Measurements in the Laboratory

Measurements are made using:

- An instrument marked and/or preprogrammed in standard units
    - Mechanical balance
    - Glassware etched with striations
- A device that can be manually set to deliver a specific volume

The International System of Measurements (SI)

Three categories used for a SI base unit measurement

- Measured Quantity
- Unit Name
- Unit Symbol

Seven SI base units

Quantity	Unit Name	Unit Symbol
Length	Meter	m
Mass	Grams	g
Temperature	Kelvin	K
Time	Second	s
Amount of Substance	Mole	mol
Electrical Current	Ampere	A
Luminous Intensity	Candela	cd

SI unit prefixes

Prefix	Symbol	Multiple Value
mega-	M	1,000,000
kilo-	k	1,000
hecto-	h	100
deca-	da	10
deci-	d	0.1
centi-	c	0.01
milli-	m	0.001
micro-	u	0.000 001

Base units and prefixes are combined to create additional common units for:

Volume Density Acceleration Force

0 7 5 1 9 6 8 4 3 0 0 1 3 8 9 4 6 2 4 6 8 7 9 3 0 1 2 9 9 4 6 8

Significant Figure – Sig Figs

Significant Figure: a measured digit that is known with certainty - represents a true value

- Measured: any measured digit is a significant figure
- Estimated: estimated digits are considered significant figures

Rule	Example	Number of Sig Figs
Digits 1-9 always significant	9845	4
Zeros between significant digits always significant	4102	4
Zeros right of a decimal point always significant	40.020	5
Zeros right of significant digits, no decimal point, not significant Zeros = place holders	4200	2
Zeros left of significant digits with decimal not significant Zeros = place holders	0.002035	4

Mathematical equations with significant figures:

Addition-Subtraction: value with least amount of decimal places reflects amount held by the sum or difference. **9.22 + 6.4 = 15.6** **or…** **9.22 – 6.4 = 2.8**

Multiplication-Division: value with least amount of significant figures reflects amount held by the product or quotient. **9.00 x 6 = 50** **or…** **9.22 / 6.0 = 1.5**

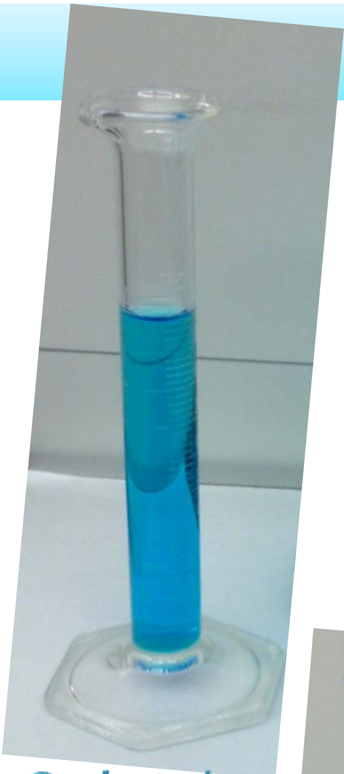
9 x 6 = 54 but the value ‘6’ represents one sig fig, 54 is rounded to 50 giving answer one sig fig

Measuring Liquids

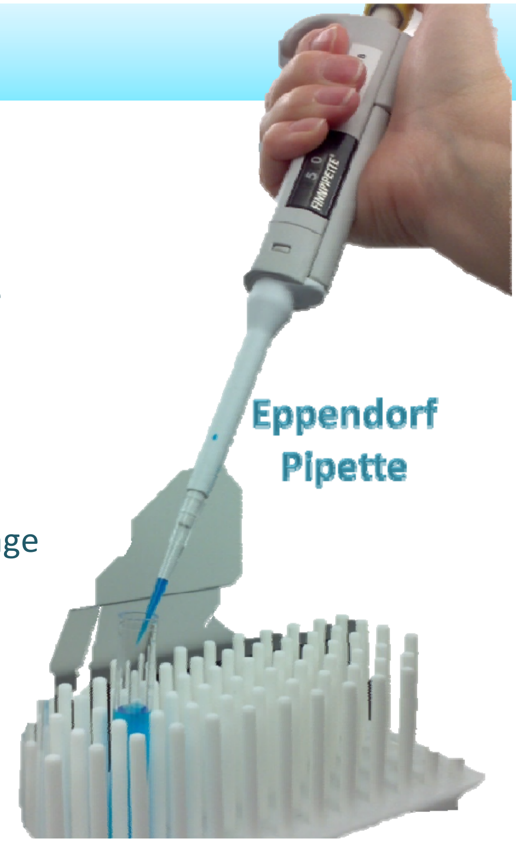
Measuring liquids in a laboratory

Tools used to measure the volume of liquids:

- **Beakers:** least accurate instrument for measuring volume
- **Graduated cylinders:**
- **Volumetric Flask:** used to measure a single predetermined volume
- **Erlenmeyer Flask:** used to measure approximate volumes, mixing, and sample storage
- **Pipettes:** used to measure a volume of liquid that is being transferred to another container



Graduated Cylinder
1% accuracy



Eppendorf Pipette

Volumetric Flask
~ 0.5% accuracy

Beaker
5% accuracy

Erlenmeyer Flask
5% accuracy

1.0 mL

50.0 mL

0.5mL

100.0 mL

5.0 mL

10.0 mL

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Accuracy or Precision?

Measurements for precision should proceed a measurement for accuracy

Accuracy: the nearness of a measure to the true or accepted value.

- ❖1 measurement
- ❖Accepted value = 50.0mL
  Measured value = 49.9mL
  This is a very accurate measurement
- ❖Accepted value = 50.0mL
  Measured value = 39.5mL
  This is an inaccurate measurement

Precision: degree of nearness a group of measured values are to each other.

- ❖multiple measurements
- ❖0.50mL, 0.51mL, 0.49mL, 0.50mL are precise measurements: we can believe that if measured again, we would get 0.50mL + or - 0.01mL.

Accuracy When Measuring Liquids

All measuring devices are subject to error.
When measuring volume with glassware, all measured digits plus one estimated digit are significant.

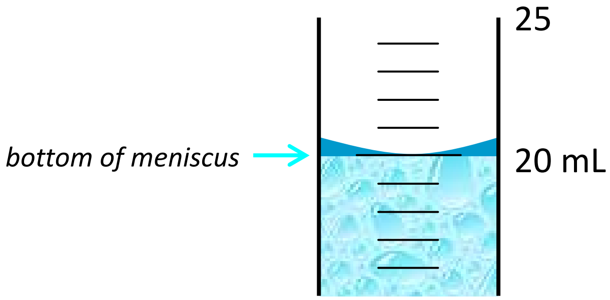
Meniscus: the concave or convex surface of a liquid due to cohesion

When measuring volume using a
- Beaker
- Graduated cylinder
- Volumetric flask
- Erlenmeyer flask
- Graduated and Volumetric Pipette

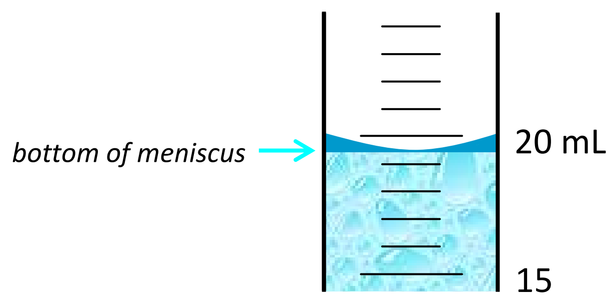
the volume recorded is that at the bottom or top of the meniscus

