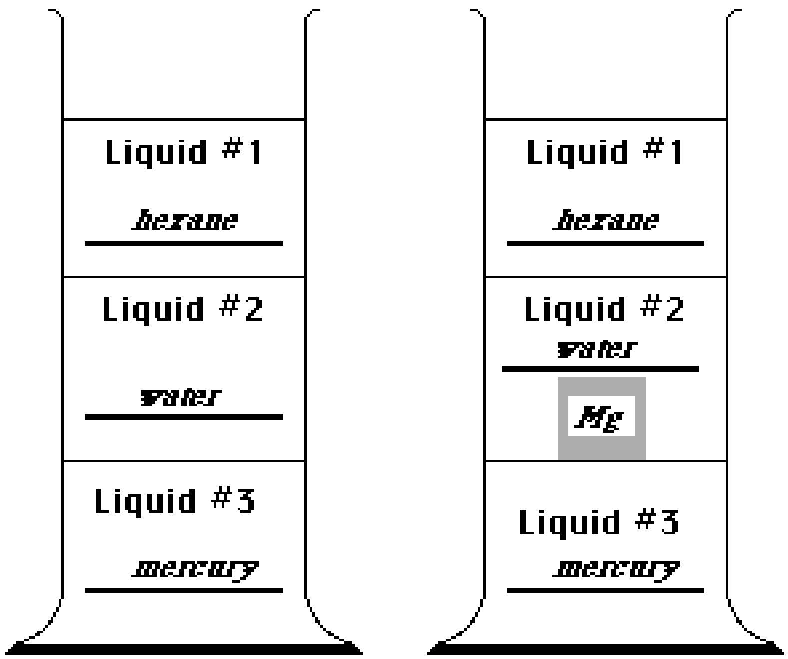
Chem 1014
In-Class Problem Set #3
Week of September 7, 1999
Fall 1999

Name___________________________
TA Name _______________________
Lab Section #______

1. Describe the order (top to bottom) of the following substances placed into the same graduated cylinder; 25 mL of water, 25 mL of hexane (similar to gasoline) and 25 mL of mercury. What would happen if a piece of magnesium were dropped into the graduated cylinder? Draw and label a picture of a graduated cylinder before and after adding the piece of magnesium. (Note: your textbook contains all the information you will need to solve this problem.)



