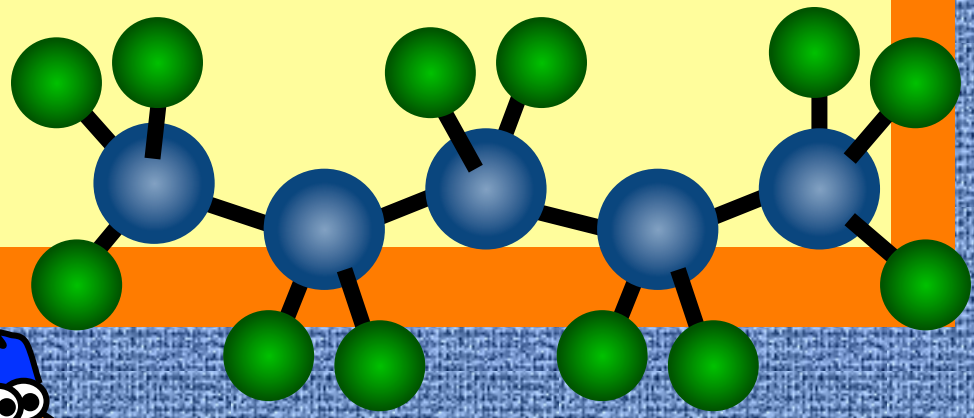
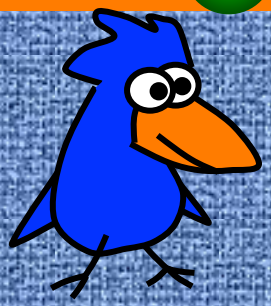
Experiment 10
5 November 2019
Intermolecular Forces

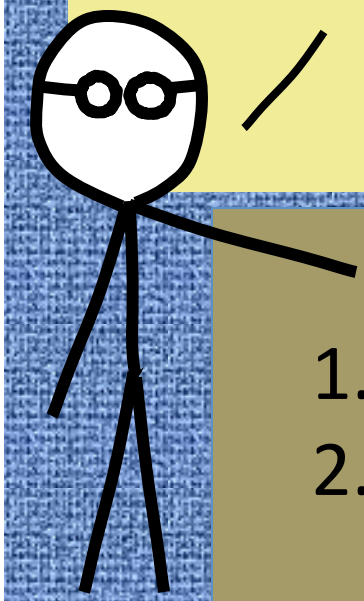
Today we will ask that age-old question: Why do molecules do that?





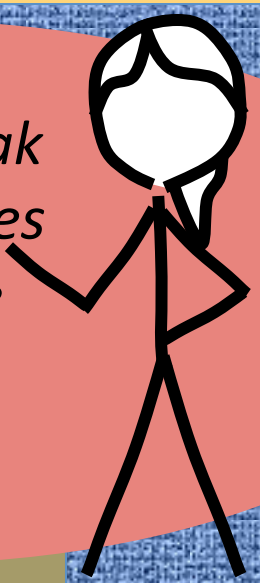
And here is one of our contestants…

Objective: To see how intermolecular forces affect rates of evaporation.



Today we will be gathering qualitative, empirical information about intermolecular forces.

Molecules with weak intermolecular forces tend to evaporate faster…
…as we shall see.



Overview:

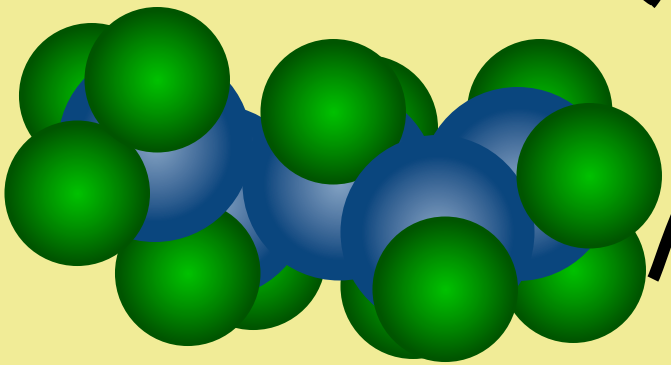
1. Intermolecular forces
2. Connecting rate of evaporation with intermolecular forces
3. Procedure: Using LoggerPro
4. Procedure: What to do today
5. Your lab report

Info for Introduction

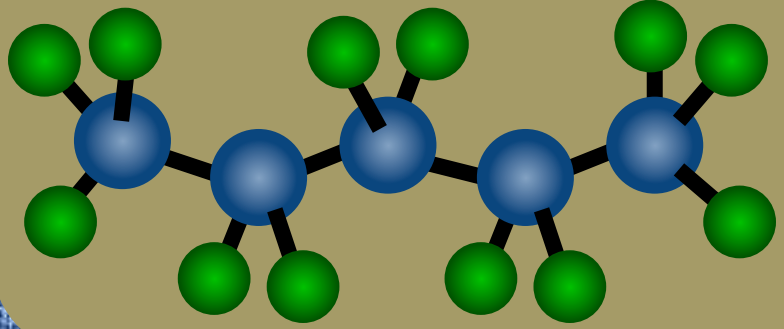
1. Intermolecular forces

This is pentane, C_5H_{12}. It can be drawn three different ways.

