Unit 1
Quantitative Chemistry

Warm-up

- Grab a meter stick and measure the length of your "What is the volume of a drop of water?" lab in centimetres.
- Write your answer on the board

S.I. (Systeme International)

S.I. Units in Chemistry

- Mass - kg (kilograms)
- Time - s (seconds)
- Temperature - K (Kelvin)
- Volume - m^3 (cubic meters)
- Pressure - Pa (Pascals)

Error - Unavoidable, but Describable

- There are TWO types of error that can occur in any experiment.
- These are <u>not</u> *could have* or *would have* events! These are things that actually happen during the course of any experiment and we need to be able to discuss and analyze them in order to make relevant suggestions for improvements.

Random vs. Systematic Errors

Random	Systematic
Error in Precision (+/-)	Error in Accuracy (how close to literature values)
Can be minimized by multiple trials (which any good experiment would have)	Cannot be minimized by repeated experiments because it's due to incorrect use of instruments or poor experimental design.
Examples: • readability of instrument • changes in environment (temperature) • misinterpreting the reading	Examples: • An electronic balance that isn't calibrated • Reading the top of the meniscus • Methodological erros
Can happen in BOTH directions	Occurs in ONE direction

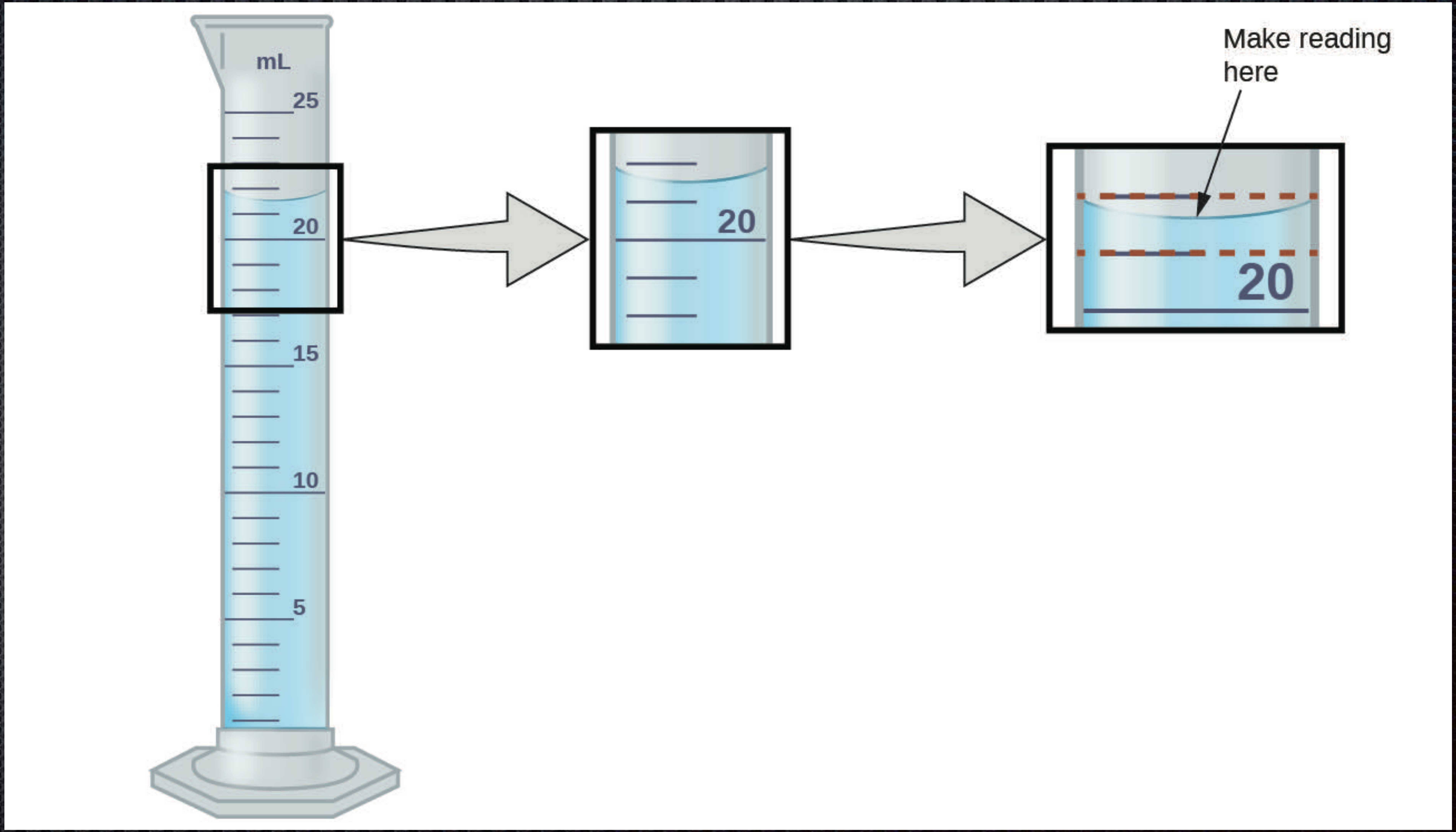
Chemistry TOK

- Systematic errors cannot be reduced by simply repeating the measurement in the same way. If you were inaccurate the first time you will be inaccurate the second.
- So, how do you know you have a systematic error. Why do you trust one set of results more than another?

