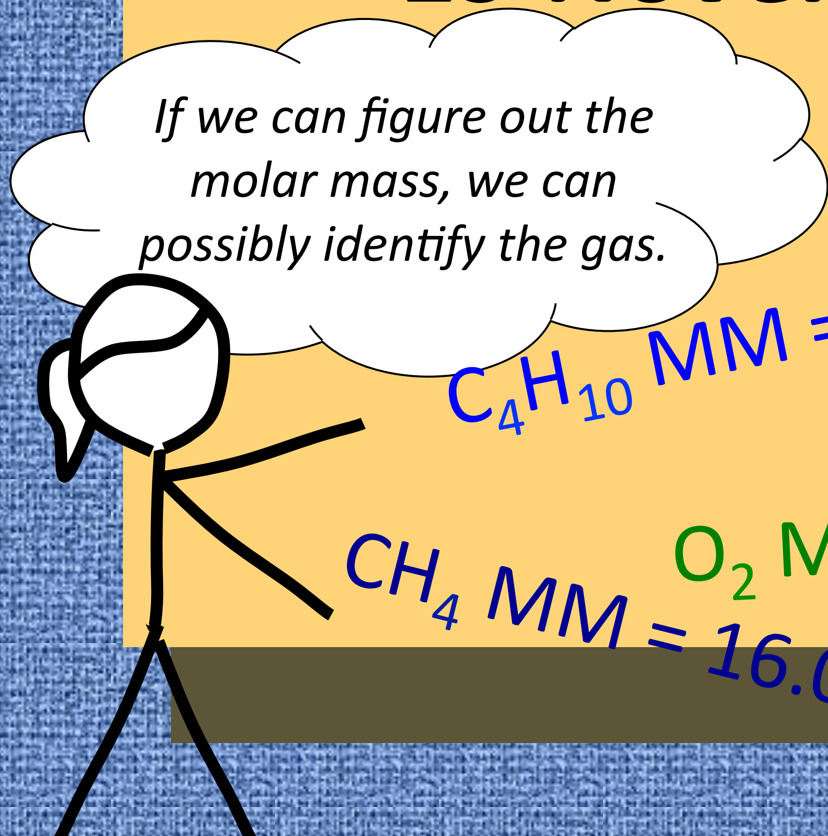
# Experiment 12
# Molar Mass of a Gas
# 19 November 2019



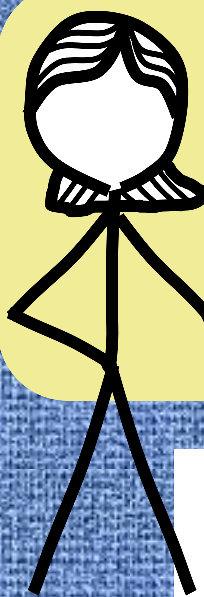

$C_4H_{10}$ MM = 58.1 g/mol

$CO_2$ MM = 44.0 g/mol

$O_2$ MM = 32.0 g/mol

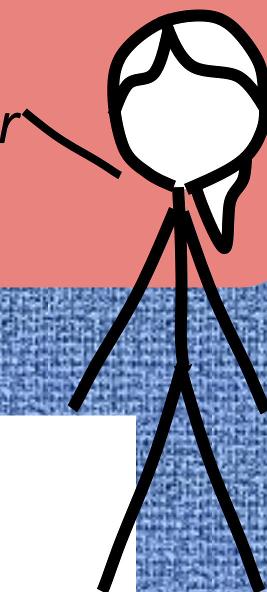
$CH_4$ MM = 16.0 g/mol

# Objectives: Use the ideal gas law to determine the molar mass of an unknown gas.



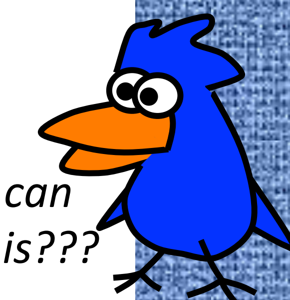
*We end this semester with an experiment that utilizes the ideal gas law in both of its forms.*