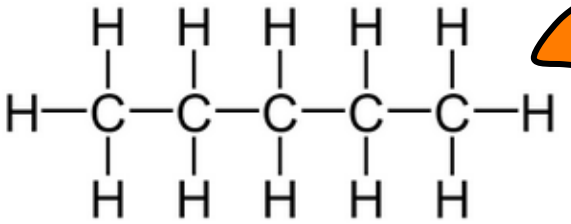
This is the "space-filling" model and is the most accurate of the them all – but Its hard to see every atom.

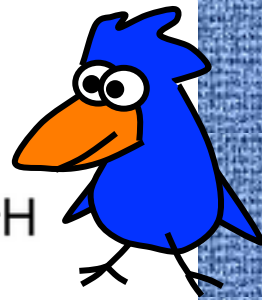


Here is the ball-and-stick model. It shows each atom and the bond angles.



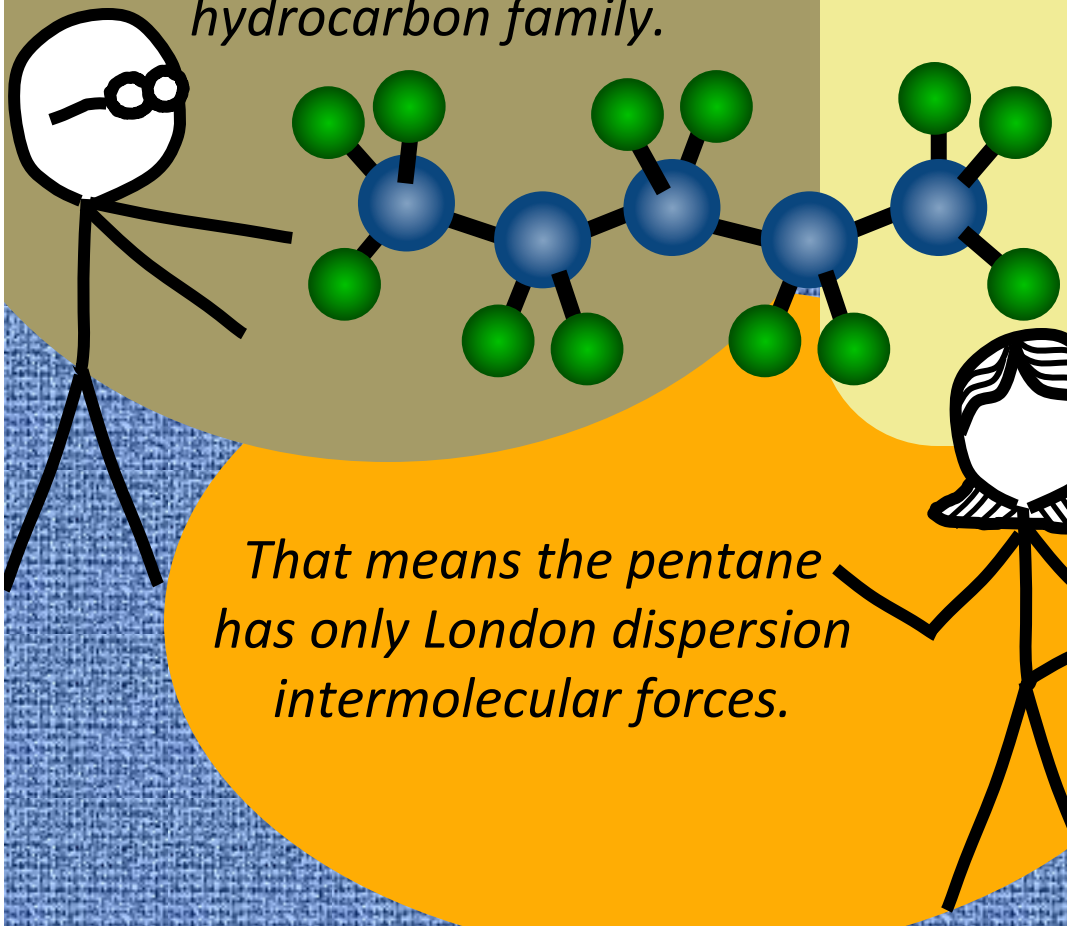
And this one I call the "road-kill" model.





1. Intermolecular forces

Pentane, C_5H_{12} has only hydrogen and carbon atoms and is a member of the hydrocarbon family.



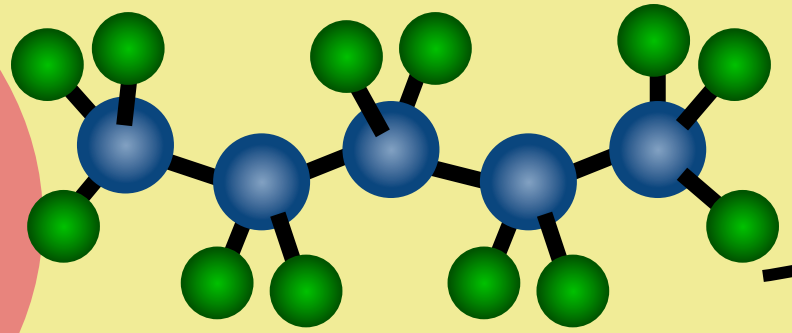
Carbon's electronegativity is 2.5 and hydrogen's is 2.1. They are so close in value that C-H bonds are relatively non-polar. The pentane molecule is functionally non-polar.

That means the pentane has only London dispersion intermolecular forces.