Measurements

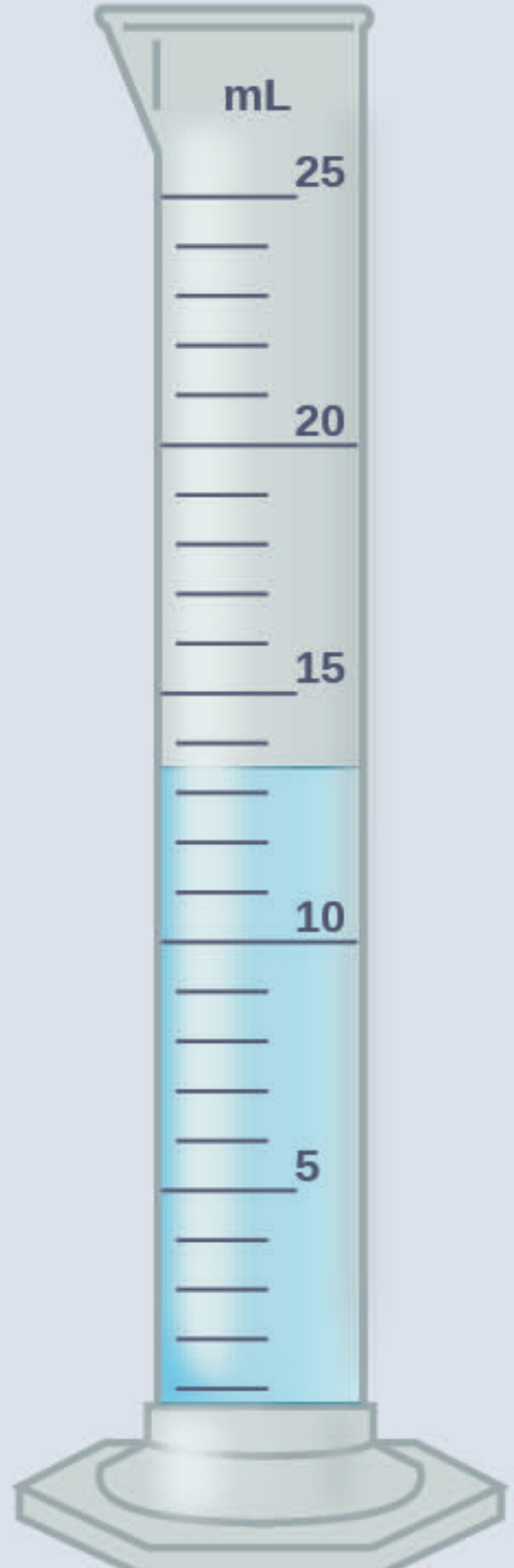
3 Parts to a Measurement

- the measurement
- the uncertainty
- the unit

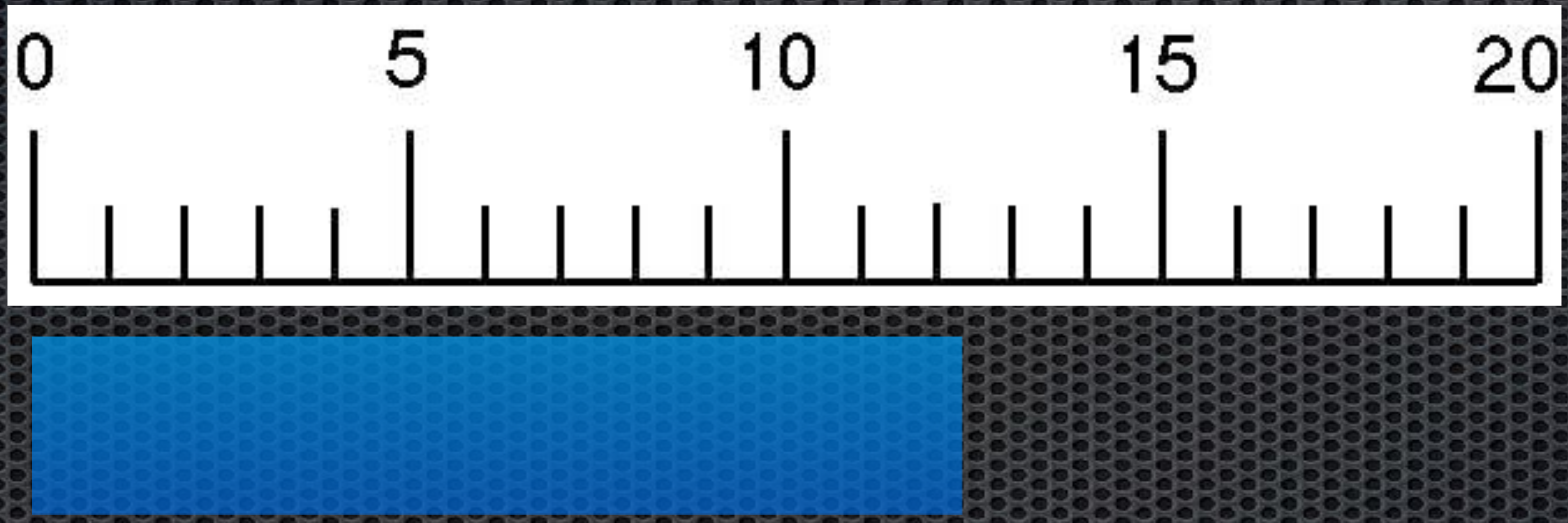


Uncertainty Measurements

- You are reasonably certain that your measurement is between 13.0 and 14.0 mL
- **For an analogue instrument, uncertainty is 1/2 of the smallest scale division.**
- Therefore, we would report this volume as 13.5±0.5 mL
  - (since the smallest scale division is 1 mL)

