Experiment 12
27 November 2018
ΔH_f for Magnesium Oxide

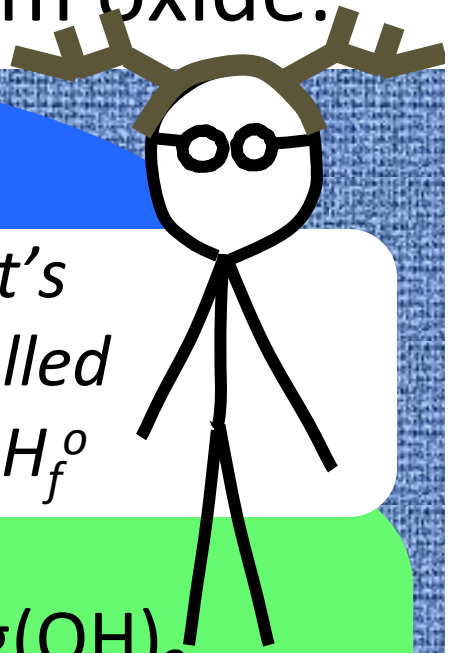
I'm asking Santa for magnesium.

Why am I not surprised?

Look Mom! I laid an egg!

Objective: To use calorimetry to determine the heat of formation for magnesium oxide.

The heat of formation is the amount of heat released or consumed when ONE mole of a substance is produced from its elements under standard conditions.



It's called ΔH_f^o

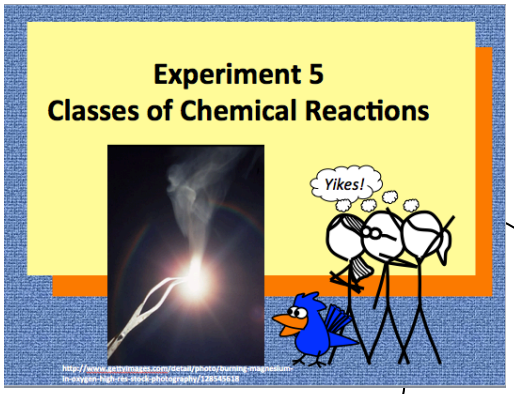
Overview:

1. Information about Mg, MgO and $Mg(OH)_2$
2. From calorimetry → ΔH (like last time)
3. Hess's law and ΔH_f^o for MgO(s)
4. Procedure: What we do today
5. Your lab report

Just looking

1. Information about Mg, MgO and $Mg(OH)_2$

There is a lot of talk about "magnesium." One can buy all sorts of dietary supplements and antacids that contain magnesium.



The magnesium can be in the form of magnesium oxide, magnesium carbonate, magnesium hydroxide, and other salts of magnesium – but ***never*** *as elemental magnesium.*

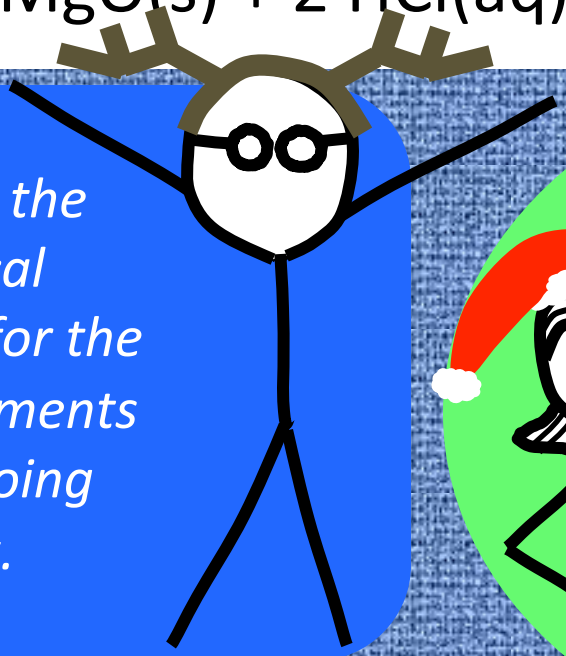
Elemental magnesium is a metal. Remember it from Experiment 5? It burns in air and reacts with acid.