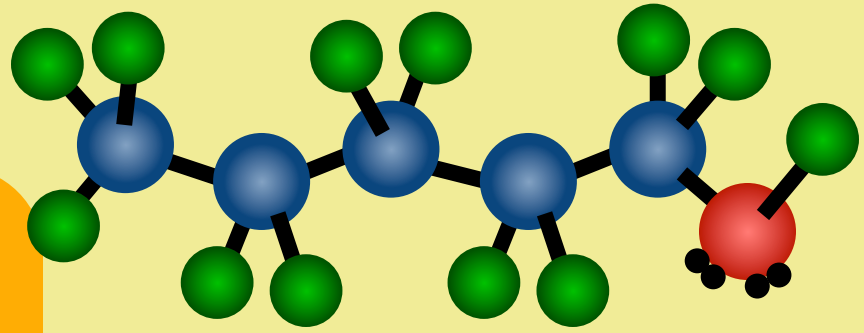
Ooo! Ooo! London forces are proportional to MM. This may be good-to-know!

1. Intermolecular forces

The other type of molecule we will be studying today is an alcohol. Here is pentane and 1-pentanol – they look rather similar except for an importance difference!



pentane

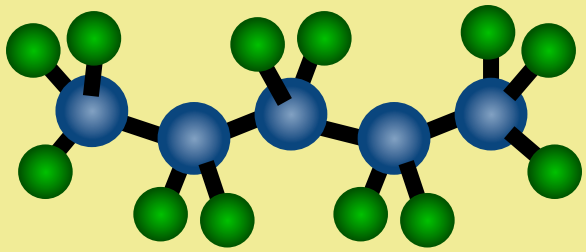


1-pentanol

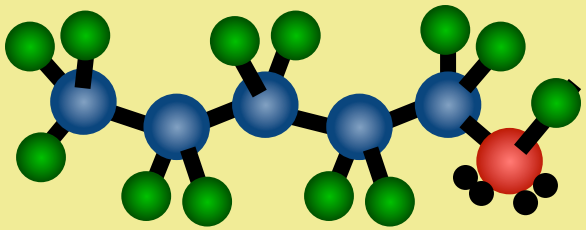
The hydrocarbon end of 1-pentanol is non-polar, but the end with the –OH group is a completely different story!

O-H as in oxygen-hydrogen! Electron pairs! Oh boy! Hydrogen bonding!

2. Connecting rate of evaporation with intermolecular forces



pentane
London dispersion forces



1-pentanol
London dispersion forces
and H-bonding

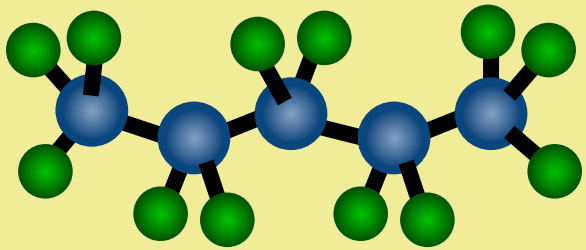
1-Pentanol should have larger intermolecular forces due to H-bonding, meaning the molecules are more attracted to each other than in pentane.

Evaporation requires the breaking of all intermolecular forces. It would take more energy to break the intermolecular forces in 1-pentanol.

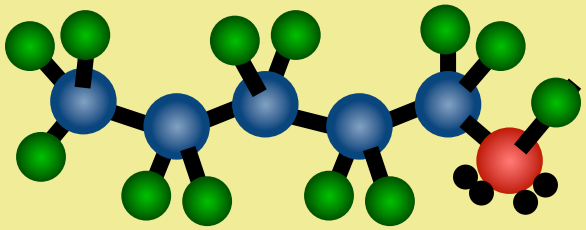
When evaporation takes place, the heat comes from the surroundings.

I feel like I can read her mind!