*We will use this to determine the molar mass of a gas.*



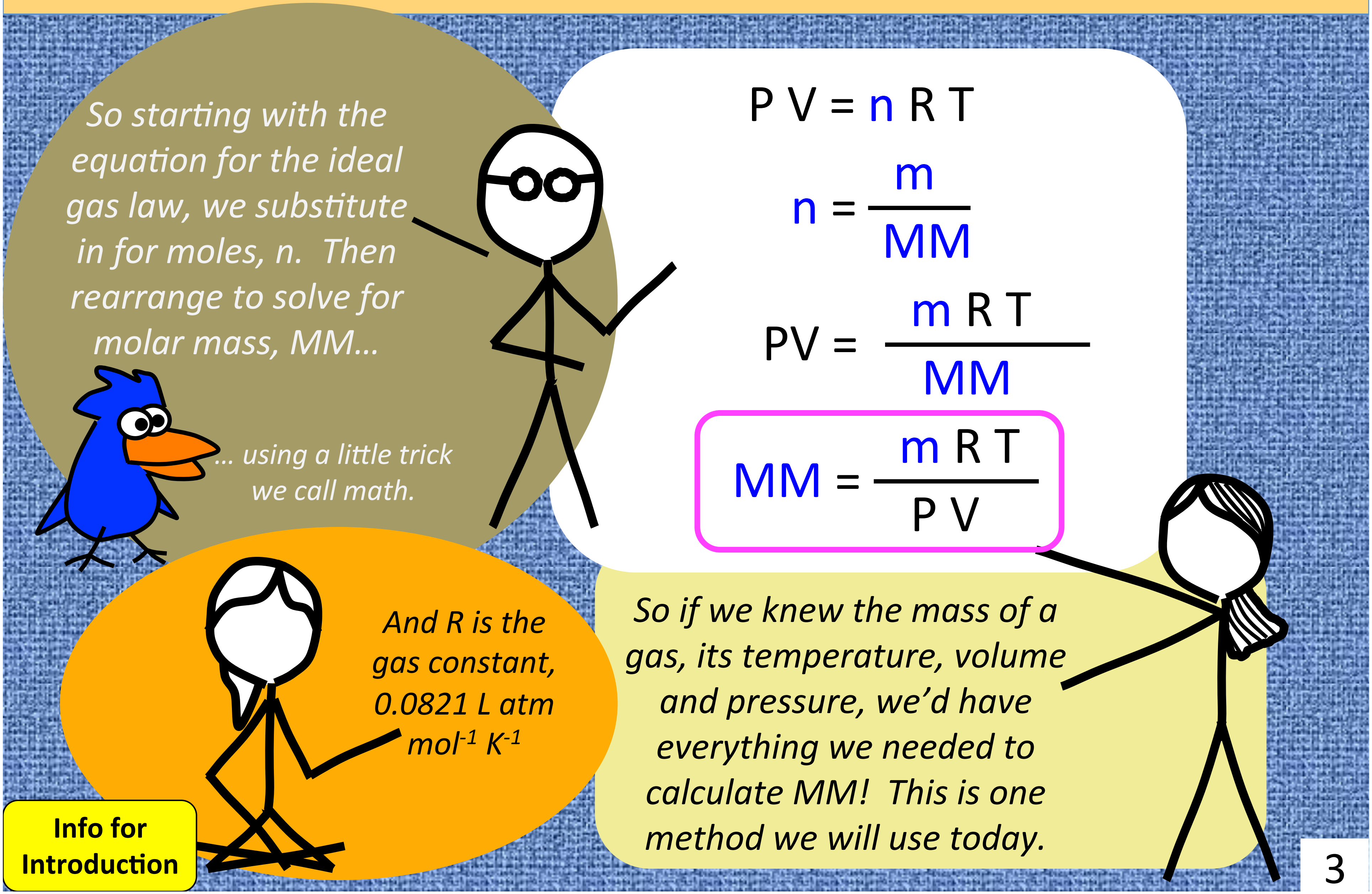
## Overview:

1. From the ideal gas law to molar mass
2. The two experiments
3. Data collection and calculations
4. Procedure: What we do today
5. Your lab report



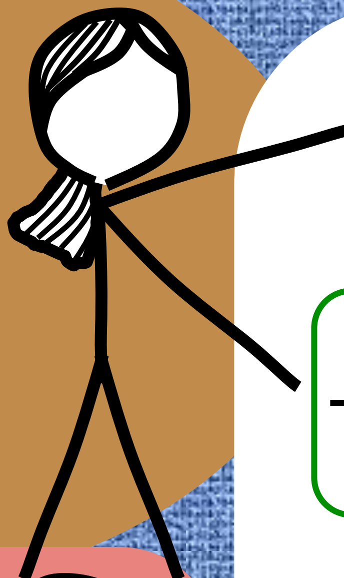

**Info for Introduction**

# 1. From the ideal gas law to molar mass



# 1. From the ideal gas law to molar mass

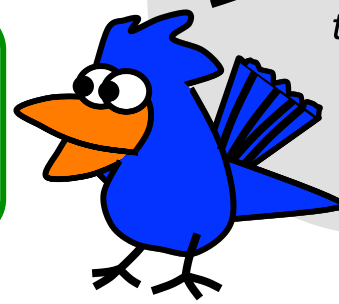
*Here's the other way we'll do it… Solve for R and realizing R is a constant, we can write the equation in the green box, where A and B are different conditions, and in our case, different gases!*



$$P V = n R T$$

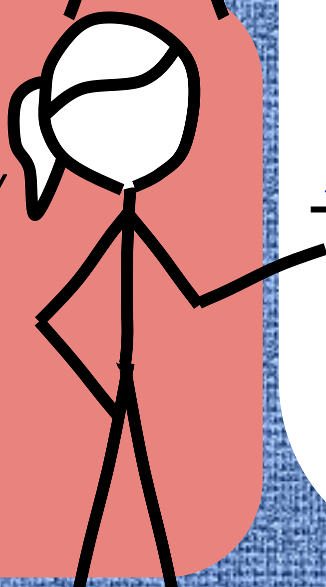
$$R = \frac{P V}{n T}$$

$$\frac{P_A V_A}{n_A T_A} = \frac{P_B V_B}{n_B T_B}$$




$$n = \frac{m}{MM}$$

*Sub in m/MM for **n** and then cancel P, V and T because they will be the same on the same day using the same vessel.*



$$\frac{\cancel{P_A}\,\cancel{V_A}\,MM_A}{m_A\,\cancel{T_A}} = \frac{\cancel{P_B}\,\cancel{V_B}\,MM_B}{m_B\,\cancel{T_B}}$$