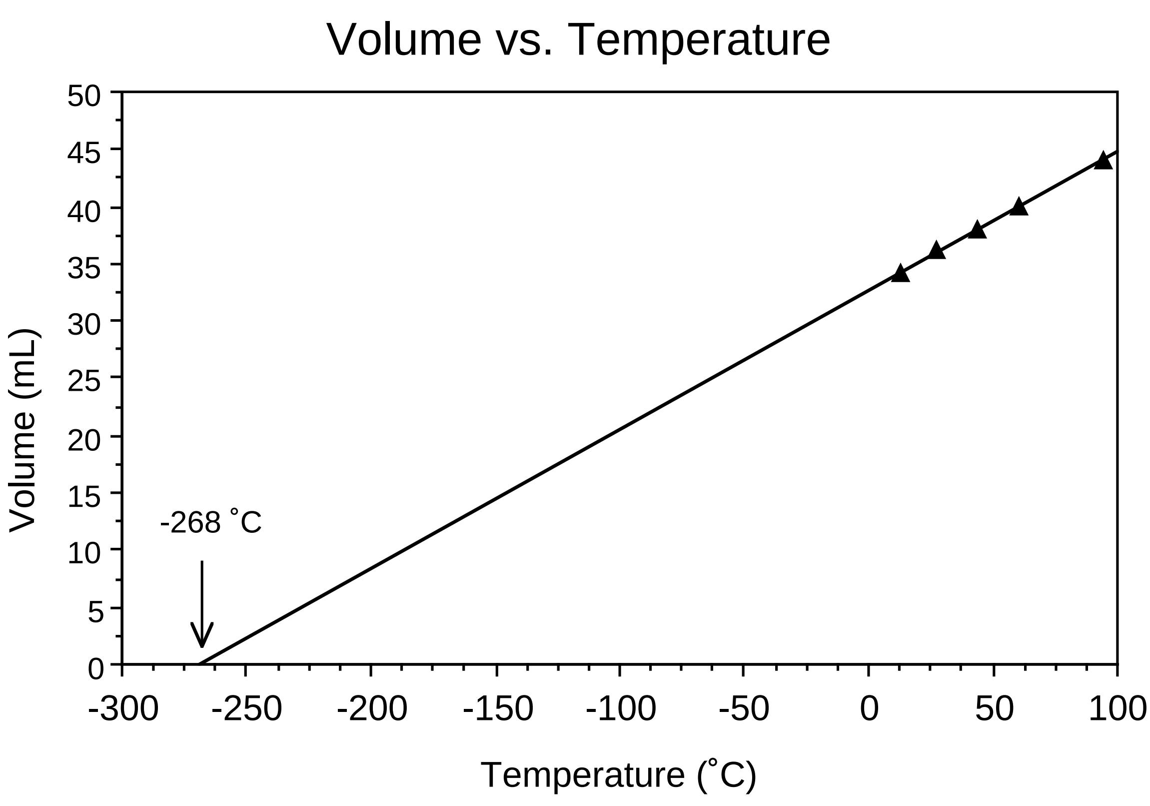
The order of the liquids is based on the densities of the liquids. Hexane has a density of 0.660 g mL^{-1}, water has a density of 1.00 g mL^{-1} and mercury has a density of 13.6 g mL^{-1}. When a piece of magnesium is added to the graduated cylinder it will rest on top of the mercury layer and at the bottom of the water layer. The density of magnesium is 1.74 g mL^{-1} which is greater than water but less than mercury. So the sample of magnesium floats on the mercury and sinks in water. Note that because the three liquids are each immiscible in the other the layers remain separated evn when the cylinder is shaken.

2. Describe the three states of matter, list the important physical characteristics of each phase.

The three states (phases) are gas, liquid and solid. From a macroscopic view solids have a definite shape and volume. Solids are not compressible. Liquids have a definite volume, but their shape is not definite. Liquids will take the shape of the container. Liquids are not very compressible either, but slightly more compressible than solids. Gases have no definite shape or volume. They will completely fill a container. Because there is so much space between particles in a gas, gases are very compressible.

3. Plot the following data, volume on the *y*-axis and temperature on the *x*-axis. (Note: Be sure to plot temperature in units of Kelvins.)

Obs.	Vol (mL)	Temp (˚C)	
1	44	95.0	
2	40	61.0	
3	38	44.0	
4	36	28.0	
5	34	13.0	



a) What is the volume of the gas when the temperature is 82 ˚C?

We can answer this question by either using our graph or determining the constant which relates volume and temperature for this particular sample of gas. For gases (we talked about this in lecture)

$$V \propto T$$

This is true as long as the temperature is expressed in units of Kelvins. To make this direct relationship an equality we need a constant.

$$V = kT$$

$$\frac{V}{T} = k$$

Obs.	Vol (mL)	Temp (˚C)	T (Kelvins)	k
1	44	95.0	368	$k = \frac{44}{368} = 0.120$
2	40	61.0	334	$k = \frac{40}{334} = 0.120$
3	38	44.0	317	$k = \frac{38}{317} = 0.120$
4	36	28.0	301	$k = \frac{36}{301} = 0.120$
5	34	13.0	286	$k = \frac{34}{286} = 0.119$

So we see that the quotient of $\frac{V}{T}$ is always 0.120. So for the same sample of gas this must hold true. In this case we need to determine the volume at 82 ˚C, so first we convert ˚C to K by adding 273 and substitute,

$$V = kT$$
$$V = 0.120\ (355\ K) = 42.6\ mL$$

b) Estimate the temperature of the gas when the volume is 30 mLs.

We can use the same approach as used in part a, only this time we'll solve for temperature.