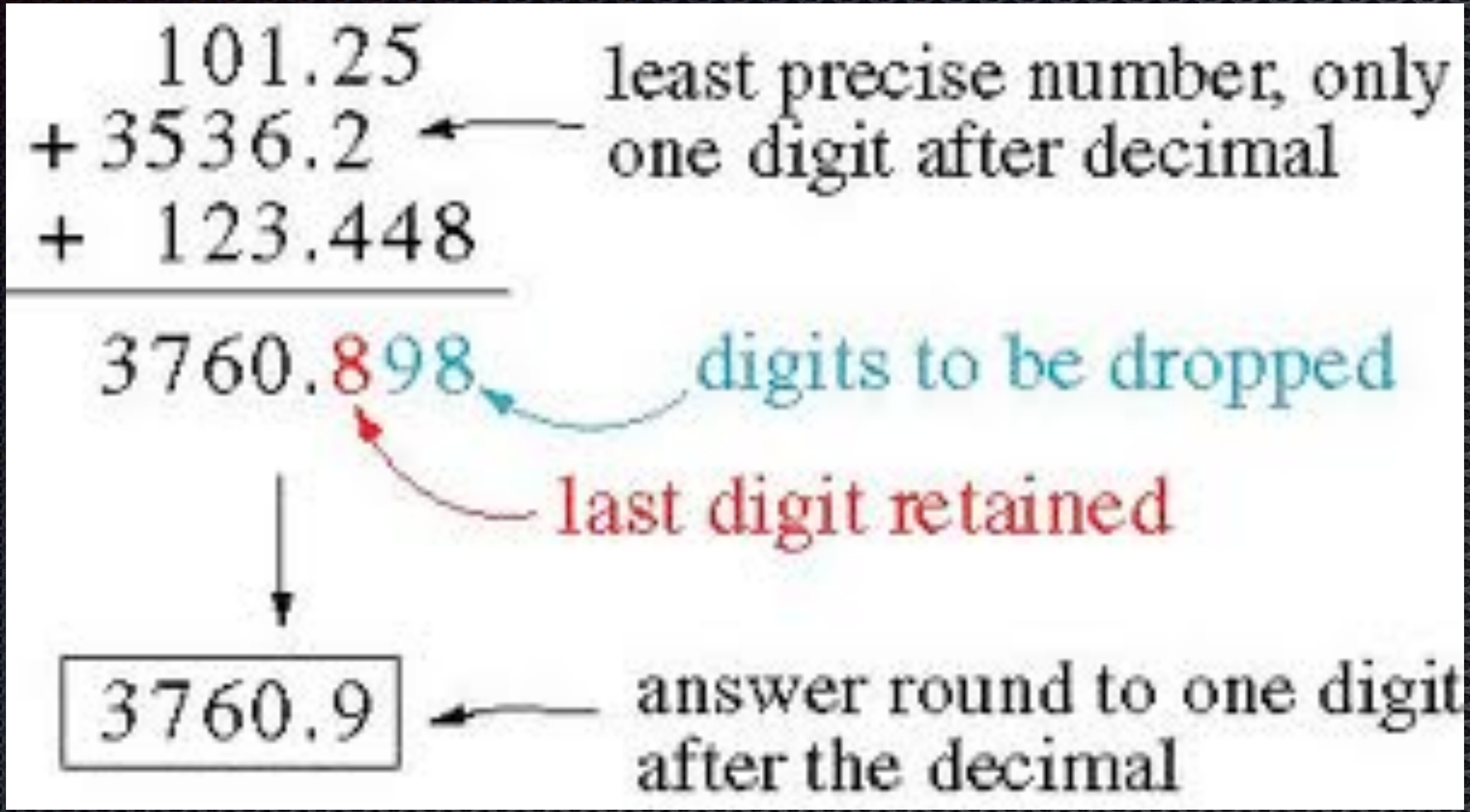


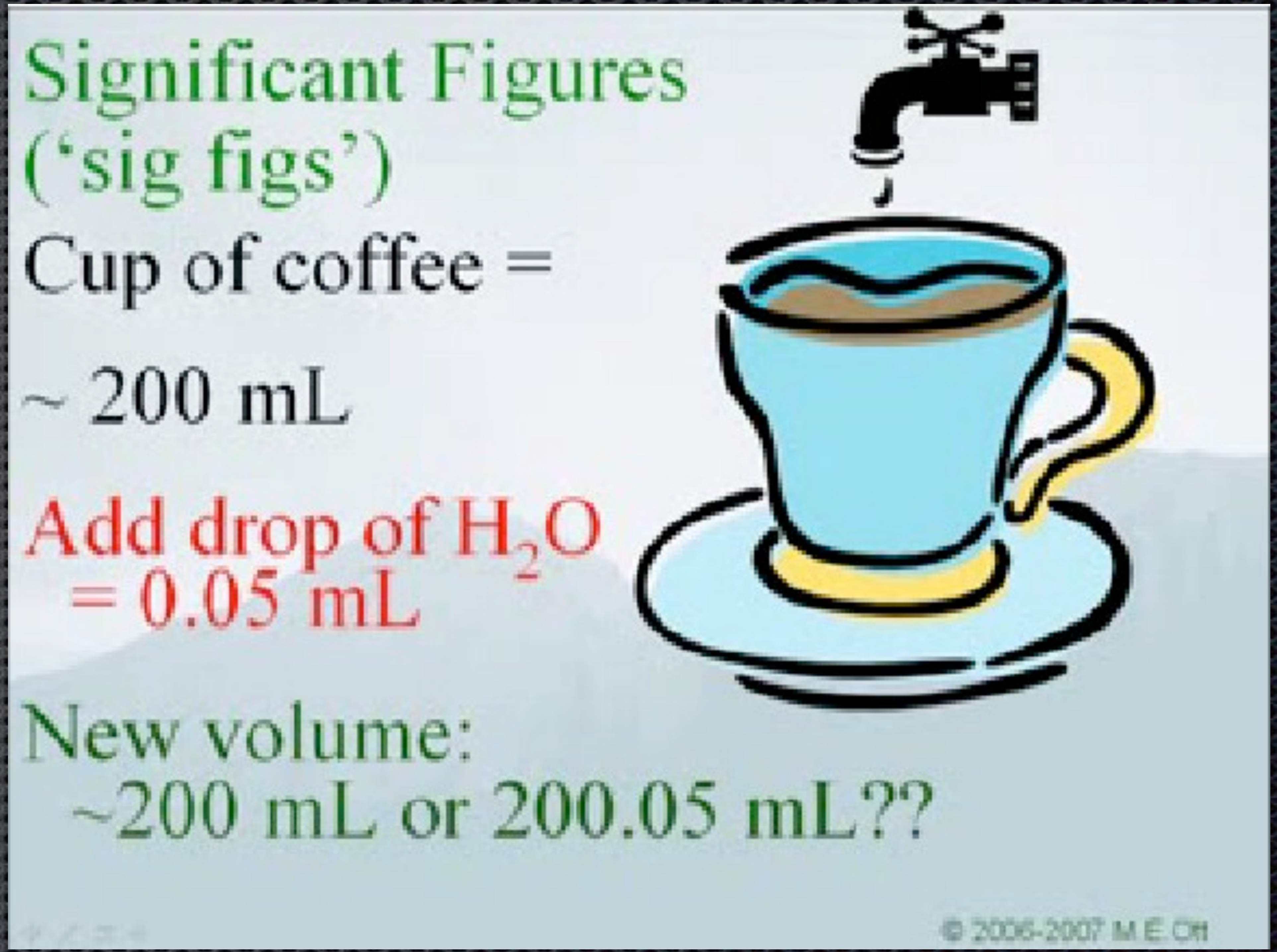
Your Turn...



What is the length of the bar?

Calculations with Sig Figs...





$$\underbrace{38.65}_{\text{4 sig figs}} \times \underbrace{105.93}_{\text{5 sig figs}} = \underbrace{4{,}094.1945}_{\text{reduce to 4 sig figs}}$$

Practice

How Many Sig Figs??

0.00400

10,000

10,000.

105.37

Error Propagation

Uncertainties are approximate!!

- 25.4 +/- 0.1 s
  - uncertainty in same units as measurement is the **absolute uncertainty**
- 25.4 +/- 0.4%
  - percentage uncertainty = uncertainty/measurement x 100%
- *not .39370%…why?*
  - Significant Figures…the error will ALWAYS go to the same decimal place as the measurement.

What happens when....?

- You take more than one measurement?
- For example, 10.0 cm^3 is delivered from a pipette (+/- 0.1cm^3) and repeated 3 total times.
  - The total volume delivered is:
    - 10.0 +/- 0.1 cm^3
    - 10.0 +/- 0.1 cm^3
    - 10.0 +/- 0.1 cm^3

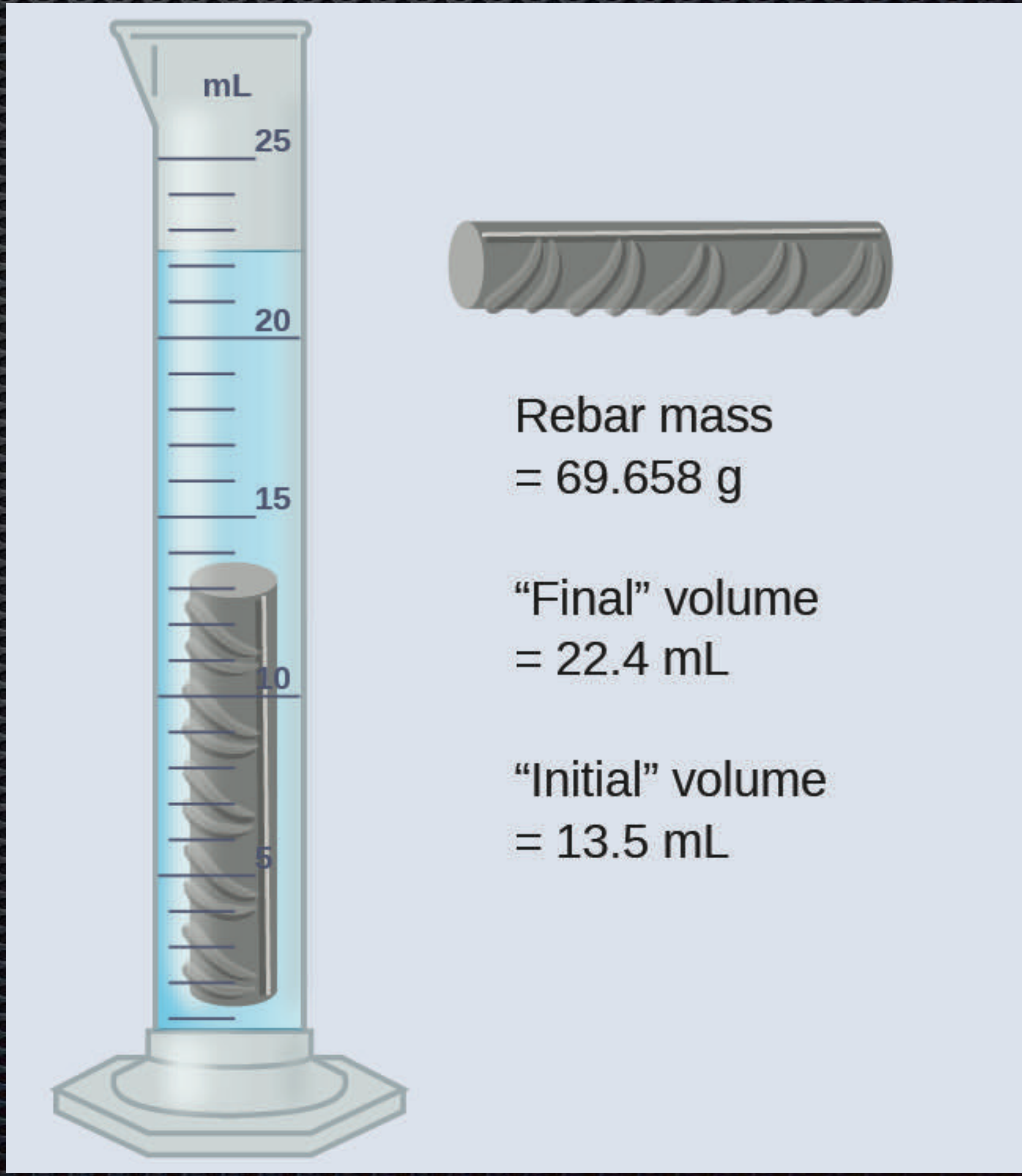
Error is additive!

