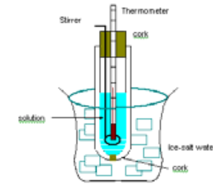
Chemistry BC2001x
Laboratory Week 6
Freezing Point Depression

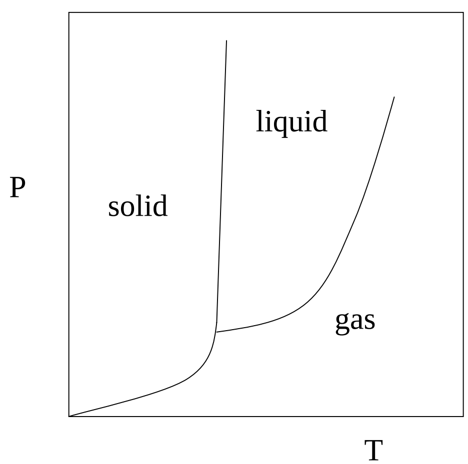
Freezing Point Depression



- Compare the freezing points of
  - pure solvent
  - solution: same solvent with weighed quantity of unknown solute
- Determine of freezing points by constructing cooling curves from data
- Topic of today's lecture:
  Preparing Good Graphs

Graphs: example
Phase diagram of a pure substance

Phase diagrams represent data that are the result of many experiments.



Creating a phase diagram for a pure substance

HOW?

Fix pressure: measure the melting and boiling points

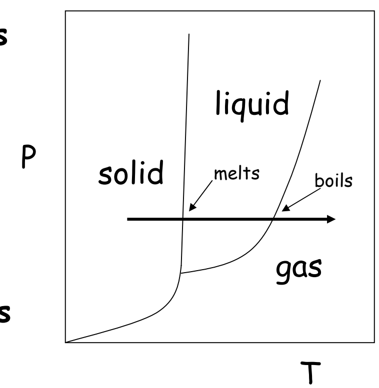
example:

(P,T) = (650 mmHg, 82°C)

Repeat at many pressures

Plot the data (points)

Connect with smooth curves



Phase Transitions: a heating curve

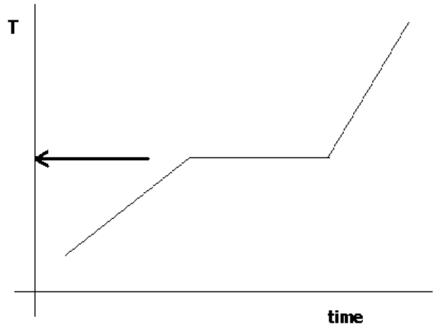
Heat a pure liquid at a constant rate

T rises linearly

Suddenly T stops rising.

Why?

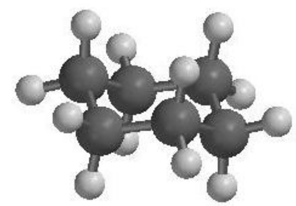
- Liquid is boiling!
- T rises again after the sample is totally vaporized.
- Boiling point is read from axis.



Today's Experiment

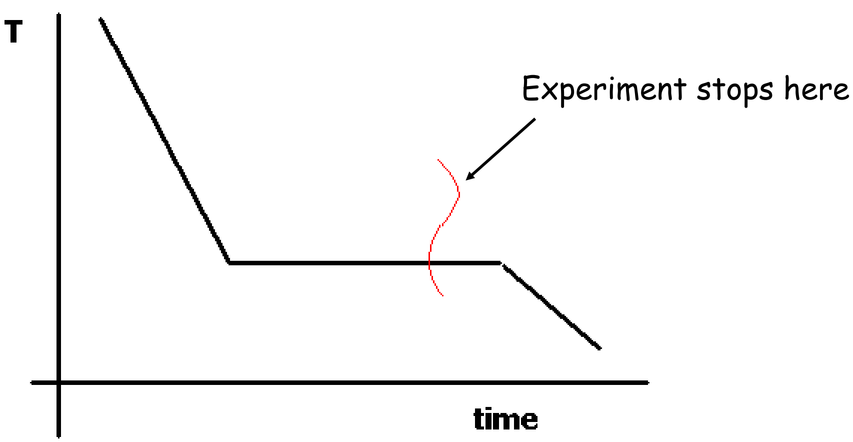
You will determine the molecular weight of an unknown solute by determining the freezing point depression of a measured weight of it in a known solvent, cyclohexane (T_{bp} = 80.7 °C, T_{mp} = 6.5 °C).

solvent:	solute:
C_6H_{12} = cyclohexane	Unknown solid

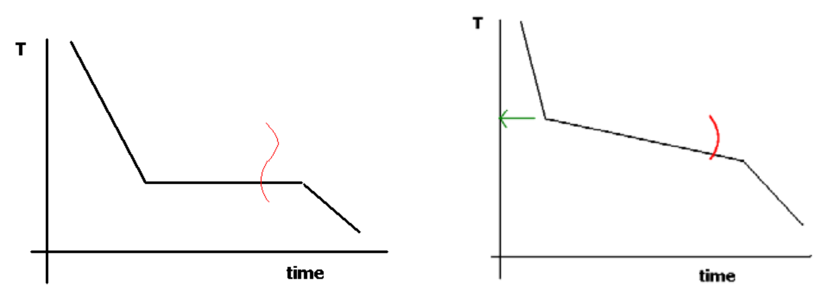


?