$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$

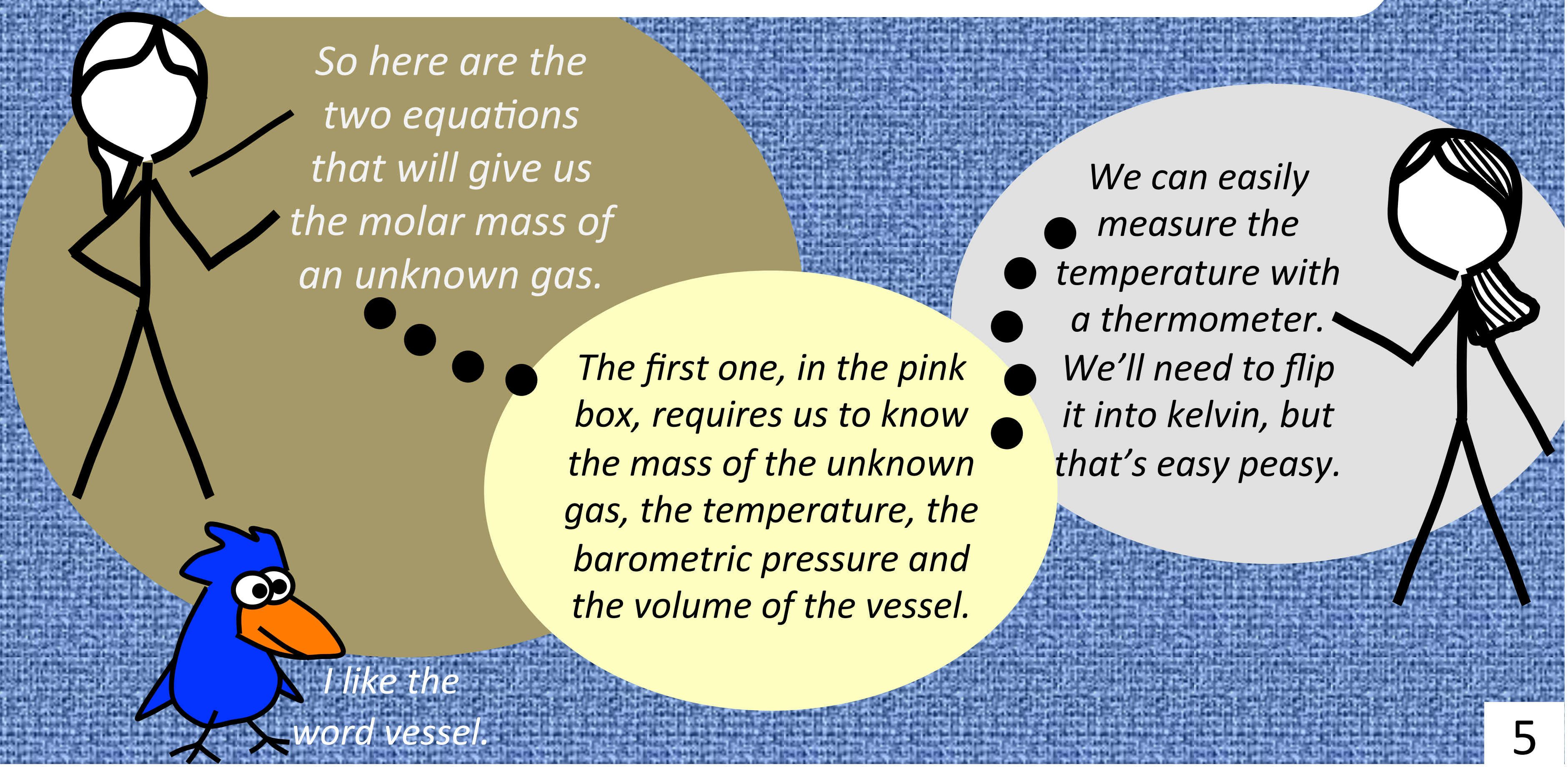
*Leaving us a pretty simple equation that we will use today!*

**Info for Introduction**

# 2. The two experiments

$$MM = \frac{m\,R\,T}{P\,V}$$

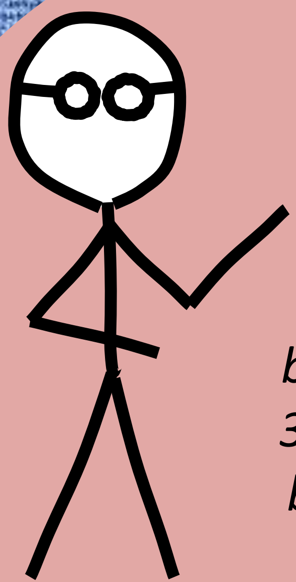
$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$



# 3. Data collection and calculations

$$MM = \frac{m\,R\,T}{P\,V}$$

$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$



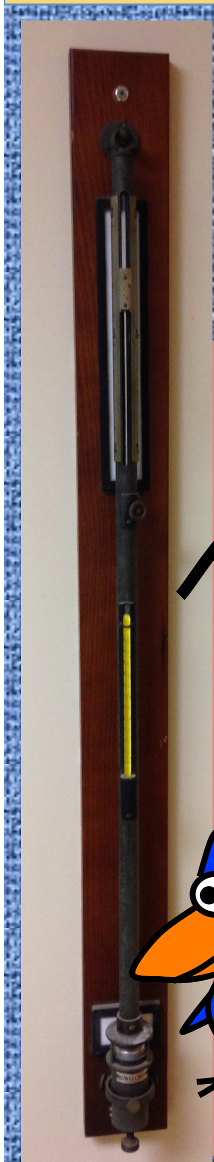
*Reading the volume is done* ***where the black seal meets the gas****. You should be able to squeak 3 sig figs out of it, but the syringe is probably only accurate to two*