Another example...

- When using a burette (+/- 0.02cm^3), you subtract the initial volume from the final volume...the volume delivered is:
  - Final volume = 38.46 +/- 0.02cm^3
  - Initial volume = 12.15 +/- 0.02cm^3

Uncertainty in Instruments

- Analogue (graduated cylinder, burette, pipette)
  - 1/2 of the smallest graduation
- Digital (balance)
  - scale reads 100.00 g, the uncertainty is ±0.01 g



Stoichiometry Refresher

- 1 atom of Carbon = 1.99265×10^{-23}g
- 1 mole of Carbon = ???? g

- How do we do it?

Avogadro’s Number

- 6.023×10^{23} “things” in a mole (on Table 1)
- Know 6×10^{23} for Paper 1 questions (no calculators)

Question of the day..

Would you rather be hit with?

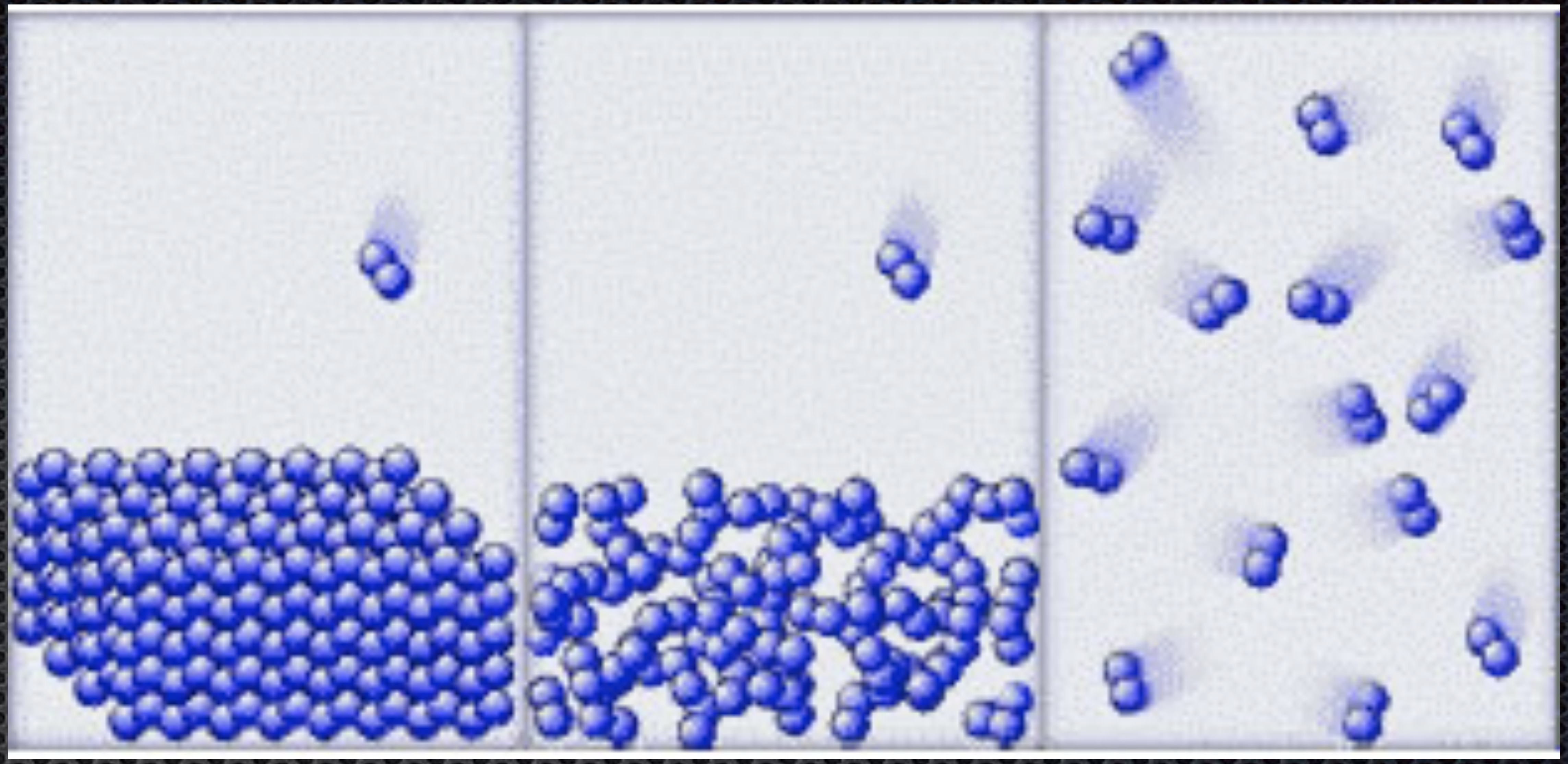
- 400g of solid water
- 400g of liquid water
- 400g of gaseous water

- interparticle forces are negligible
- they are zero for an ideal gas
- no fixed shape or volume

- relatively close together
- forces are weak enough that allows the particles to change places with each other, but their movement is restricted to a fixed volume

- closely packed in fixed positions
- interparticle forces restrict movement to vibration around a fixed position
- fixed shape