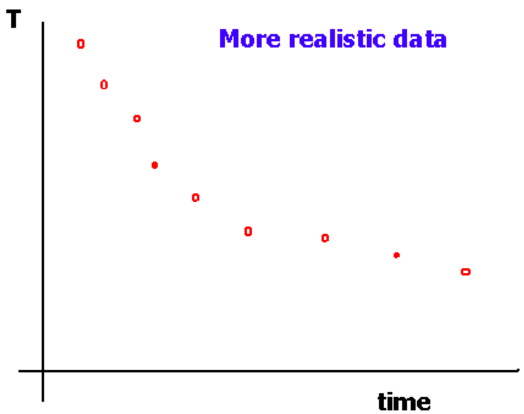
Idealized Cooling Curve
pure substance



Idealized Cooling Curves
pure solvent vs. solution

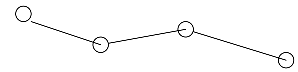


Real Cooling Curves: from Data Points

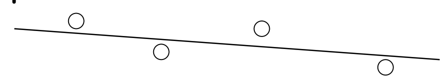


What curve (or line) should you draw through the points?

NEVER "follow the dots"

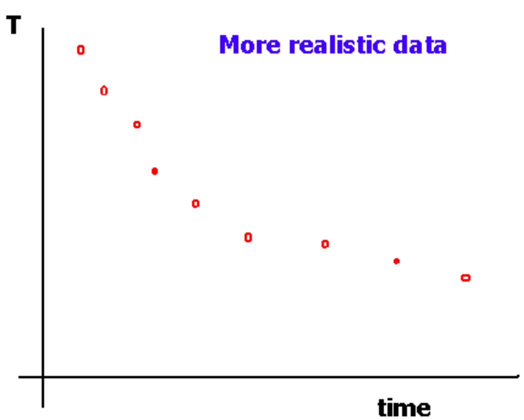


Instead draw a smooth curve (or line) which passes close to the data.



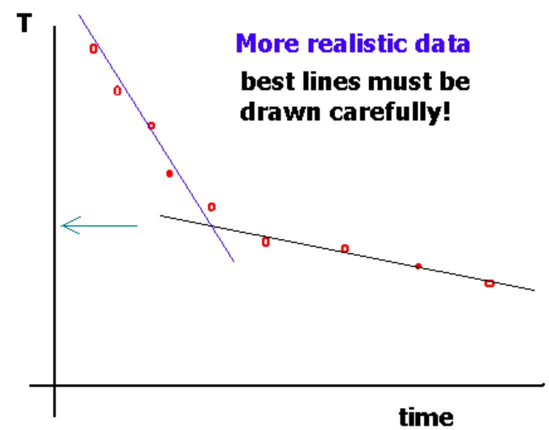
When in doubt, consult !

Real Cooling Curves: from Data Points



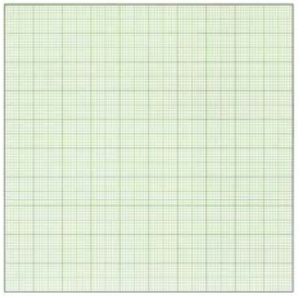
use a transparent ruler: move it around until you get a good fit
some points should be above, some below.

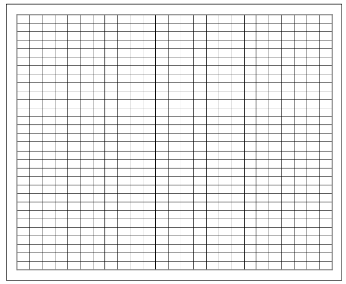
Real Cooling Curves: adding the lines!



do not circle the intersection: only data should be circled.

Graph Paper





Millimeter ruled paper is appropriate for this laboratory because you are working with your precise data.

More widely spaced lines would result in less accurate readings from your carefully collected data.

Plotting experimental data: questions you must ask

1) Which variable goes on which axis?

Answer is sometimes natural (one variable is independent), sometimes by convention, sometimes arbitrary.

(the paper can be oriented either way)

2) What scale is used on each axis?

Answering this question correctly is the KEY to good graphing technique!

Criteria for Scales on Axes

Scales on both axes satisfy the following criteria:

1) span or exceed the full range of the data.
(all points fit, with no extensions!)

2) spread the data across most of the page.