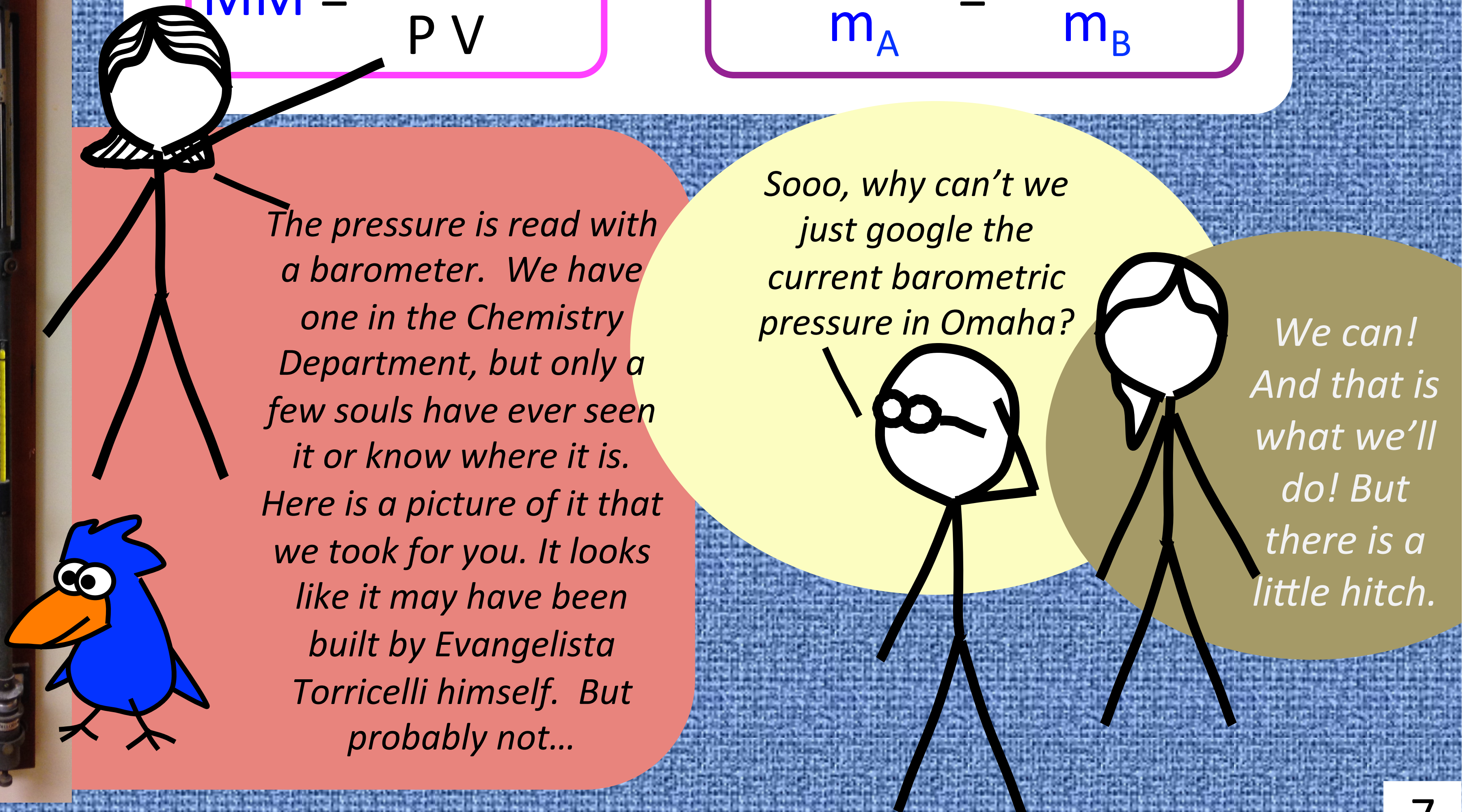

*Right here: 58.0 mL*

# 3. Data collection and calculations

$$MM = \frac{m\,R\,T}{P\,V}$$

$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$

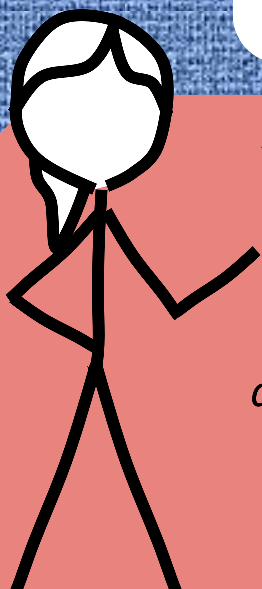




# 3. Data collection and calculations

$$MM = \frac{m\,R\,T}{P\,V}$$

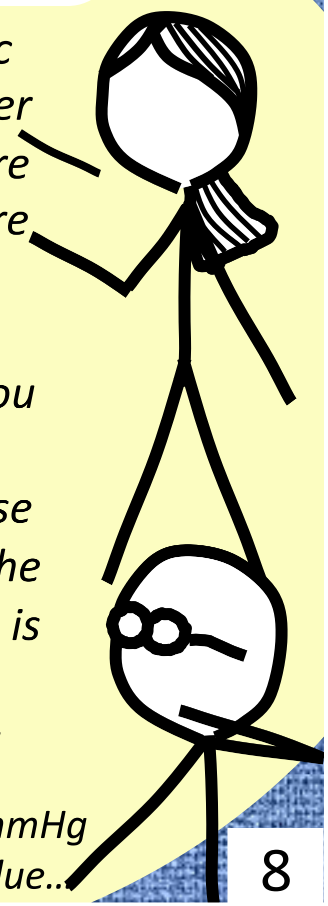
$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$