2. Connecting rate of evaporation with intermolecular forces



pentane
London dispersion forces



1-pentanol
London dispersion forces
and H-bonding

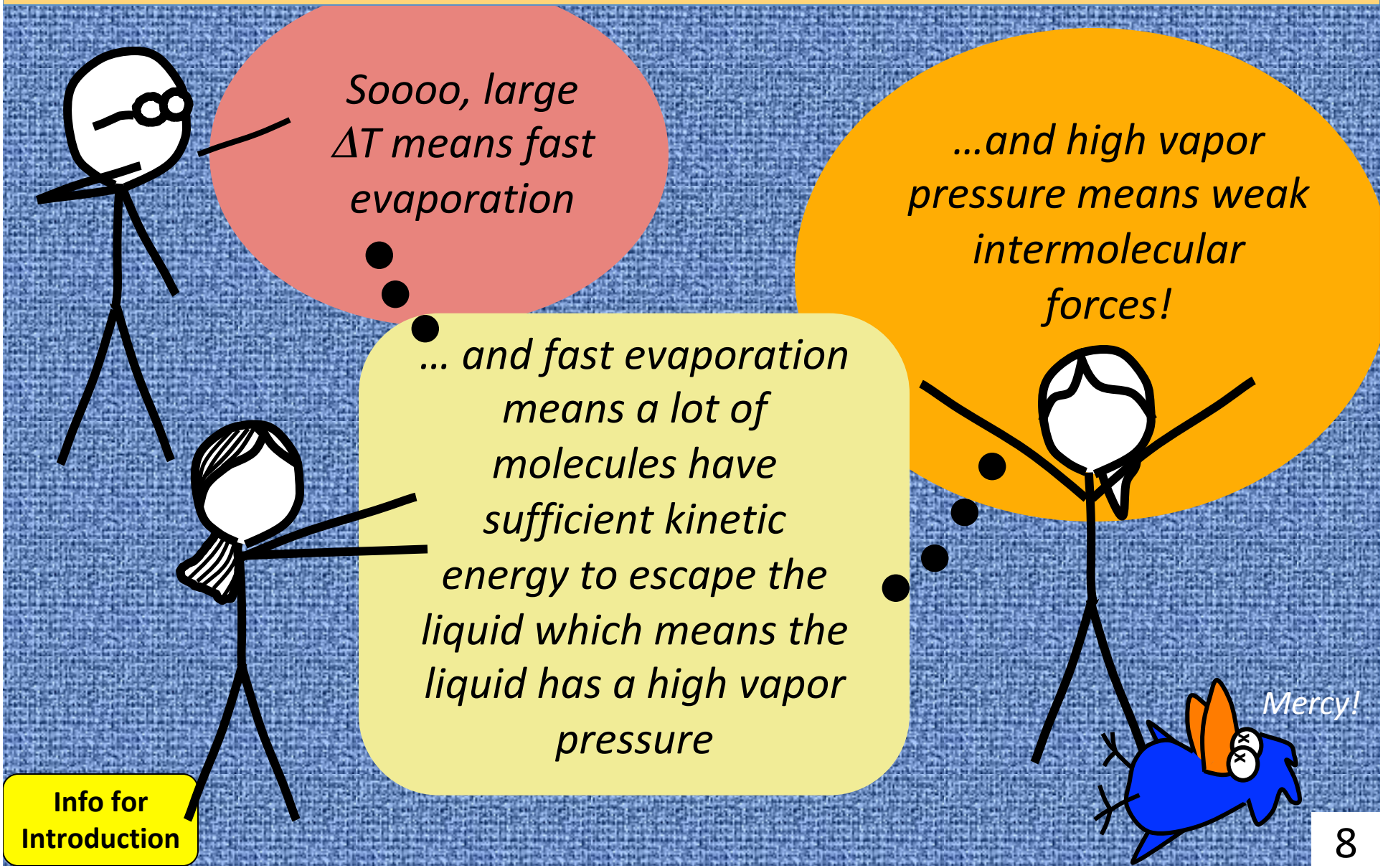
At the temperature of the lab, fewer molecules of 1-pentanol would have enough energy to evaporate.

So 1-pentanol is slower to evaporate and the surroundings don't get quite as cold.