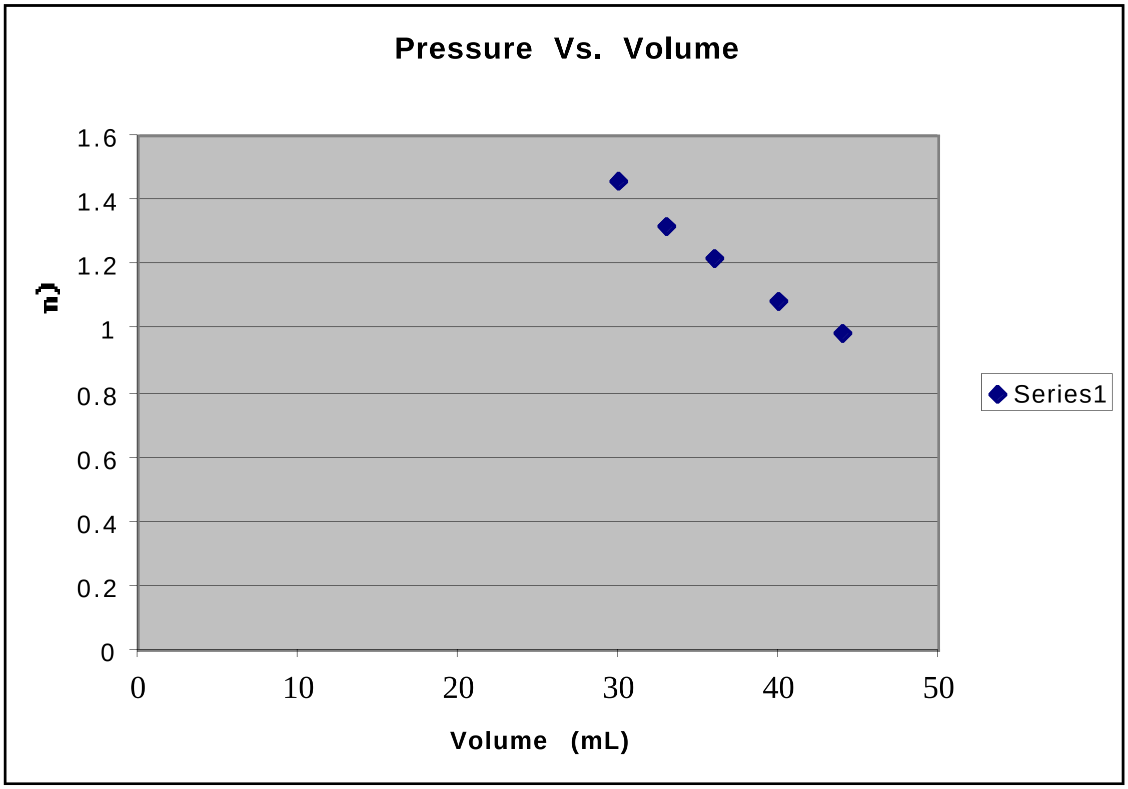
$$V = kT$$

$$\frac{V}{k} = T$$

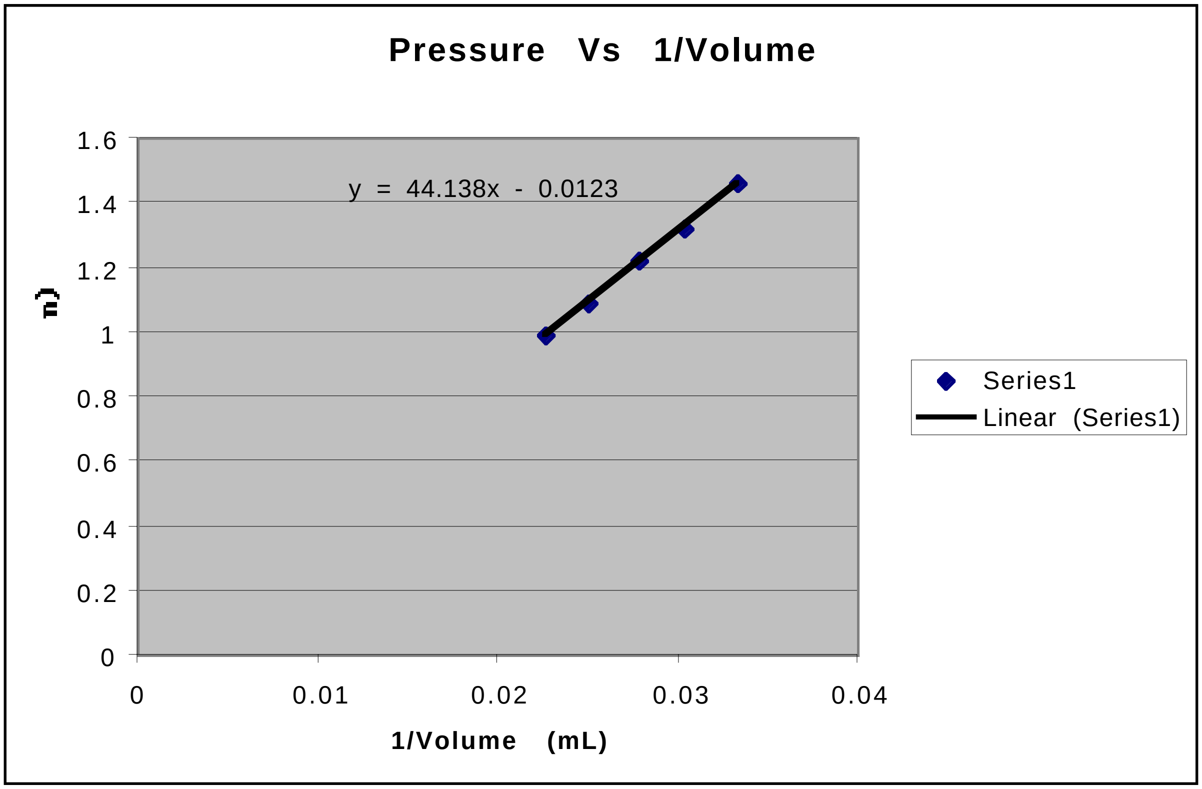
$$\frac{30}{0.120} = 250\ K\ (-23\ ˚C)$$

4. Plot the following data, pressure on the *y*-axis and volume on the *x*-axis.

Obs.	Vol (mL)	Pressure (atm)	
1	44	0.99	
2	40	1.09	
3	36	1.22	
4	33	1.32	
5	30	1.46	



a) Plot pressure versus V^{-1}.



b) Determine the volume of the gas when the pressure is 1.15 atm.

We can answer this question by either using our graph or determining the constant which relates volume and pressure for this particular sample of gas. For gases (we talked about this in lecture)

$$\mathbf{P \propto \frac{1}{V}}$$

To make this direct relationship an equality we need a constant.

$$\mathbf{P = k \cdot \frac{1}{V}}$$

$$\mathbf{PV = k}$$

Obs.	Vol (mL)	Pressure (atm)	k
1	44	0.99	**44 · 0.99 = 43.6**
2	40	1.09	**40 · 1.09 = 43.6**
3	36	1.22	**36 · 1.22 = 43. 9**
4	33	1.32	**33 · 1.32 = 43. 6**
5	30	1.46	**30 · 1.46 = 43.8**

So we see that the quotient of PV is always 43.6. So for the same sample of gas this must always hold true. In this problem we need to determine the when the pressure is 1.15 atm, so substituting,

$$\mathbf{PV = k}$$

$$\mathbf{V = k \cdot \frac{1}{P} = 43.6 \cdot \frac{1}{1.15} = 37.9\ mL}$$

c) Determine the pressure of the gas when the volume is 34 mLs.

We can use the same approach as used in part a, only this time we'll solve for pressure.

$$\mathbf{PV = k}$$

$$\mathbf{P = k \cdot \frac{1}{V} = 43.6 \cdot \frac{1}{34} = 1.3\ atm}$$