*You can find the current barometric pressure in Omaha on-line. It is probably not given in atmospheres – it may be in inches of mercury. Start by converting the pressure into mmHg.*

*1 inch = 25.4 mmHg – an exact number, BTW.*

*Then things get weird. The barometric pressures given by the National Weather Service and all other weather outlets are elevation adjusted – to give the pressure as if Omaha were at sea level. A nice thought. The weather people have a reason for doing this. So the number you get from the internet is* ***27.2 mmHg higher than the actual pressure*** *because of Omaha's elevation. For example, if the value you get from the Weather Service is 768.9 mmHg, the actual pressure in Omaha is 768.9 – 27.2 = 741.7 mmHg*

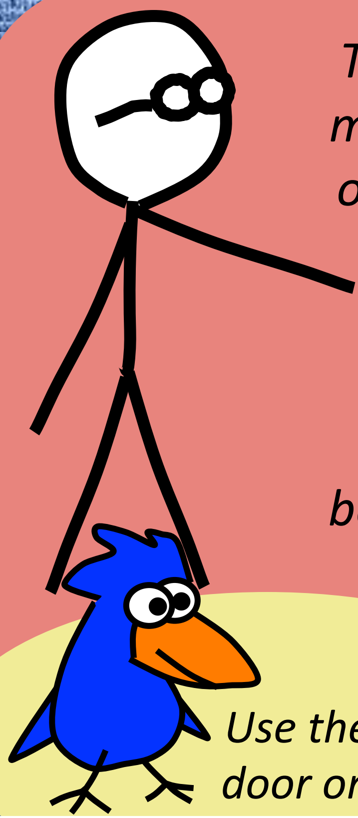


*So… I subtract 27.2 mmHg from the internet value…*

# 3. Data collection and calculations

$$MM = \frac{m\,R\,T}{P\,V}$$

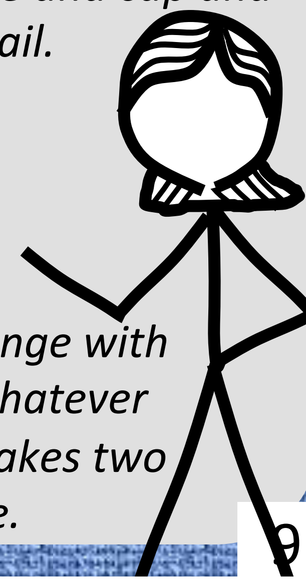
$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$



That leaves us with measuring the mass of the gas. See how the syringe can stand on its little cap? This lets us place it on the balance standing on its cap!

Use the balance door on the top!

Measure the mass of the syringe with the gas, then shoot the gas out and mass it again under vacuum. Use the same balance and cap and nail.



Filling the syringe with a vacuum, whatever that means, takes two people.

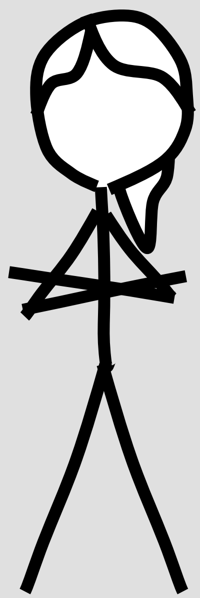
# 3. Data collection and calculations

$$MM = \frac{m\,R\,T}{P\,V}$$

We measure the masses with the best balance we can find – using all decimal places.

Pressure comes from the internet converting to mmHg and subtracting 27.2 mmHg due to the elevation correction…

… then convert to atmospheres for use with R.