Info for Introduction

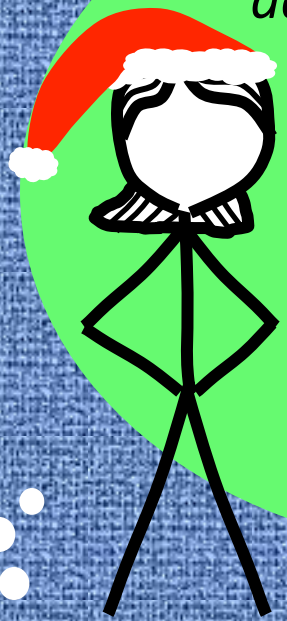
2. From calorimetry → ΔH (like last time)

Expt 1. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ $\Delta H_{rxn} = ?$

Expt 2. $MgO(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ $\Delta H_{rxn} = ?$

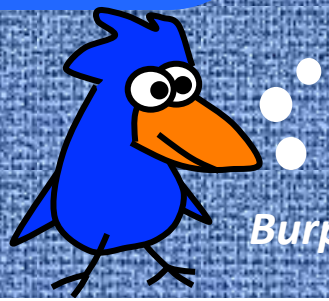


Here are the chemical equations for the two experiments we are doing today.



In Experiment 1, we add magnesium metal to acid in our calorimeter.

There will be a lot of heat and hydrogen gas formed – not the kind of thing you'd want to happen in your stomach.



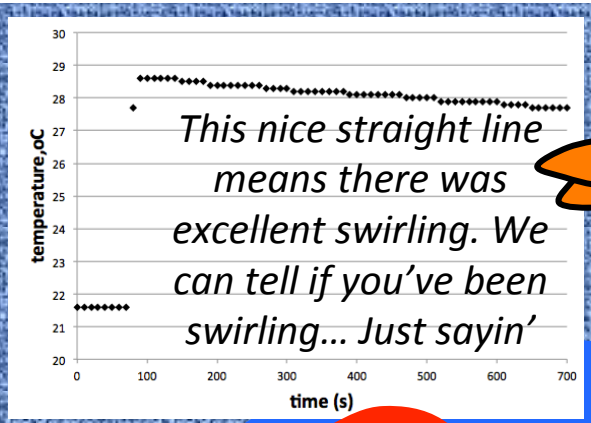
Burp.

Info for Introduction

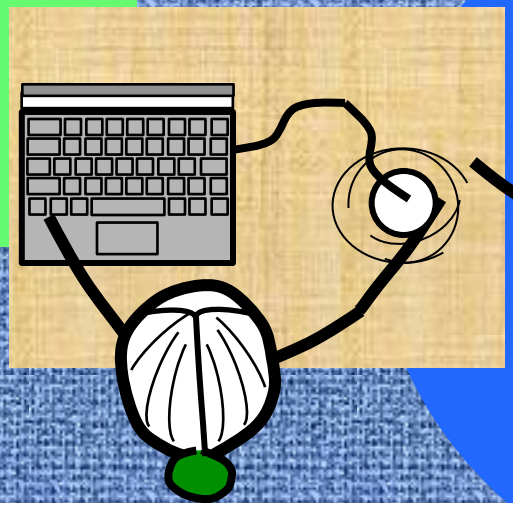
2. From calorimetry → ΔH (like last time)

Expt 1. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ $\Delta H_{rxn} = ?$

Let's start with the magnesium reaction. We'll use LoggerPro just like last time. Plug in the probe and launch LoggerPro on your laptop.