Fun Fact:
one drop = ~ 50 µL

Concave – molecules of the liquid attracted to container

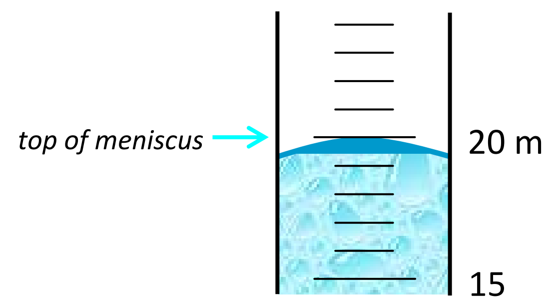


Measured digit = 20 mL
Estimated digit = 0.0 mL
Measured volume = 20.0 mL



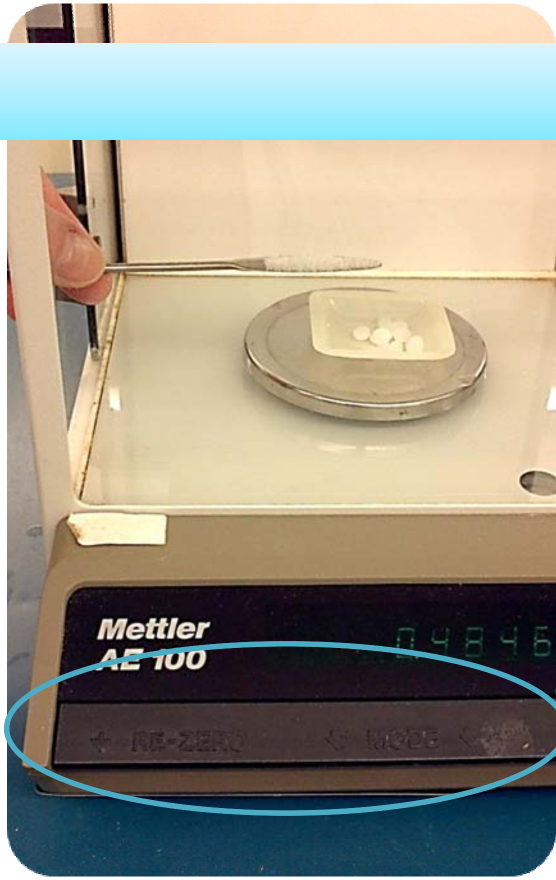
Measured digit = 19 mL
Estimated digit = 0.5 mL
Measured volume = 19.5 mL

Convex – molecules of the liquid attracted to each other



Measured digit = 20 mL
Estimated digit = 0.0 mL
Measured volume = 20.0 mL

Measuring Mass

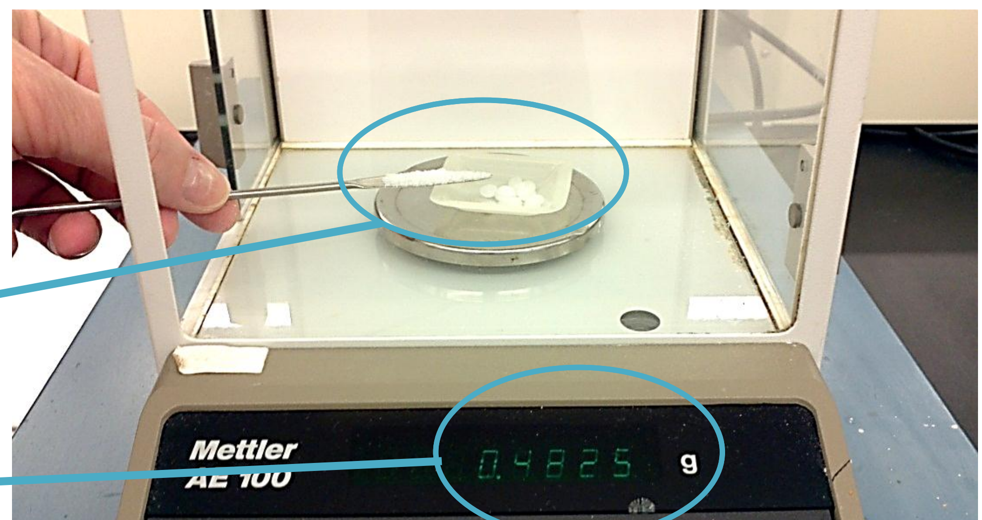


Control bar

Mettler Balance: a mechanical device used to measure mass in grams to the ten-thousandths place of accuracy.

Process of using a Mettle Balance:

1. Interior should be particle free
2. Both side and the top glass doors are shut
3. Balance is then re-zeroed (tared) by pressing the control bar
4. Sample is placed onto the balance
5. All glass doors are shut
6. Once stability of the measured value has been reached, it is recorded as the mass in grams of your sample



Sample + Container

Measured value

Tarring the balance with the clean empty sample container allows for a specific measuring of only the sample's mass.

Sources of Error and Uncertainty

Causes of experimental error:

Procedural limitations

Instrument limitations

Questions to ask yourself:

Was the experiment performed properly?

Were the directions followed correctly?

Was the instrument used correctly?

Were the correct regents and chemicals used?

Was good technique used?

Where calculations performed properly?

Causes of Experimental uncertainty:

Poor precision of the apparatus

Imperfect experimental procedures

Imperfect judgments by the operator

Limitation due to random error

Unpredicted or unforeseen changes in the procedure or experiment

Random errors are sometimes unavoidable

Reducing random errors:

Always use high-quality laboratory equipment

Use consistent technique