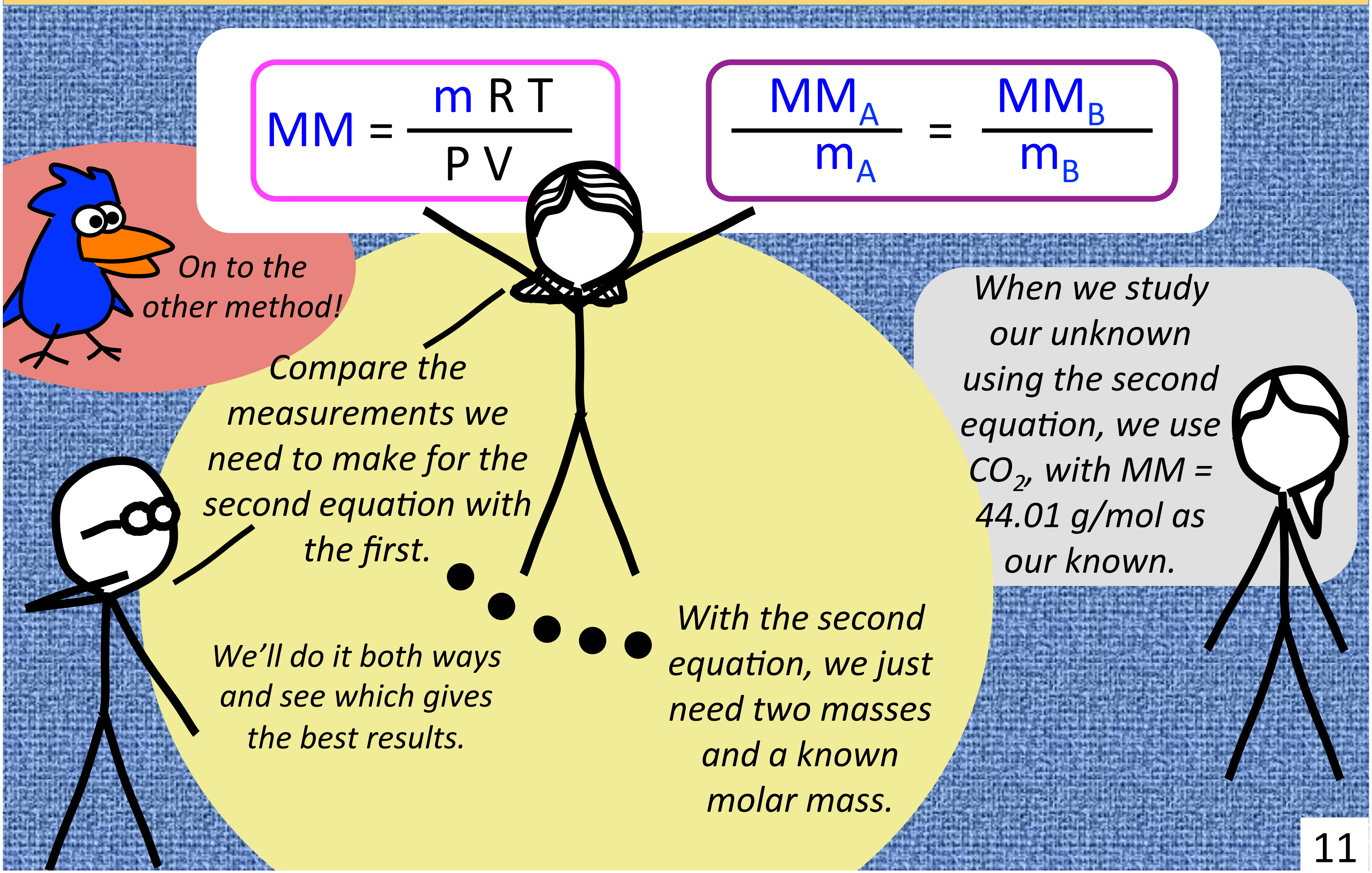
We measure the temperature as carefully as possible – two significant figures. When we convert to kelvin we get three sig figs, due to the rule for adding numbers.

And volume is read from where the black seal meets the gas. Oh, and convert to liters.