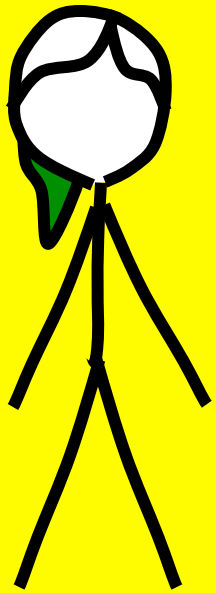


This nice straight line means there was excellent swirling. We can tell if you've been swirling… Just sayin'

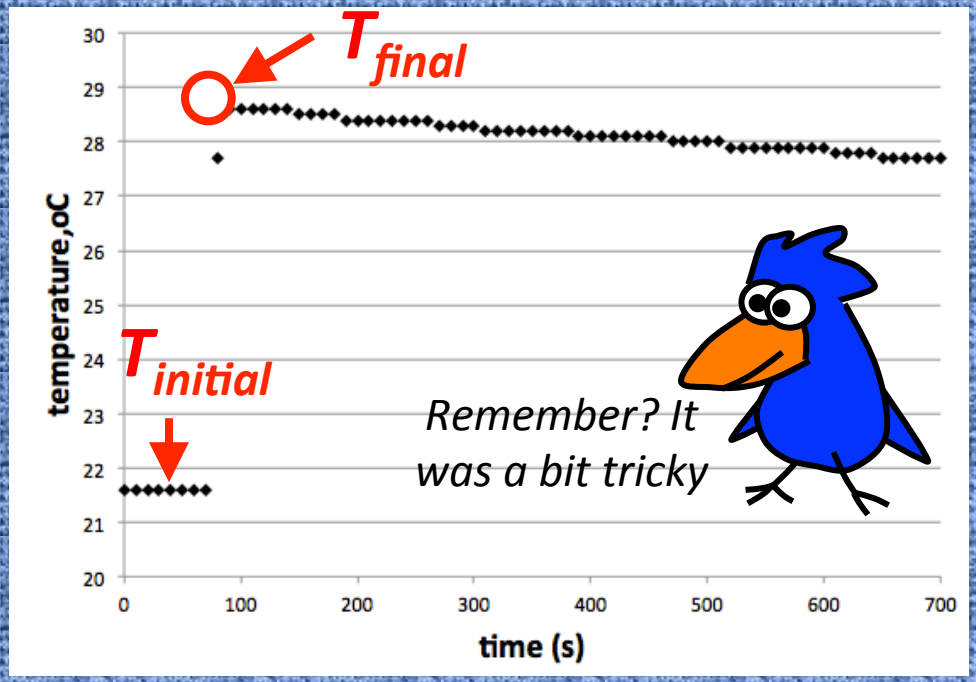


See how she is swirling the solution during data collection?

2. From calorimetry → ΔH (like last time)



And ΔT is determined just like we did last experiment. See Slides 10 – 13 from last time to review.



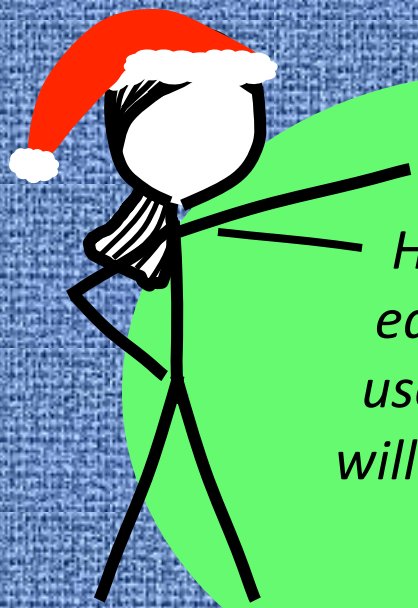
These slides from last time showed two ways to determine T_f. You can do either way, but record how you did it.