3) scale is easy to subdivide

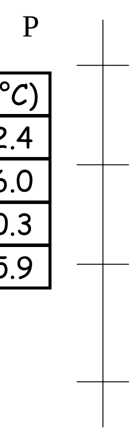
e.g. 7 boxes per unit is hard to divide, while 10 boxes per unit is much easier.

Points 2 and 3 may have to be balanced.

ZERO NEED NOT BE INCLUDED IN EITHER SCALE!

Choosing appropriate axis scales: example

P(mmHg)	T(°C)
31.2	22.4
72.4	26.0
137.9	30.3
204.3	35.9



The ordinate P (y-axis)

values from ~30 to ~205 mmHg
range = 175

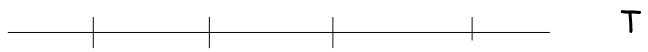
Suppose the paper has 25 large boxes; 175/25 = 7, so

7 mmHg = 1 box would fit

Good scale: 30, 37, 44, 51..?
NO: difficult to divide

better scale: 10 mmHg = 1 box
P From 0 to 250

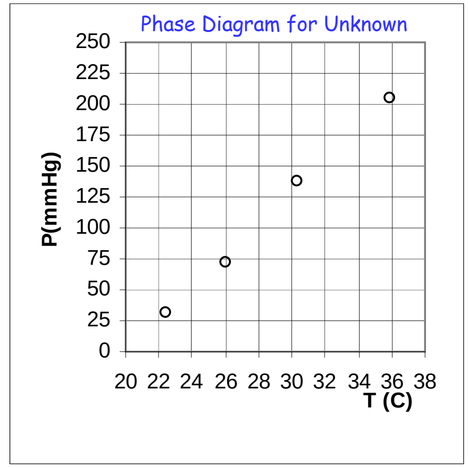
Choosing appropriate scales: example



P(mmHg)	T(°C)
31.2	22.4
72.4	26.0
137.9	30.3
204.3	35.9

The abscissa T (x-axis)
range ~22 to 36
→ 14 degrees
boxes: 18
so 1 box = 1 degree
Good scale: T = 20 to 38
note that O is NOT part of this scale.

Plotting the data

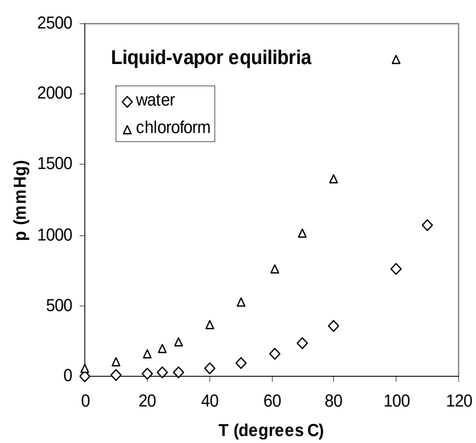


Label each axis with variable, units, and scale (label tic marks).
Add informative title (*not* "P vs. T").
Mark points clearly

P(mmHg)	T(°C)
31.2	22.4
72.4	26.0
137.9	30.3
204.3	35.9

With Multiple Sets of Data

- **Use different symbols to distinguish curves**
- **Put a small dot to locate exactly the center of each**
- **Prepare a legend to identify the symbols**



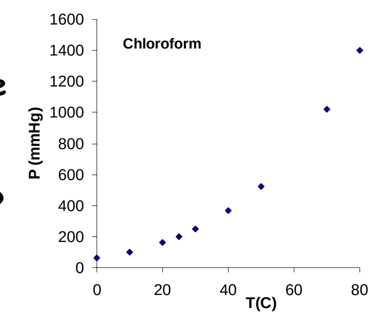
Many uses for graphs in Chemistry

Getting a feel for the data

- **Is there a trend?**
- **Is the data linear or curved?**
- **This is when a rough plot on wide-ruled paper may be sufficient.**

Interpolation

- **Finding a number within the range of measured points**
- **Example: what is normal boiling point of chloroform? read T where P = 760**



What units for ΔT?

In $\Delta T = K_f m$, what units for ΔT?

Kelvin or Celsius?

$$T(K) = t(C) + 273.15$$

Suppose you measure t_1 and t_2 in °C:

convert each to K

$\Delta T = (t_2 + 273.15) - (t_1 + 273.15)$

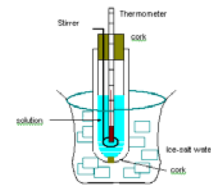
$= t_2 - t_1 = \Delta t$

so no need to convert! Same size degree.

but incorrect to add 273.15 to Δt

Why can't you simply record T when you first see crystals form?

1) There may be supercooling
2) The first crystals may be microscopic, difficult to see.
3) Temperature may not be uniform (small crystals may form at edges of the tube which is not at the same T as the thermometer).



Cooling curves give a much more reliable freezing point