Absolute Zero



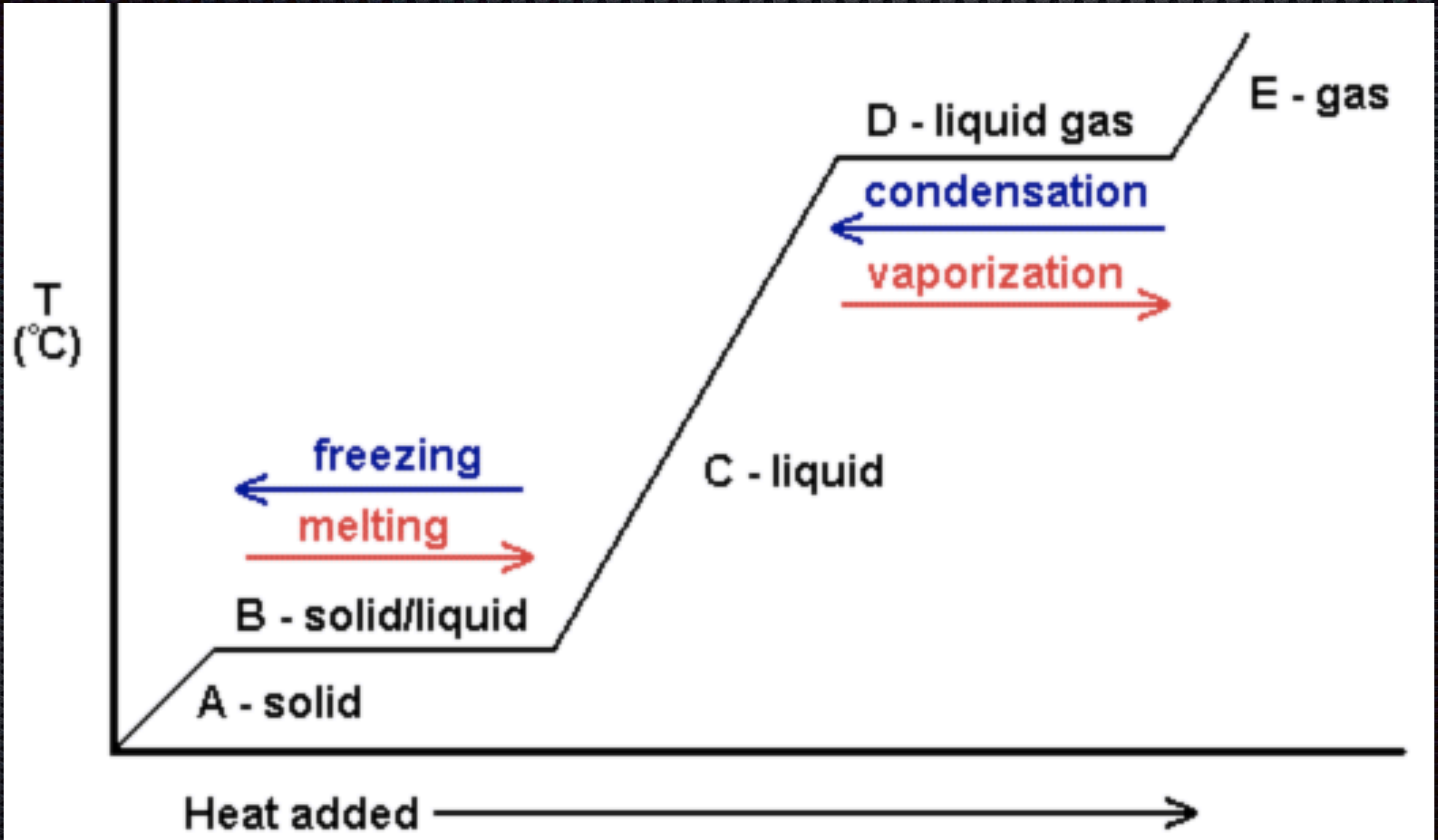
- The point at which all motion stops
- The Kelvin scale emphasizes the relationship between temperature and average kinetic energy of the particles
- Particles move twice as fast @ 200K than they do @ 100K
    - This is NOT true for Celsius!! (different scale!)

Question...

Which of these samples will have the highest kinetic energy?

- He @ 100K
- O_2 @ 300K
- H_2 @ 200K
- H_2O @ 400K

Heating Curve...



Question…

A flask contains water and steam @ its boiling point. Distinguish between the two states on a molecular level by referring to the average speed of the molecules and relative molecular distances.

- Answer:
  - As the two states are @ the same temperature, they have the same average KE and are moving at the same speed. The separation between the particles of the gas is much larger than that in the liquid

Practice...

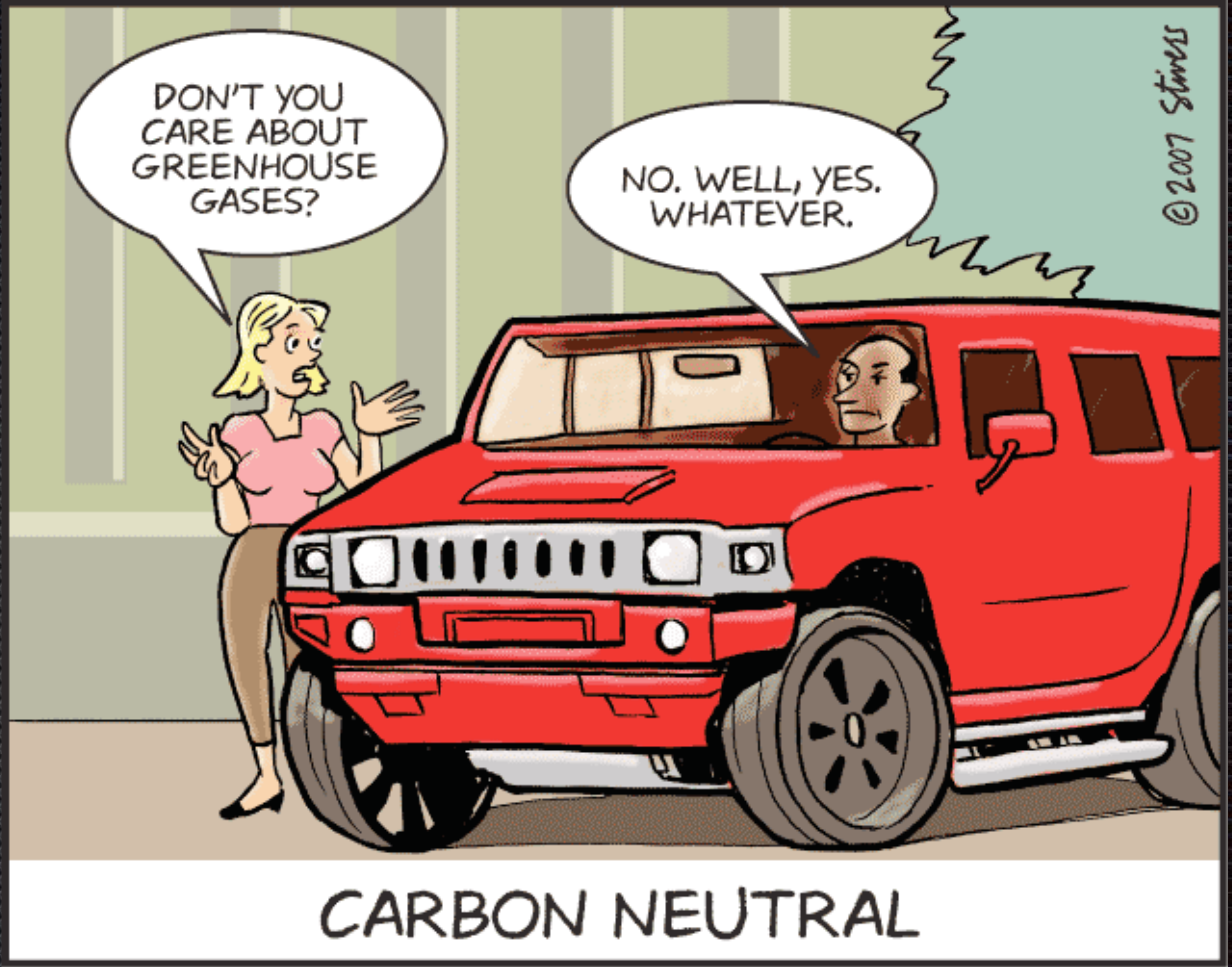
- 40 cm^3 of CO is reacted with 40 cm^3 of oxygen.
    - $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$
- What is the volume of carbon dioxide that it produced? Assume all volumes are measured at the same temperature and pressure.