Info for Calculations

2. From calorimetry → ΔH (like last time)

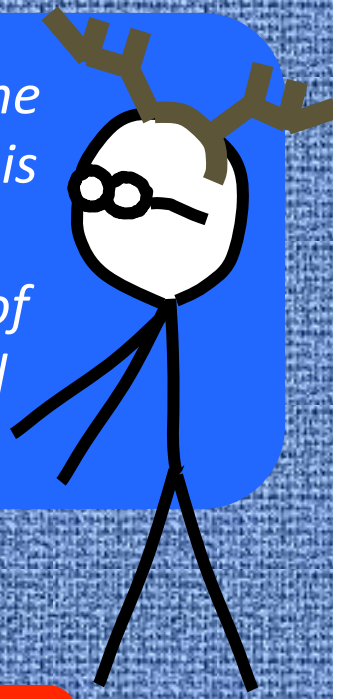
Expt 1. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ $\Delta H_{rxn} = ?$

$$q_{cal} = c_{sol'n} \times m_{sol'n} \times \Delta T_{sol'n}$$



Here is the heat equation that we used last time and will use again today.

Be careful with $m_{sol'n}$ (the mass of the solution) It is the mass of the 2 M HCl(aq) plus the mass of the magnesium added together.



$$m_{sol'n} = m_{HCl(aq)} + m_{Mg}$$

Alert! *The mass of the HCl comes from the volume times the density, 1.043 g/mL.*

Info for Calculations

2. From calorimetry → ΔH (like last time)

Expt 1. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ $\Delta H_{rxn} = ?$

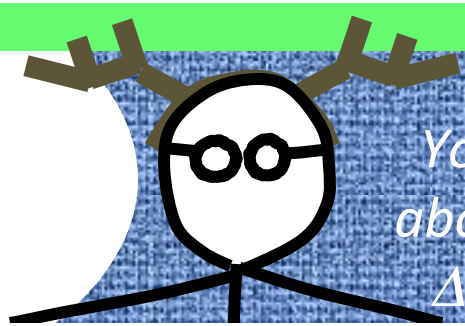
$$q_{cal} = c_{sol'n} \times m_{sol'n} \times \Delta T_{sol'n}$$

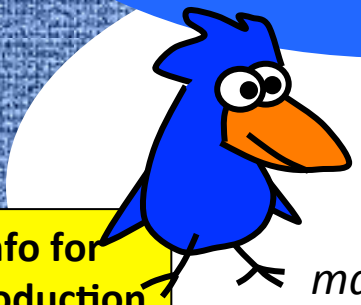
The specific heat is given in the lab manual as 4.046 J g^{-1} deg^{-1}. After we figure out $\Delta T_{sol'n}$ like we did last time, we can calculate q_{cal}.

Then we can calculate ΔH from these two equations. Watch the units.

$$q_{rxn} = -q_{cal}$$

$$\Delta H_{rxn} = q_{rxn} / n_{Mg}$$





Info for Introduction

You can convert mass of magnesium to moles of magnesium. That's what n_{Mg} is.

You should get about -500 kJ for ΔH (ballpark).

2. From calorimetry → ΔH (like last time)

Expt 2. $MgO(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ $\Delta H_{rxn} = ?$

Now we do a second calorimetry experiment with MgO(s) instead of magnesium metal.

$$\Delta T = T_{final} - T_{initial}$$

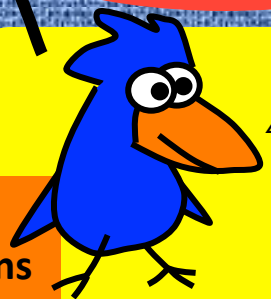
$$q_{cal} = c_{sol'n} \times m_{sol'n} \times \Delta T_{sol'n}$$

$$q_{rxn} = -q_{cal}$$

$$\Delta H_{rxn} = q_{rxn} / n_{MgO}$$

ΔH should come out to be about -150 kJ

Info for Calculations



ΔT will be smaller, but otherwise the same four calculations as with Mg. Watch the units.

3. Hess's law and ΔH_f^o for MgO(s)

Goal: $Mg(s) + \frac{1}{2} O_2(g) \rightarrow MgO(s)$ $\Delta H_f^o = ?$

Eye on the prize!