So the wimpier the intermolecular forces, the cooler it gets due to evaporation

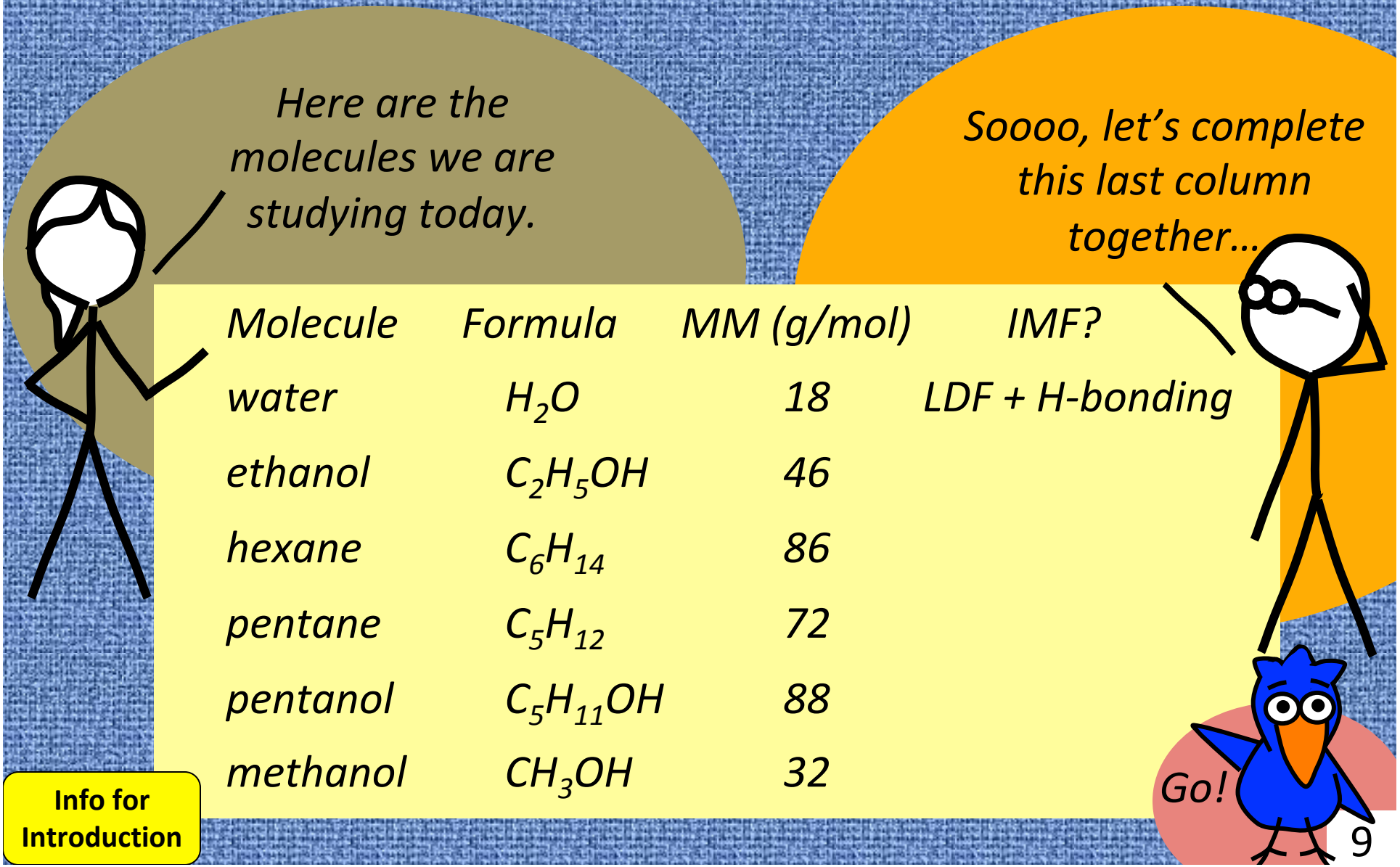
I know it seems backwards…

2. Connecting rate of evaporation with intermolecular forces



Info for Introduction

2. Connecting rate of evaporation with intermolecular forces

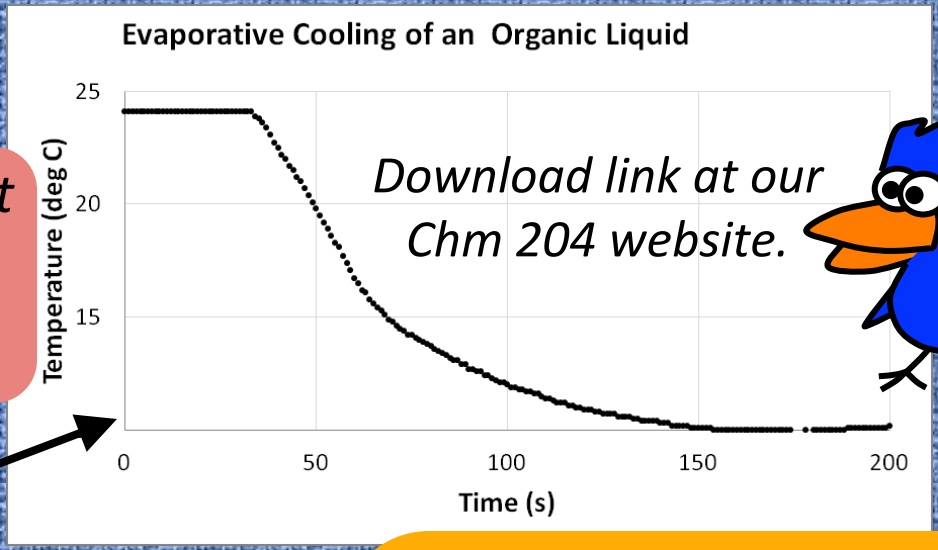


Molecule	Formula	MM (g/mol)	IMF?
water	H_2O	18	LDF + H-bonding
ethanol	C_2H_5OH	46	
hexane	C_6H_{14}	86	
pentane	C_5H_{12}	72	
pentanol	$C_5H_{11}OH$	88	
methanol	CH_3OH	32	