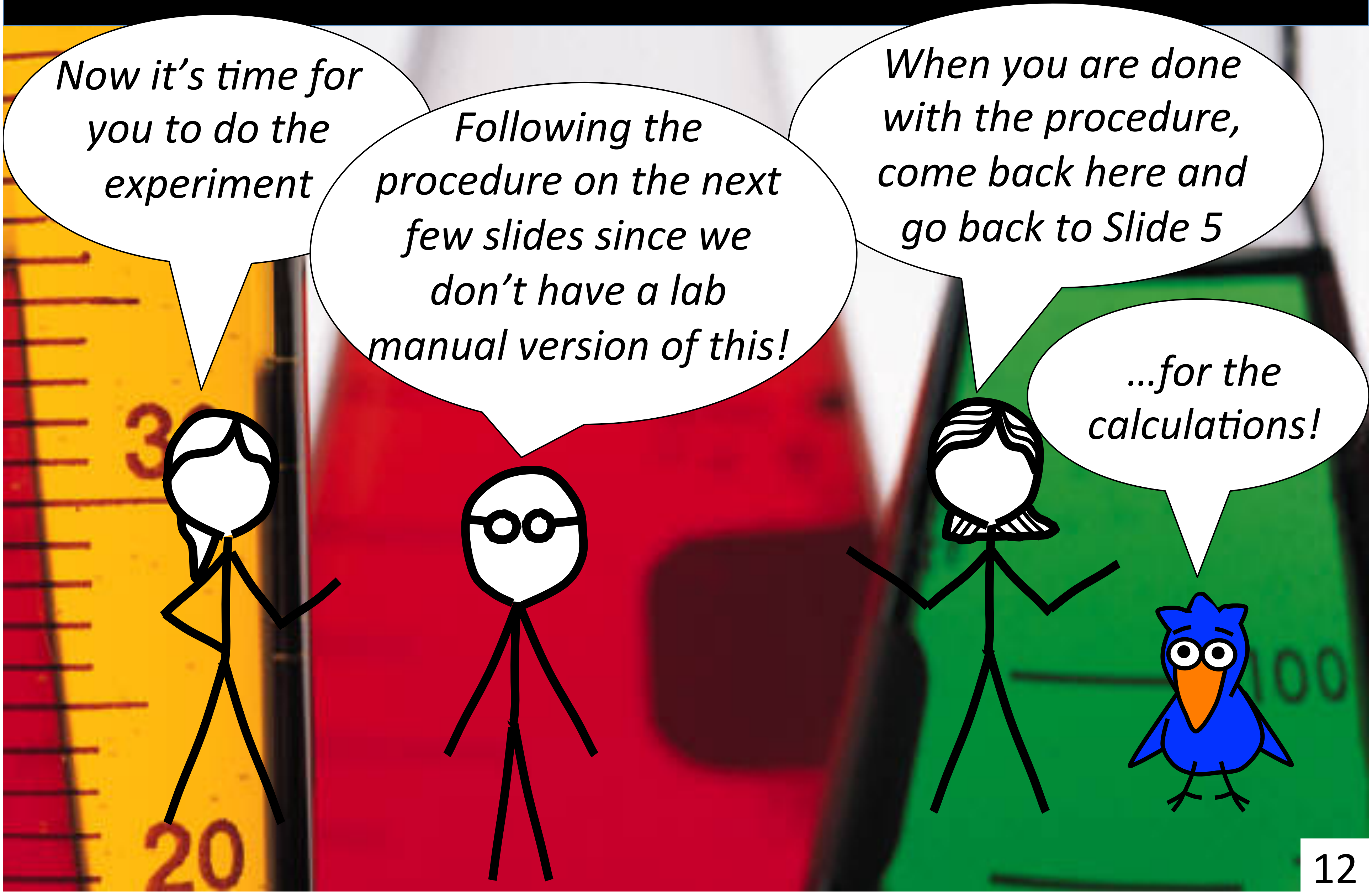
# 3. Data collection and calculations

$$MM = \frac{m\,R\,T}{P\,V}$$

$$\frac{MM_A}{m_A} = \frac{MM_B}{m_B}$$



# 4. Procedure: What we do today



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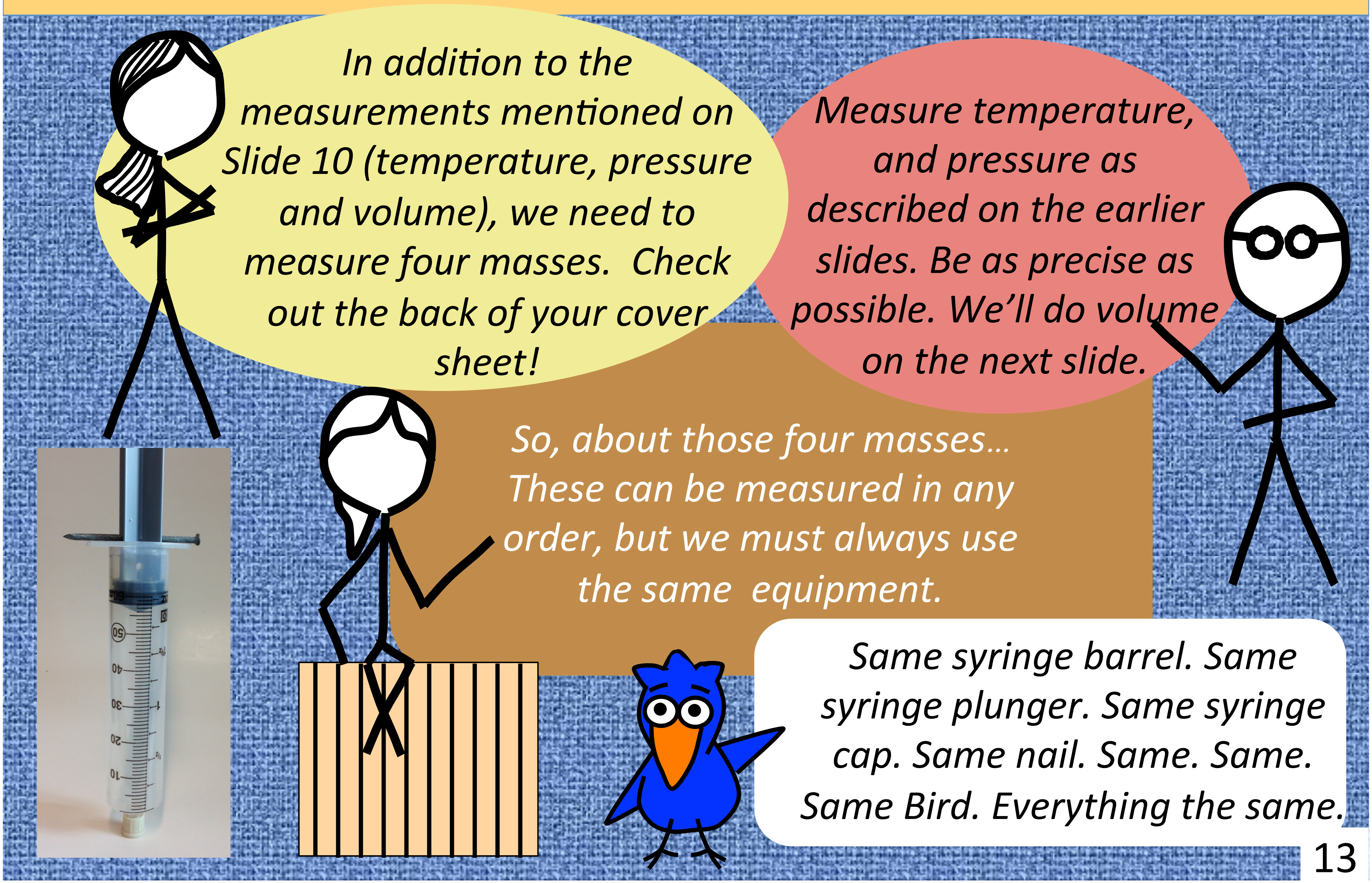
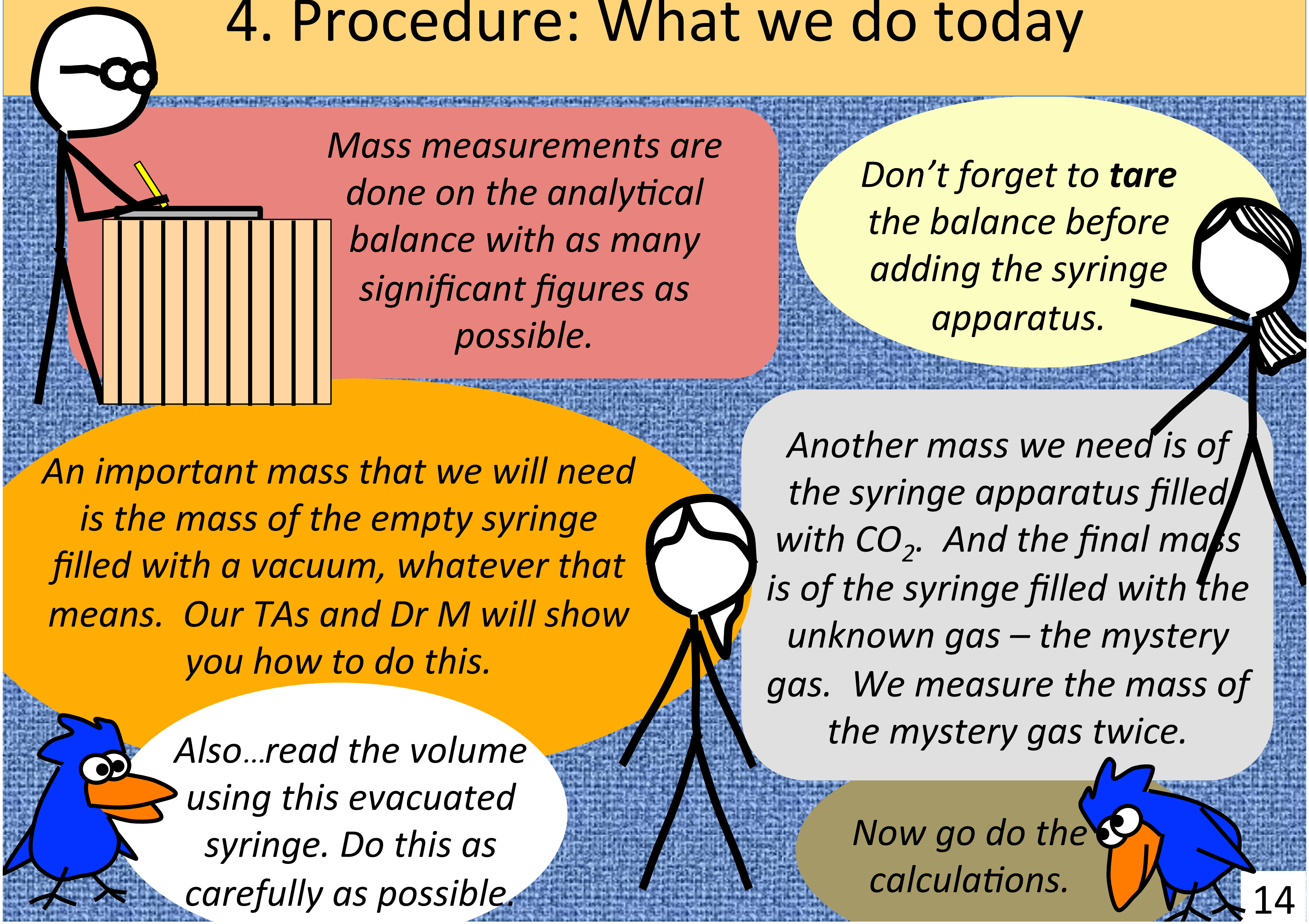


