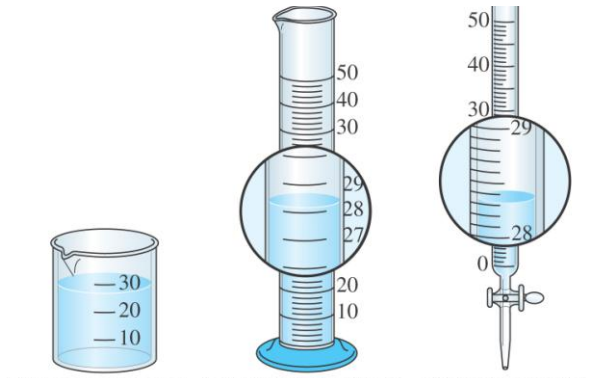
Uncertainty in measurement

- *Every measurement has error associated with it.*
- *The more precise the measurement the less error.*
- *Error in a measurement is indicated by the number of significant figures in the number*

Uncertainty in measurement

- *Which measurement has less error?*
- *Which measurement is more precise?*
- *Which measurement has more significant figures?*

29.2°C or 29.25°C

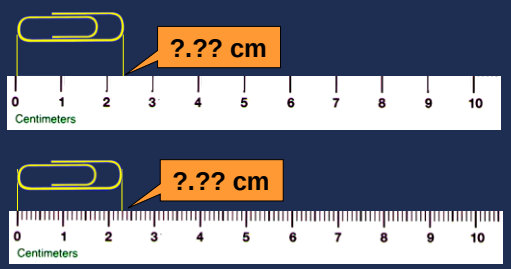


(a) Beaker calibrated in 10-milliliter units (b) Graduated cylinder calibrated in milliliters (c) Buret calibrated in tenths of a milliliter

Significant Figures

- **Indicate precision of a measurement.**
  Sig. figs. do not apply to exact numbers
- **Recording Sig Figs**
  - Sig figs in a measurement include the known digits plus a final estimated digit

ignificant Figures (cont.)



Significant Figures (cont)

- **Counting Sig Figs** (p.18)
  - Count all numbers EXCEPT:
    - Leading zeros -- 0.0025
    - Trailing zeros without a decimal point -- 2,500

Significant Figures (cont)

Counting Sig Fig Examples

1. 23.50 — 4 sig figs
2. 402 — 3 sig figs
3. 5,280 — 3 sig figs
4. 0.080 — 2 sig figs

SEE SUMMARY PAGE 21

Calculating with Significant Figures

- **Rounding numbers**

Definition - Dropping insignificant digits after a calculation.

DOES NOT APPLY TO MEASUREMENTS

Calculating with Significant Figures (cont)

Rounding rules:

1. **Round starting from the first digit to the right of the uncertain digit.**
2. **If the digit to be dropped is less than 5 leave the digit before it unchanged**

Example: round *6.784998* to 3 sig. figs.:

6.784998

Numbers to be kept

Numbers to drop

rounds to 6.78

Calculating with Significant Figures (cont)

Rounding rules (cont):

3. **If the digit to be dropped is 5 or more increase the digit before it by one.**

Example: round *6.785498* to 3 sig. figs.:

6.785498

Numbers to be kept

Numbers to drop

rounds to 6.79

Calculating with Significant Figures (cont)

- **Multiply/Divide - The # with the fewest sig figs determines the # of sig figs in the answer.**

$(13.91 g/cm^3)(23.3 cm^3) = 324.103 g$

4 SF 3 SF

3 SF

324 g

Calculating with Significant Figures (cont)

Add/Subtract - The # with the lowest decimal value determines the place of the last sig fig in the answer.

3.75 mL
+ 4.1 mL
7.85 mL → 7.9 mL

224 g
+ 130 g
354 g → 350 g

Calculating with Significant Figures (cont)

- **Calculating with Sig Figs (con't)**
  - Exact Numbers do not limit the # of sig figs in the answer.
    - Counting numbers: 12 students
    - Exact conversions: 1 m = 100 cm
    - "1" in any conversion: 1 in = 2.54 cm

Calculating with Significant Figures (cont)

Practice Problems

(15.30 g) ÷ (6.4 mL) = 2.390625 g/mL

```
  18.9   g
- 0.84 g
  18.06 g
```

Scientific Notation

65,000 kg → 6.5 × 10^4 kg

- **Converting into Sci. Notation:**
  - Move decimal until there's 1 digit to its left. Places moved = exponent.
  - Large # (>1) ⇒ positive exponent
    Small # (<1) ⇒ negative exponent
  - Only include sig figs.

Scientific Notation (cont.)

Practice Problems

7. 2,400,000 μg **sci. notation**
8. 0.00256 kg **sci. notation**
9. 7 × 10^{-5} km **decimal notation**
10. 6.2 × 10^4 mm **decimal notation**

Scientific Notation

- **Calculating with Sci. Notation**

(5.44 × 10^7 g) ÷ (8.1 × 10^4 mol) =

Type on your calculator:

5.44 [EXP/EE] 7 [÷] 8.1 [EXP/EE] 4 [EXE/ENTER]

= 671.6049383

Scientific Notation

- **Rounding**

(5.44 × 10^7 g) ÷ (8.1 × 10^4 mol) =

3 sig figs 2 sig figs

= 671.6049383 = 670 g/mol = 6.7 × 10^2 g/mol