Molar Volume of a Gas

STP?

Molar Volume

- All gases have the same molar volume at the same temperature and pressure
- STP: 0°C or 273K and 1 x 10^5 Pa
  - one mole of a gas occupies 22,700cm^3 or 22.7dm^3 (L)
- @ 298K a gas will occupy 24L (room temp.)



Calculate...

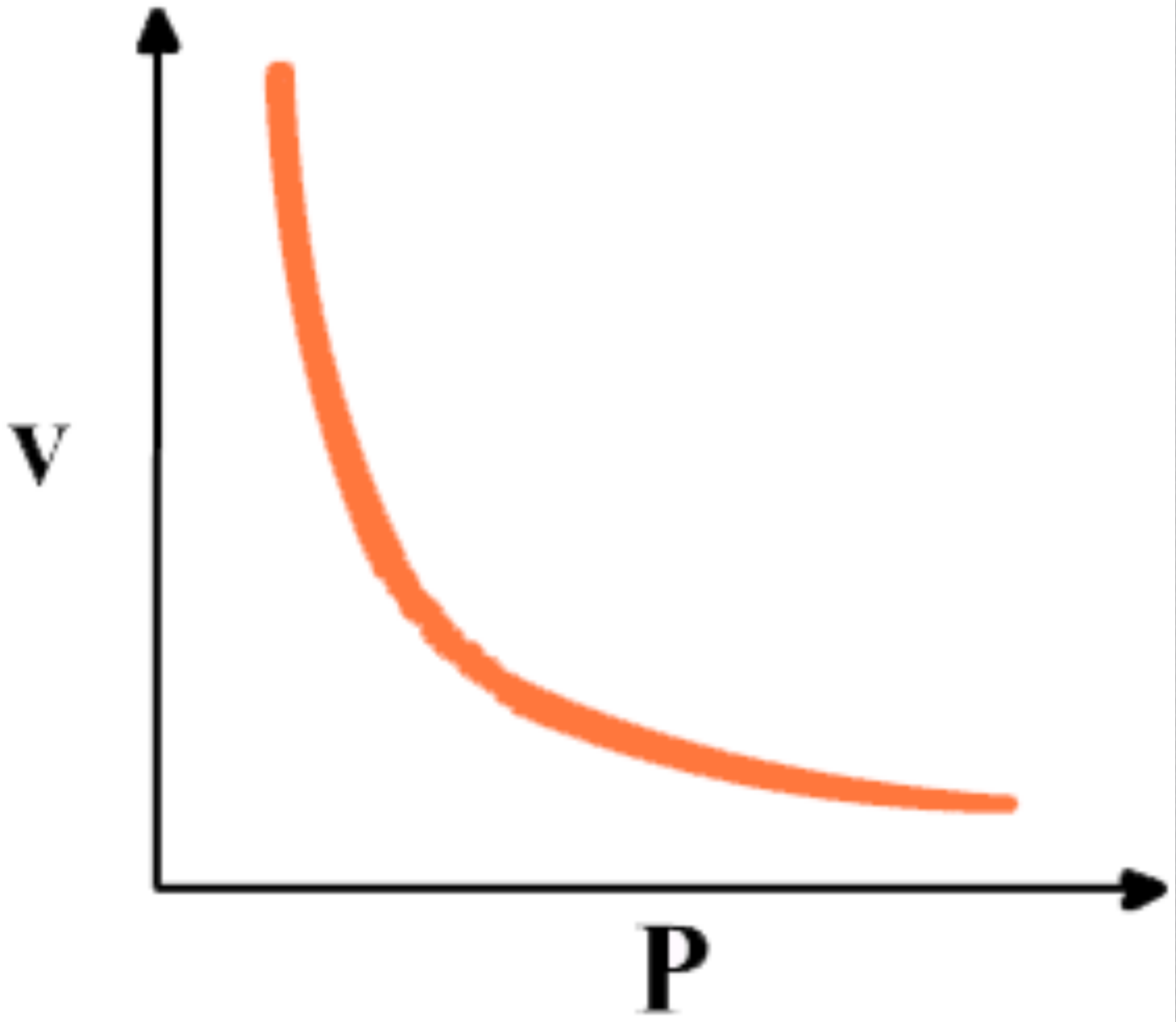
- Calculate the amount (g) of chlorine gas in 44.8 cm^3 @ STP

Another…

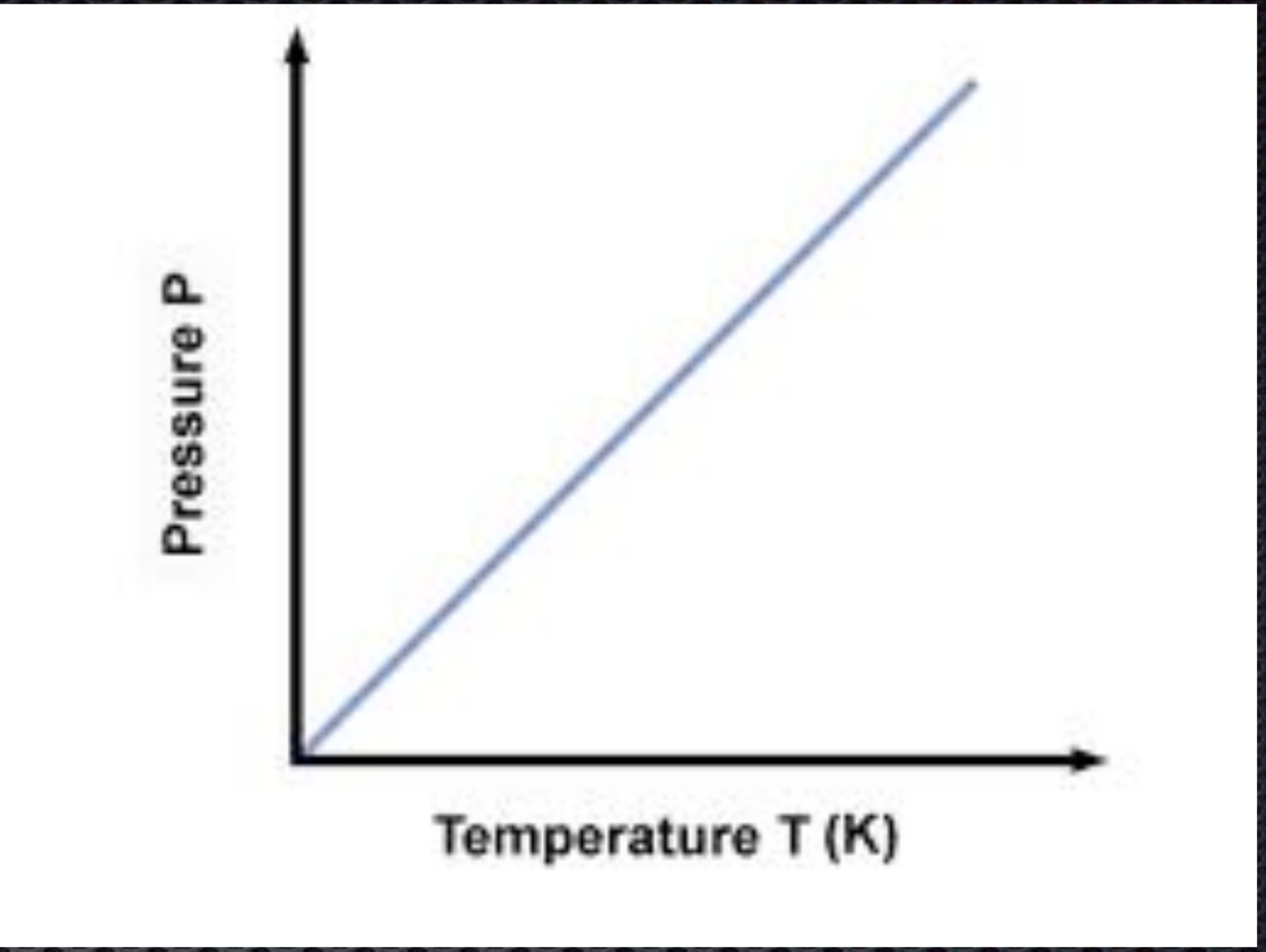
- What **volume** of hydrogen gas is produced when 0.056 grams of Li reacts completely with water?
  - What do you need to know?
  - EQUATION!!
  - $2Li_{(s)} + 2H_2O_{(l)} \rightarrow 2LiOH_{(aq)} + H_{2(g)}$

