

Name: Date: Score: / 26

The digit you are allowed to guess

Counting significant figures in a printed number is the easy half of this topic. The hard half is deciding how many digits a reading is entitled to in the first place, and that is settled at the instrument.

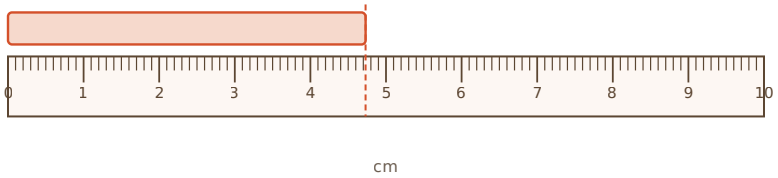
The rule is the same for every analogue scale: write down every digit the marks give you for certain, then **estimate one more** between the marks. A cylinder marked every 1 mL is read to the nearest 0.1 mL. The estimated digit is uncertain, but it is still significant, and leaving it off reports less than the instrument can do.

Accuracy and **precision** are separate questions. Accuracy is how close a reading is to the truth; precision is how close repeated readings are to each other. Readings can be beautifully precise and completely wrong, which is what a systematic error looks like, and taking more of them will not help.

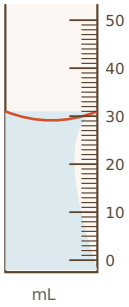
The rules

- Read every digit the **marks** give you for certain.
- Then **estimate one more** digit between the marks. That estimated digit is significant and must be written down.
- A scale marked every 1 mL is read to the **nearest 0.1 mL**.
- **Accuracy** is how close a reading is to the true value.
- **Precision** is how close repeated readings are to each other.
- A set of readings can be precise and wrong: that is a **systematic** error, and taking more readings will not fix it.

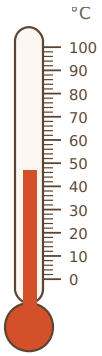
Part A — Read the instruments record each reading with the right number of figures (8 marks)



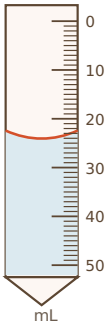
Ruler, marked every 0.1 cm



Cylinder, marked every 1 mL



Thermometer, marked every 2 °C



Burette, marked every 0.1 mL, reads downward

1. Ruler: _____ significant figures: _____

2. Cylinder: _____ significant figures: _____

3. Thermometer: _____ significant figures: _____

4. Burette: _____ significant figures: _____

Part B — How far can you read it? (4 marks)

Instrument	Estimate to the nearest…
A ruler marked every 1 mm	
A cylinder marked every 10 mL	
A balance reading to 0.01 g	
A thermometer marked every 5 °C	

Part C — Accuracy or precision? label each target (4 marks)



A B C D

1. Write "accurate", "precise", "both" or "neither" for each target: A _____ B _____ C _____ D _____

Part D — Think it through (10 marks)

1. A student masses the same object four times and gets 12.41 g, 12.42 g, 12.41 g and 12.42 g. The true mass is 12.00 g. Describe the readings using both words, and suggest what caused it.

2. Another student records a cylinder marked every 1 mL as "24 mL". Explain what is wrong with that and write it correctly.

3. Explain why taking more readings fixes one of these two kinds of error but not the other.

Accuracy and Precision — Answer Key

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Part A — Read the instruments

1. Ruler → **4.73 cm** (3 s.f.)
2. Cylinder → **31.0 mL** (3 s.f.)
3. Thermometer → **47.0 °C** (3 s.f.)
4. Burette → **22.40 mL** (4 s.f.)

> In every case the final digit is the estimated one, read between the marks.

Part B — How far can you read it?

1. A ruler marked every 1 mm → **0.1 mm**
   For example 12.34 cm.
2. A cylinder marked every 10 mL → **1 mL**
   For example 85.0 mL.
3. A balance reading to 0.01 g → **0.001 g**
   For example 4.567 g.
4. A thermometer marked every 5 °C → **0.5 °C**
   For example 36.5 °C.

Part C — Accuracy or precision?

1. **A — Accurate and precise.**
   Close together and centred on the true value.
2. **B — Precise but not accurate.**
   Tightly grouped but off target: a systematic error, such as a balance that was never zeroed. More readings will not help.
3. **C — Accurate but not precise.**
   Scattered, but centred, so the average is close. Random error.
4. **D — Neither.**
   Scattered and off target.

Part D — Think it through

1. **Precise but not accurate.**
   They agree to within 0.01 g but sit 0.41 g above the true mass. A balance left unzeroed, or the object weighed in its container, would do this; any systematic cause earns the mark.
2. **It should be 24.0 mL.**
   Marks every 1 mL are estimated to the nearest 0.1 mL, so the tenths digit is written even when it is zero.
3. **Averaging reduces random error but not systematic error.**
   Random errors fall either side of the truth and cancel. A systematic error pushes every reading the same way, so the average stays wrong by the same amount however many you take.