# 4. Procedure: What we do today



# 4. Procedure: What we do today

① *Wearing your safety glasses is always prudent, but today we will not be enforcing it. No special attire needed today. We are not making a mess.*

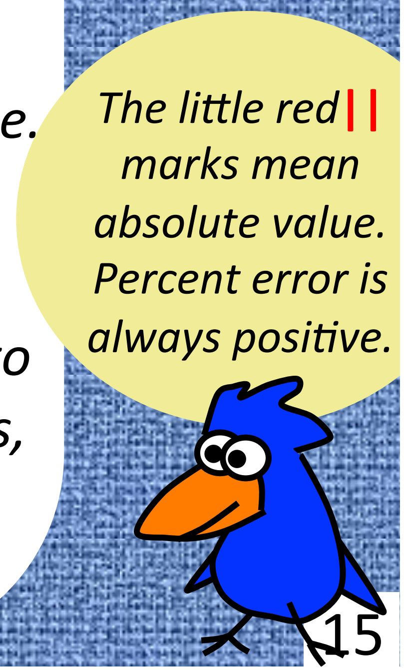
② *Take time writing an introduction in your own words before lab.*

③ *We follow the procedure part of the lab manual carefully today.*

④ *Record observations and details as carefully as possible. Show your calculations (both ways) with formulas, units, and significant figures!*

⑤ *Write your conclusions in your own words. Take time to do this carefully and with thought. In your conclusions, address percent error given by the formula:*

**% error = 100% x |Actual – Experimental|/Actual**



# 5. Your lab report


1. First, the cover page with TA initials.
2. Next, the trimmed copy pages from your lab notebook stapled together. Staple all together.
3. **On-line results** due at the end of class today. Late submissions are not graded – see the syllabus.
4. Turn in lab report ***today*** or ***before*** the start of class tomorrow. Late labs may not be graded – see the syllabus.