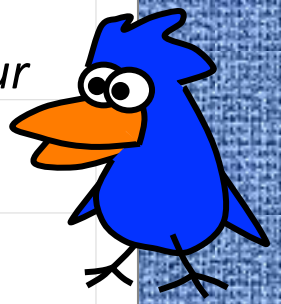
Info for Introduction

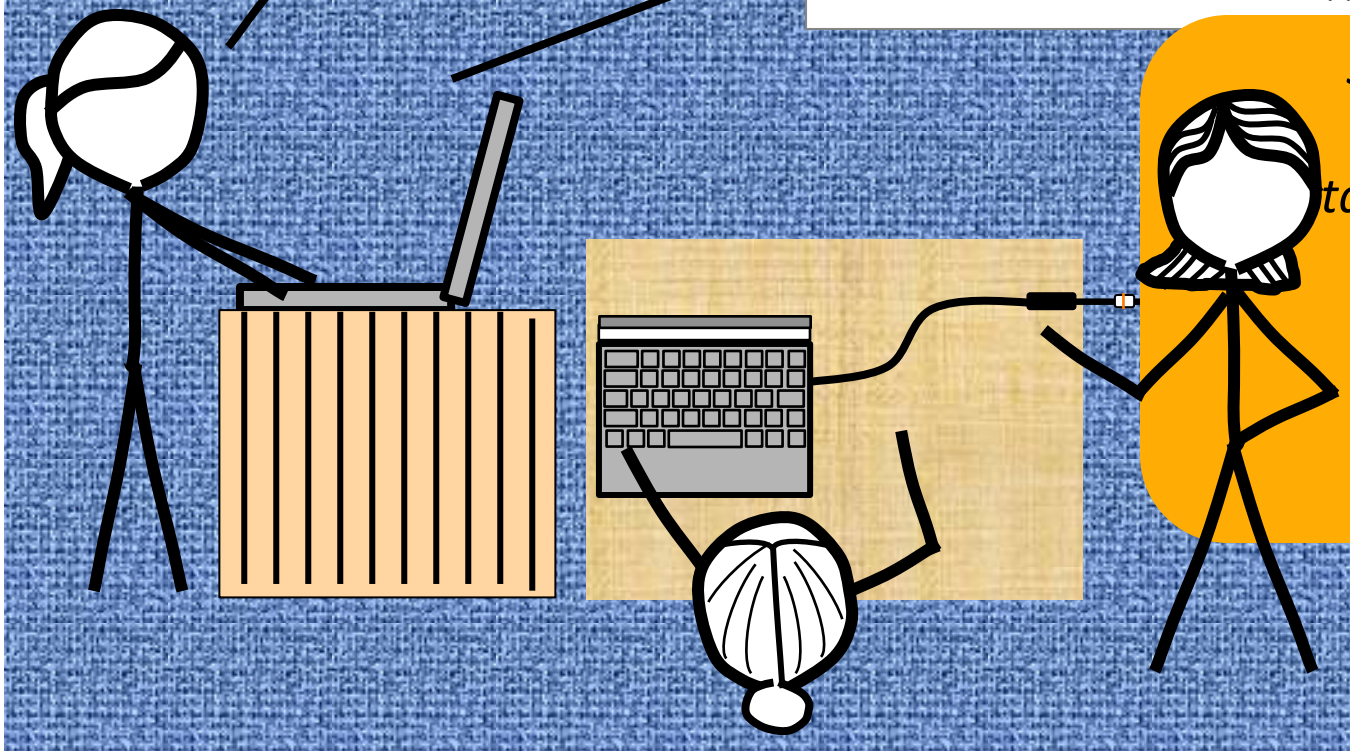
3. Procedure: Using LoggerPro

We'll use LoggerPro for the first time. Make sure it is downloaded onto your laptop.

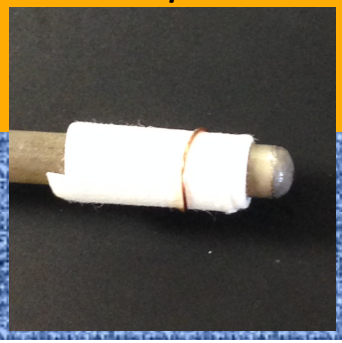


Download link at our Chm 204 website.



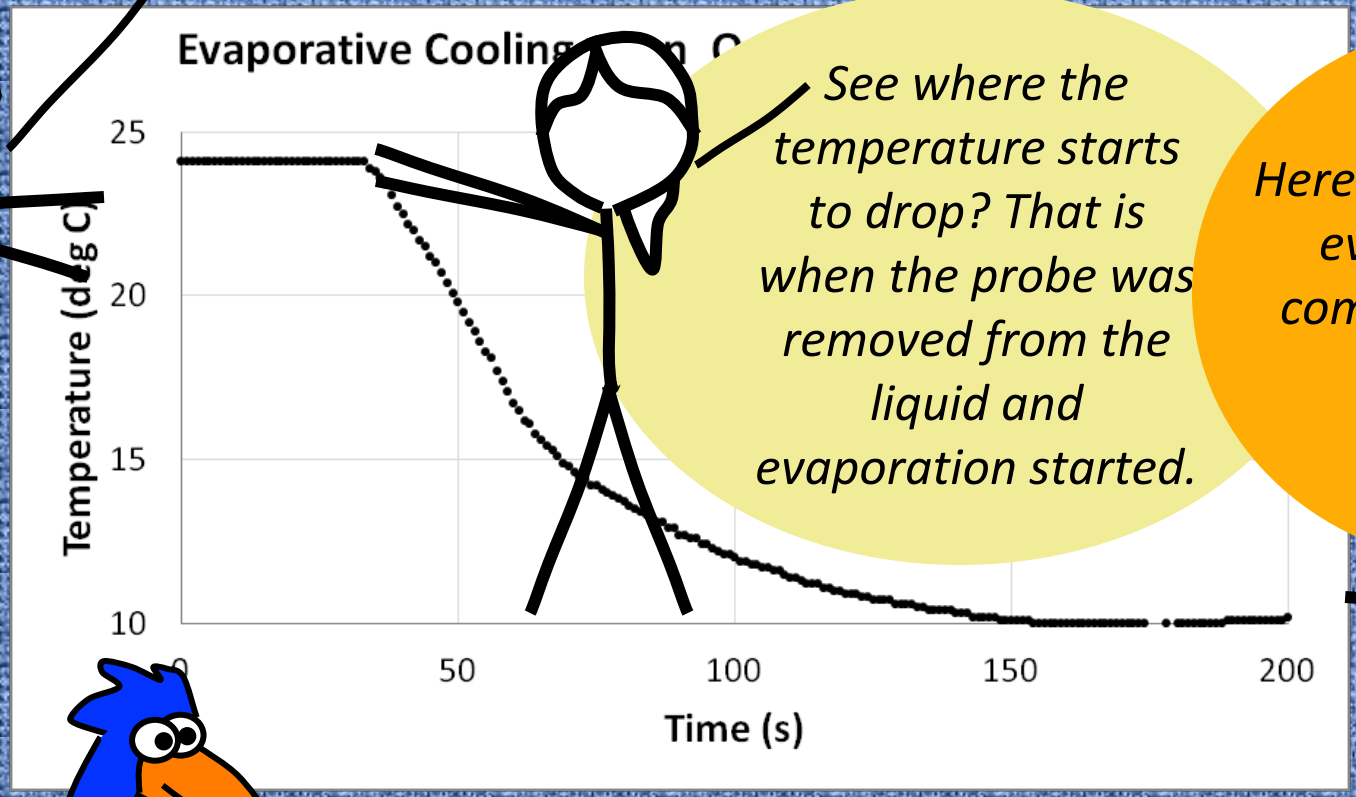


See how the probe rests over the edge of the table? And this is how the filter paper should look when wrapped properly to the probe:



3. Procedure: Using LoggerPro

This is a typical cooling curve. Evaporation is endothermic so the temperature drops.