Rxn 1. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ $\Delta H_{rxn} \sim -500$ kJ

Rxn 2. $MgO(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ $\Delta H_{rxn} \sim -150$ kJ

Given: $H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(l)$

$\Delta H_f^o = -285.8$ kJ/mol $H_2O(l)$

Ok, we are done with the calorimetry. Now we do the Hess's law calculations. Our goal is to estimate ΔH_f^o for MgO – the equation shown at the very top.

Info for Calculations

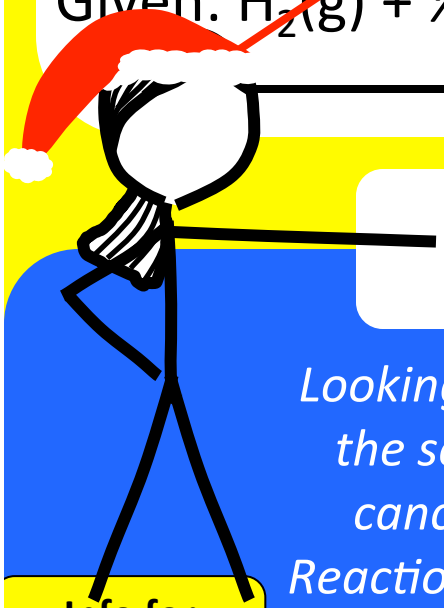
We'll need this equation as you will see. It is the heat of formation for water.

3. Hess's law and ΔH_f^o for MgO(s)

Rxn 1. $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ $\Delta H_{rxn} \sim -500$ kJ

Rxn 2(rev): $MgCl_2(aq) + H_2O(l) \rightarrow MgO(s) + 2\ HCl(aq)$ $\Delta H_{rxn} \sim +150$ kJ

Given: $H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(l)$ $\Delta H_f^o = -285.8$ kJ/mol $H_2O(l)$



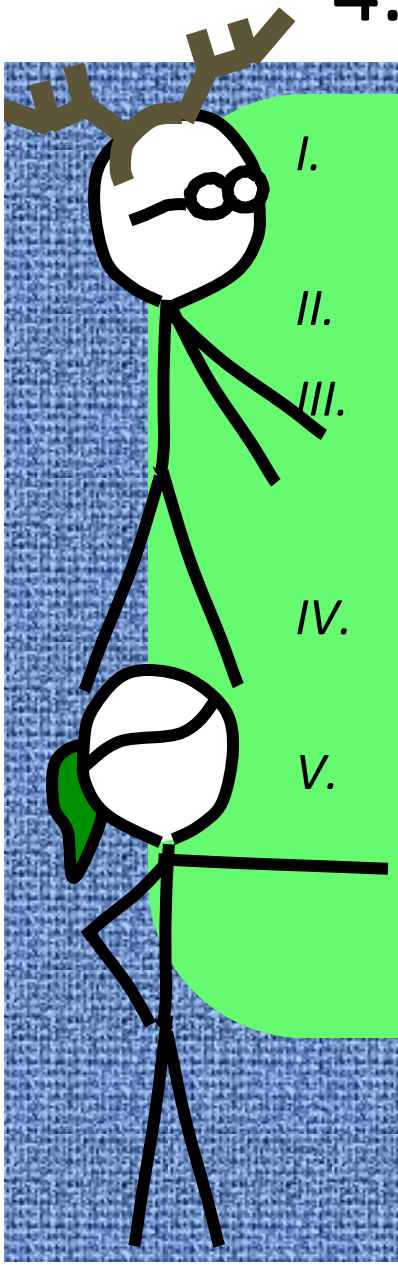
Goal: $Mg(s) + \frac{1}{2}\ O_2(g) \rightarrow MgO(s)$ $\Delta H_f \sim -600$ kJ

Looking at the goal equation, we flip the second equation (above) so it cancels with Hess's law. ΔH for Reaction 2 switches sign when we flip the equation.

