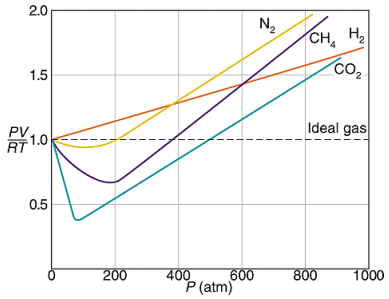
1 Morning class Week 2 Day 2: van der Waals gases

1. For van der Waals gases, a plot of pV/nRT vs. p is insightful. Scientists actually like the former variable, pV/nRT, so much that it's been given a name, the *compressibility*.

   (a) Please examine the compressibility vs. pressure graph, shown below. The graph is for one mole of a van der Waals gas.



   i. Please plot compressibility vs. pressure for one mole of an ideal gas.

   ii. What differences are there between your last answer and the van der Waals compressibility plots shown above?

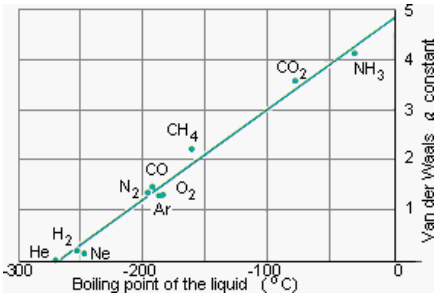
   iii. Set the van der Waals b term equal to zero. Use algebra to find out if, under these conditions, compressibility is always greater or smaller than 1.

   iv. Set the van der Waals a term equal to zero. Use algebra to find out if, under these conditions, compressibility is always greater or smaller than 1.

   v. If we are in the region where compressibility is greater than one, is the a term or b term dominant?

   vi. If we are in the region where compressibility is less than one, is the a term or b term dominant?

   (b) Please examine the graph below. The boiling point is the temperature where at 1 atm the liquid turns into a gas or conversely the temperature where a gas turns into a liquid.



   i. Please state an approximate formula relating a to the boiling point of a liquid.

   ii. Recall the argument used in class to derive the constant a. Please discuss with your neighbors why a is directly proportional to boiling point.

(c) Please examine the table below.

Table of van der Waals Constants

	a (L^2atm/mol^2) #	b (L/mol) *
Acetic acid	17.48	0.1065
Acetone	15.81	0.1124
Acetylene	4.457	0.0522
Ammonia	4.170	0.0371
Argon	1.337	0.032
Benzene	18.57	0.1193
Bromine	9.62	0.0591
Butane	13.71	0.1164
Carbon dioxide	3.610	0.0429
Carbon disulfide	11.10	0.0726
Carbon monoxide	1.453	0.0395
Chlorine	6.260	0.0542
Chlorobenzene	25.5	0.1454
Chloroethane	11.51	0.0903
Chloromethane	7.467	0.0648
Cyclohexane	21.53	0.1411
Diethyl ether	17.23	0.1333
Dimethyl ether	8.58	0.0774
Ethane	5.51	0.0651
Ethanol	12.40	0.0871
Ethylene	4.552	0.0582
Fluorine	1.156	0.029
Helium	0.0341	0.0238
Hexane	24.52	0.1744

i. Please find He and Ar on the table. Does the lighter or heavier noble gas have greater intermolecular attraction? In this case, these attractions are caused by the intermolecular dispersion interaction.

ii. Please find F_2, Br_2, and Cl_2 on the table. Do the lighter or heavier halogen gases have greater intermolecular attractions? In this case, these attractions are caused by the intermolecular dispersion interaction.

iii. What trends do the above two answers suggest about the intermolecular dispersion interaction?

iv. Please explain how the above information correlates with the observation at STP that chlorine is a gas, bromine a liquid and iodine a solid.

(d) Please review everything you have learned over the last three classes about van der Waals gases.