See where the temperature starts to drop? That is when the probe was removed from the liquid and evaporation started.

Here at about 200 s, evaporation is complete and you can stop.

Temperature is a measure of energy…so when energy goes into making liquid evaporate, the surroundings cool down

Info for Introduction

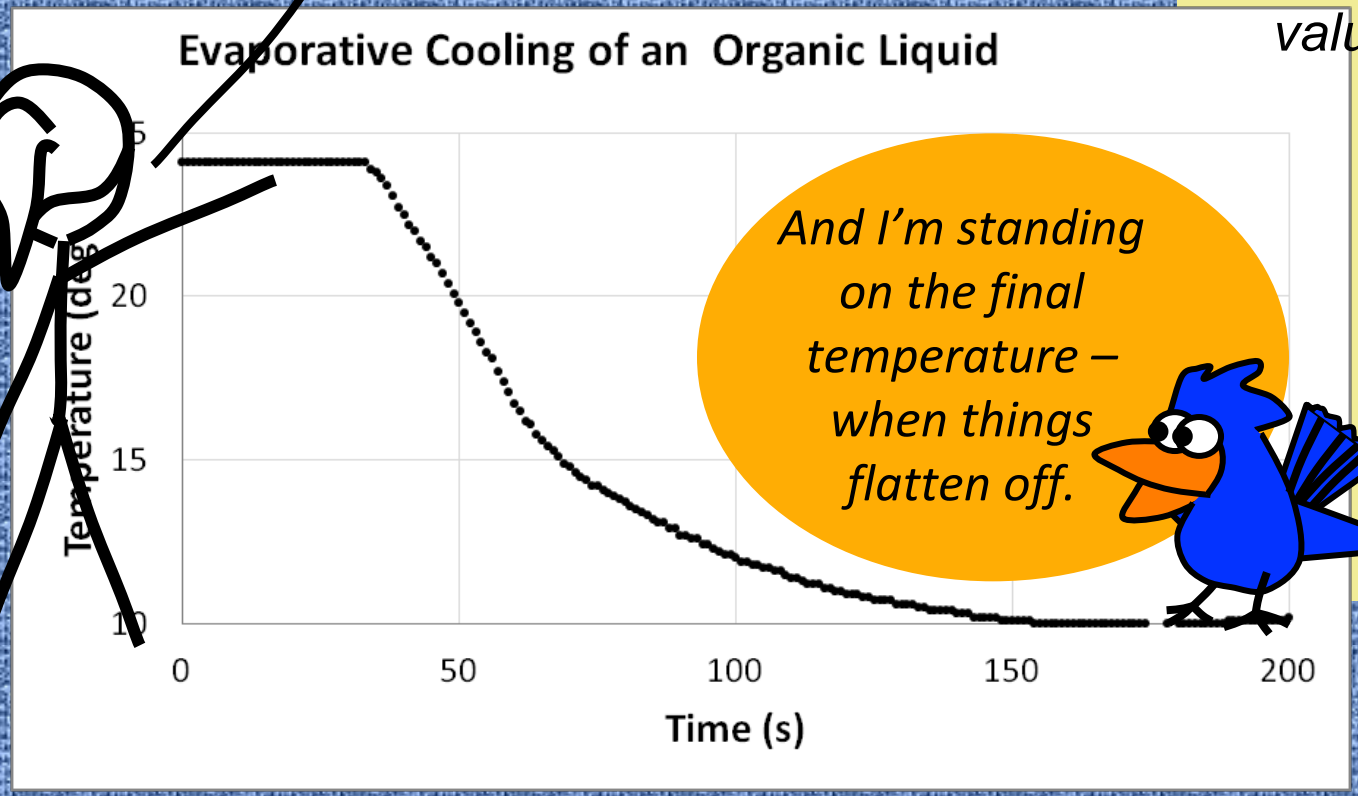
3. Procedure: Using LoggerPro

This is the initial temperature – anywhere along the flat line before the probe is removed from the liquid

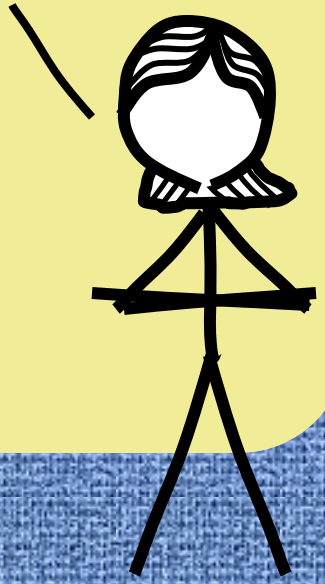
We know:

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

but today we want to report just the absolute values for ΔT –they will all be positive.

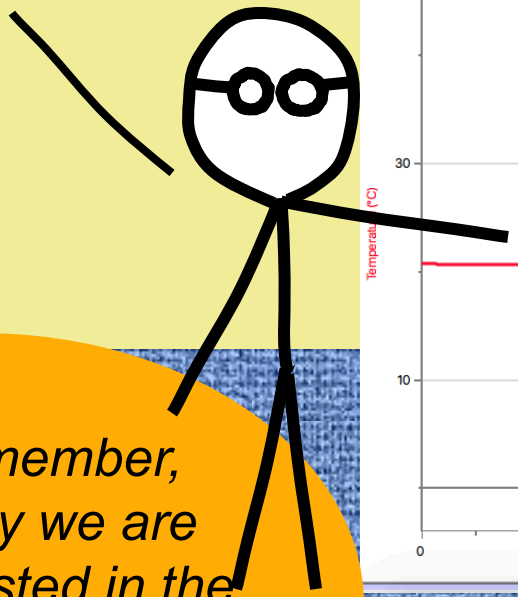


And I'm standing on the final temperature – when things flatten off.