Check out all the canceling! Veritable carnage.

Info for Introduction

4. Procedure: What we do today



I. *Wear your safety glasses today. And we need to dress for a mess.*

II. *We follow the manual carefully.*

III. *If your graphs look good (meaning you swirled without splashing stuff around), you are done with the experimental part. Not so good? There is time to try again!*

IV. *As usual, record observations and details as carefully as possible.*

V. *Your report will include the calculations shown in this presentation, along with your calculation of percent error from the literature value for* ΔH_f^o***, -601.7 kJ/mol MgO.***

5. Your lab report

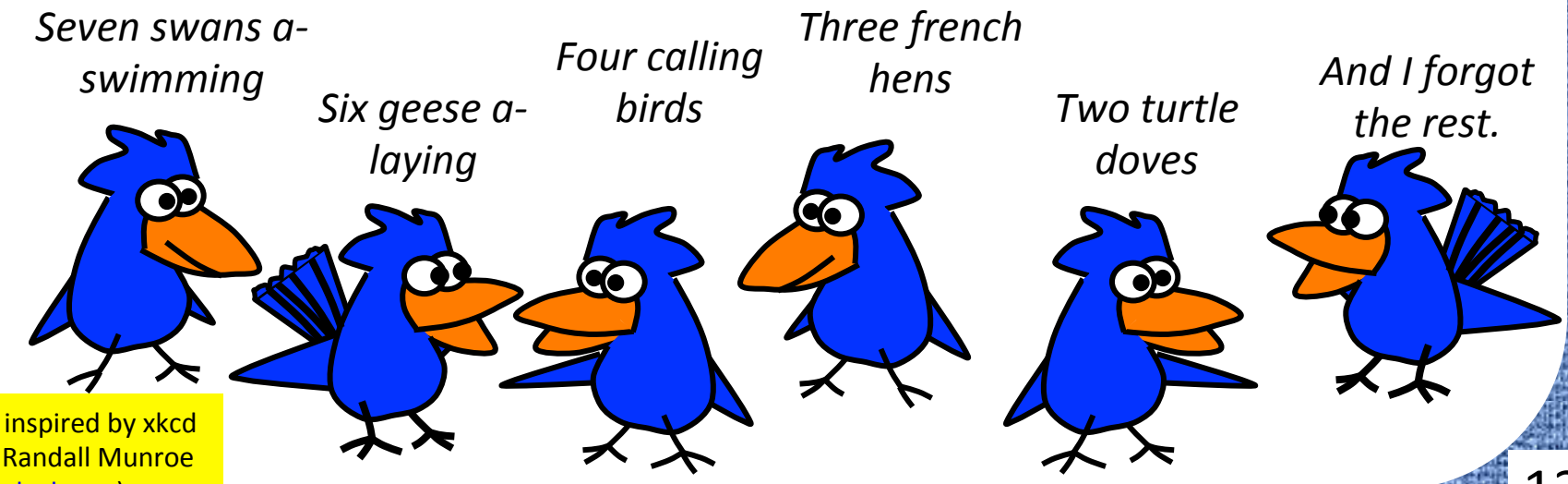
① First, the cover page with TA initials.

② Next, the trimmed copy pages from your lab notebook stapled together.