Gas Laws

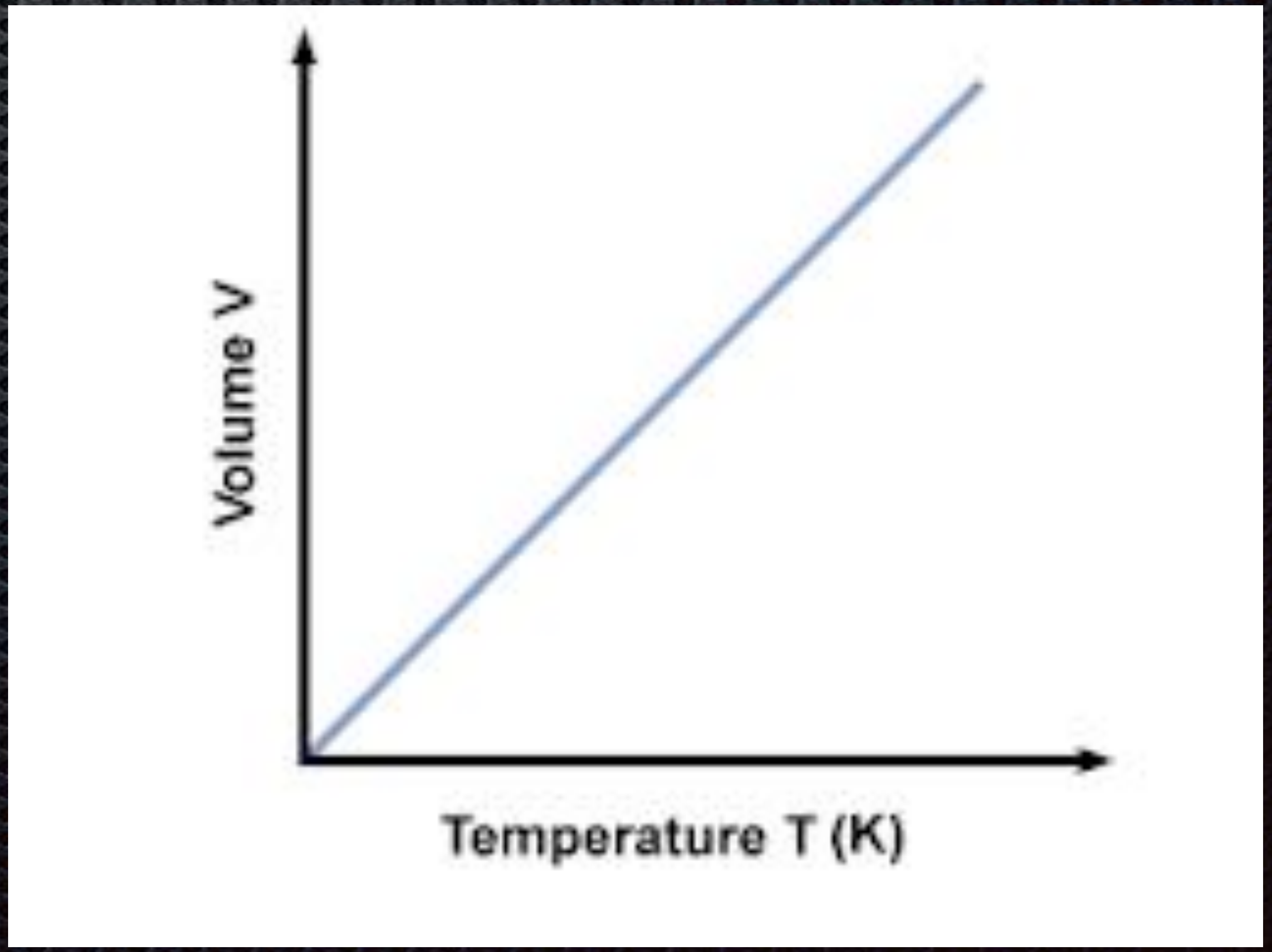
Boyle's Law



Charles' Law



Gay-Lussac's Law



Combined Gas law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Boyle's Law

$$PV = k$$

Charles' Law

$$\frac{V}{T} = k$$

Gay-Lussac's Law

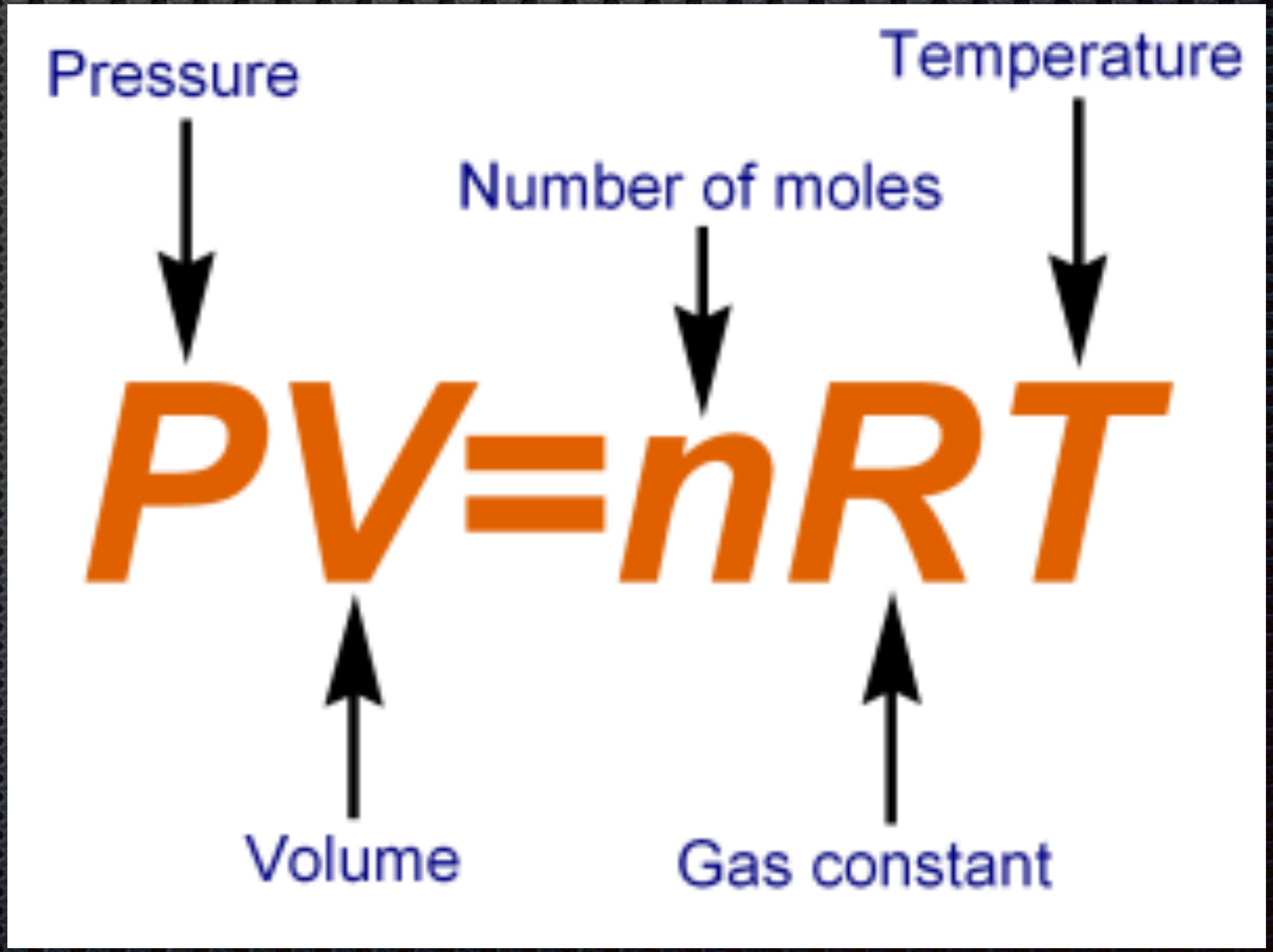
$$\frac{P}{T} = k$$

Combined Gas Law

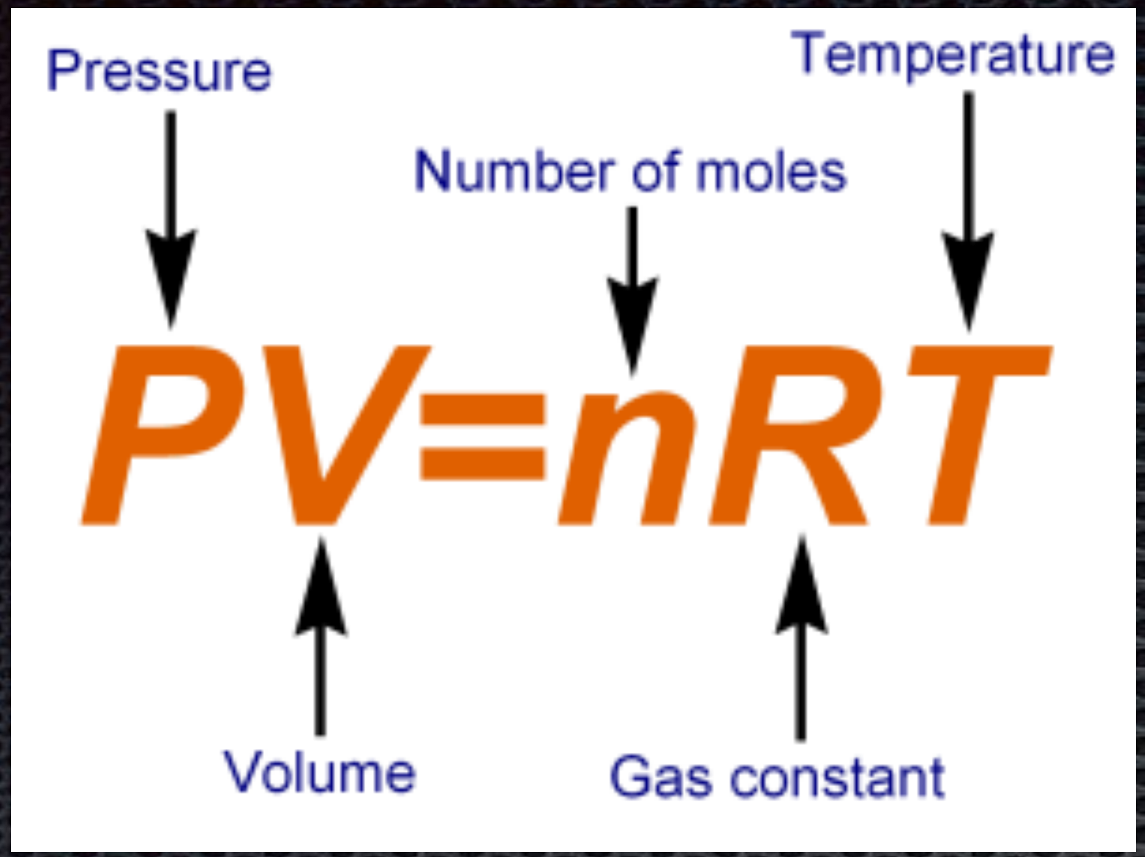
$$\frac{PV}{T} = k$$

Question...

- What is the problem with REAL gases?
- Where does that go in the combined gas law formula?



IDEAL GAS LAW



$$\frac{PV}{nT} = \frac{nRT}{nT} \qquad R = \frac{PV}{nT}$$

What is R?

$$R = \frac{(101.3\ \text{Kpa})(22.4\ \text{dm}^3)}{(1\ \text{mole})(273\ \text{K})}$$

OR

$$R = \frac{(1.013 \times 10^5\ \text{Pa})(.0224\ \text{m}^3)}{(1\ \text{mole})(273\ \text{K})}$$

<u>ideal conditions</u>: $P = 101.3\ \text{KPa}$ or $1.013 \times 10^5\ \text{Pa}$ *

$V = 22.4\ \text{dm}^3$ or $.0224\ \text{m}^3$

$T = 273\ \text{K}$

Practice…

- A helium party balloon has a volume of 18.0 dm^3. At room temperature (25°C), the internal pressure is 1.05 atm. Calculate the number of moles of helium and the mass to inflate it.

$V = 18.0\ dm^3$

$P = 1.05\ atm$

$\left(1.65 \times \frac{101.3\ kPa}{1}\right)\left(18.0\ dm^3\right) = n\,(8.31)(298K)$

$PV = nRT$

$\left(1.05 \times \frac{1.013\times10^5\ Pa}{1\ atm}\right)\left(18\ dm^3 \times \frac{1\ m^3}{1000\ dm^3}\right) = n\,(8.31)(298)$

$(1.05\ atm)(18.0\ dm^3) = n\,(8.31)(25\ ^\circ C)$