3. Procedure: Using LoggerPro

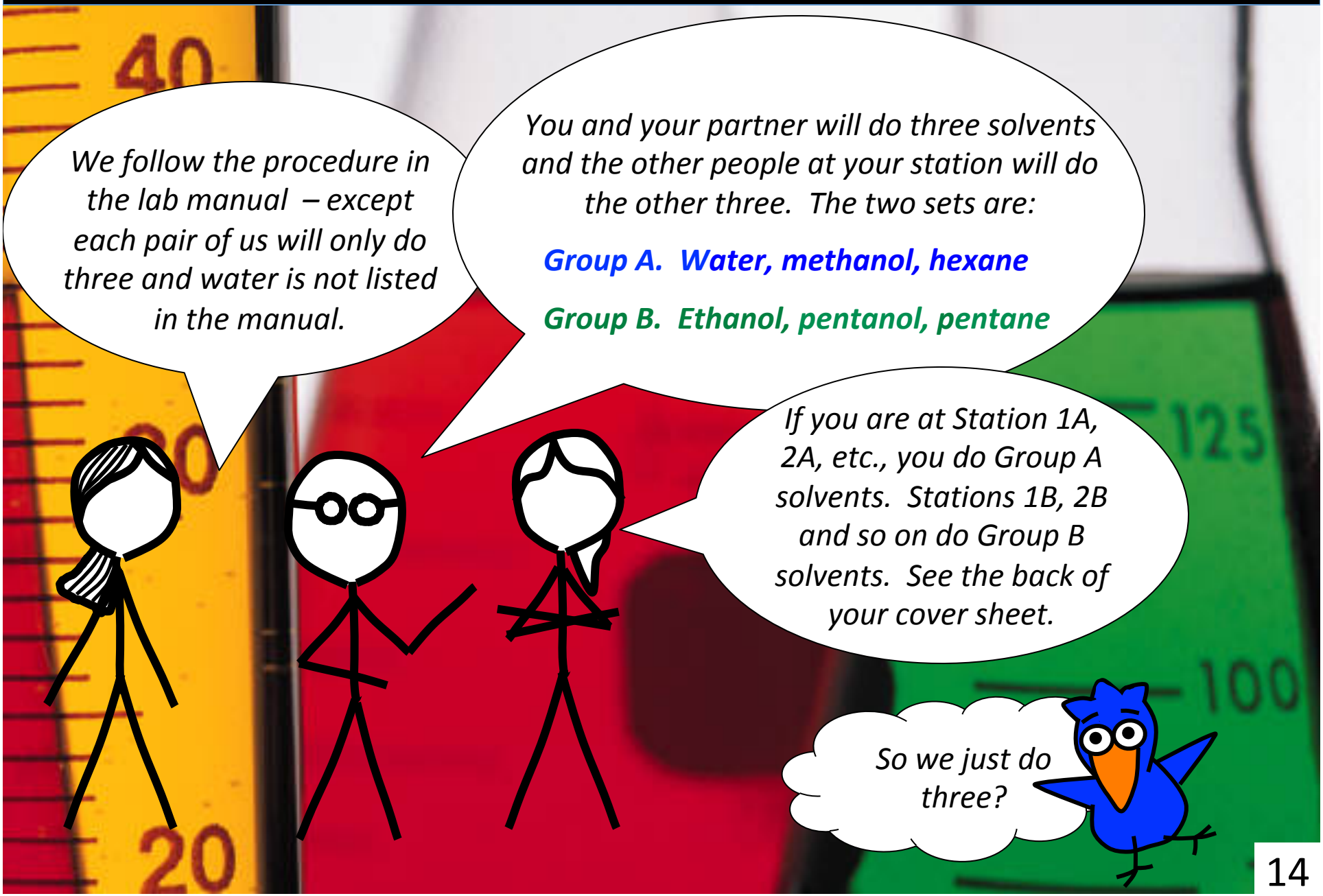
Some solvents completely evaporate and the the filter paper starts to warm up again. If this happens, we want to use the minimum temperature as T_{final}.



Remember, today we are interested in the absolute value of ΔT – it'll be positive.

T_{final} is right here.

4. Procedure


We follow the procedure in the lab manual – except each pair of us will only do three and water is not listed in the manual.
You and your partner will do three solvents and the other people at your station will do the other three. The two sets are:
Group A. Water, methanol, hexane
Group B. Ethanol, pentanol, pentane
If you are at Station 1A, 2A, etc., you do Group A solvents. Stations 1B, 2B and so on do Group B solvents. See the back of your cover sheet.
So we just do three?

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 Turn in your ΔT values as soon as you have them. Dr. Mattson will announce when the average values are ready.

④ **On-line results** due at the end of class today. Late submissions are not graded – see the syllabus.

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

Today we will pay special attention to how you use the collected data from the graphs.

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

Chem Lab with the Stick People and Bird *was created and produced by Dr. Bruce Mattson, Creighton Chemistry. Enjoy it and share it if you wish.*