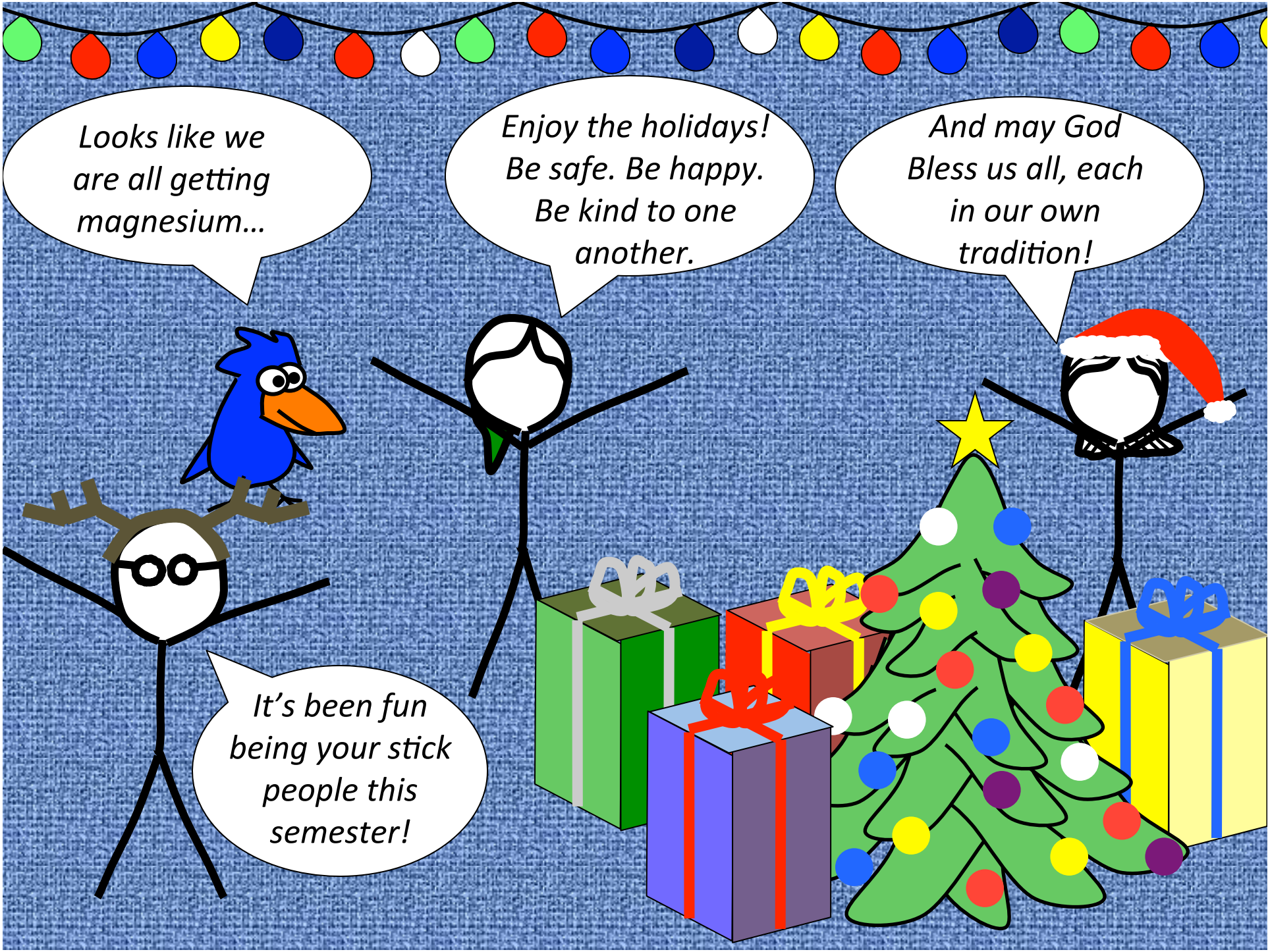
③ **On-line results** due at the end of class today. Late submissions are not graded – see the syllabus.

④ Your LoggerPro charts (2) attached.

⑤ Turn in lab report ***today*** or ***before*** the start of class tomorrow. Late labs may not be graded – see the syllabus.



Stick people inspired by xkcd cartoons by Randall Munroe (www.xkcd.com)


Looks like we are all getting magnesium…
Enjoy the holidays! Be safe. Be happy. Be kind to one another.
And may God Bless us all, each in our own tradition!
It's been fun being your stick people this semester!