Gas Law / Solutions review!

Assume that any acids in this worksheet are strong acids.
You'll need the vapor pressure charts for some of these problems.

1. (You'll need a vapor pressure chart for these)
a. If the temperature is 24.0 °C when the relative humidity is 54%, find the vapor pressure of water in the atmosphere.

b. What is the relative humidity on a 29°C day, if the vapor pressure of water is 25.4 mmHg?

c. What is the boiling point of water at a very high elevation, where air pressure is 400. mmHg?

2. Consider this chart of Vapor Pressure vs. Temperature, for ethanol and acetone.

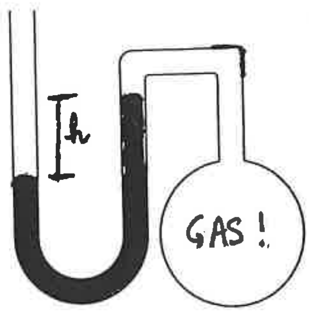
Temperature °C	Ethanol VP mmHg	Acetone VP mmHg
-2.3	10	71
19.0	40	188
34.9	100	354
48.0	200	571
56.5	300	761
63.5	400	958
78.4	760	1510
97.5	1520	2560
126.0	3800	5100

a. Explain why the equilibrium vapor pressure of a liquid increases as temperature increases.

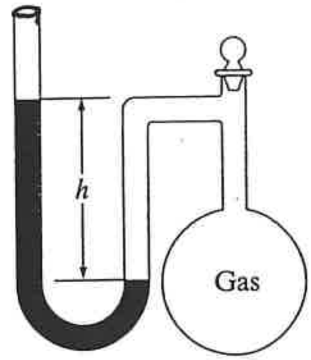
b. Estimate the normal boiling point of acetone. ________
c. Estimate the boiling point of ethanol if it is in a pressure chamber, where air pressure is 5 atm. ____________
d. Which liquid has stronger intermolecular forces? Explain how you can tell from the data.

3. Consider the following mercury manometers. Each are open to the atmosphere on the left side. Assume that the atmospheric pressure is 745 mmHg. Determine the pressure of the gas sample in each case.

a. h = 3.5 cm



b. h = 95 mm



c. In part (a), what would the height be if the fluid in the tubing is water, instead of mercury?

4. $Ba(OH)_2$ and $C_2H_4(OH)_2$ can both dissolve into water.

a. Compare these two compounds in terms of:

Total concentration of solute particles in a 0.02 M (aq) solution.

Electrical conductivity of their 0.02 M (aq) solutions.

Type(s) of bonding involved in the compound.

b. Draw a picture showing an aqueous solution of $Ba(OH)_2$.

c. Classify each compound as an electrolyte or non-electrolyte:

$C_4H_{10}O$ $CaBr_2$ $NaBrO$ HNO_3 $LiOH$ CH_3OH HBr

5. Consider two samples of gases:

10.0 liters of fluorine at 1.0 atm and 5.0 °C

10.0 liters of butane (C_4H_{10}) at 1.0 atm and 5.0 °C

For each letter, determine which sample has the higher value of the quantity listed (or indicate whether they are equal) For the ones when one sample has a higher value of the quantity, find the ratio of the higher value to the lower value of that quantity. Assume that the gases are behaving ideally.

a. Density	fluorine	butane	they are equal
b. rate of effusion	fluorine	butane	they are equal
c. number of atoms	fluorine	butane	they are equal
d. number of molecules	fluorine	butane	they are equal
e. average kinetic energy	fluorine	butane	they are equal
f. root-mean-square speed	fluorine	butane	they are equal

6. For the two samples of gas in the above problem:

a. What temperature (in °C) would be needed to double the root mean square speeds of the gases?

b. What temperature (in °C) would be needed to double the average kinetic energies of the gases?

c. How could you change the conditions listed above (they are still fluorine and butane, though) to cause the gases to increase their densities?

d. What is the rms speed of fluorine at the conditions listed in #1?

e. How could you change the temperature and pressure of the gases to cause them to deviate more from ideal behavior? In what ways will the gases act less "ideal" and more "real" if you do this?

6f. Sketch a graph showing the distribution of speeds for the gases in #1. (so, for fluorine and butane, both at 5 °C) (Put the Boltzmann distribution for both gases on the same graph).
g. Still on the same graph, sketch the curve for fluorine again, but at 100 °C
h. What would the Boltzmann distribution look like if the gases could be cooled to zero Kelvin?

i. Even at the same T and P, butane gas is less ideal than fluorine, because butane molecules are larger (occupy more volume) and also have stronger attractive forces to each other. Suppose you calculated the pressure of a different sample of butane according to the ideal gas law ($P = nRT/V$) and then you measured the pressure of the sample.

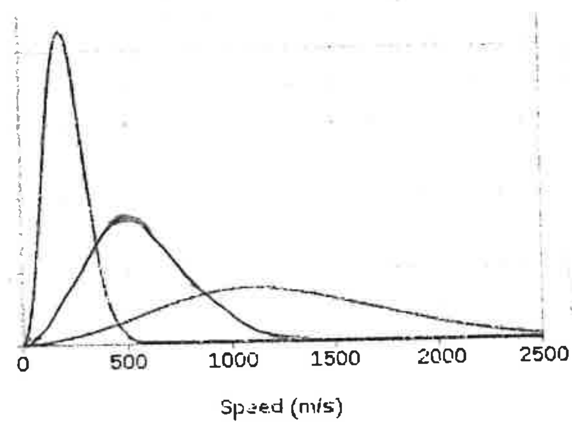
i1. If intermolecular forces were present (but the space occupied by molecules was still negligible), how would the actual pressure compare to the calculated ("ideal") pressure?

i2. If the molecules themselves occupy significant volume (but had no significant attractive forces), how would the actual pressure compare to the calculated ("ideal") pressure?

7. The Boltzmann distributions for Ne, Xe, and He are shown below/right.
All gases are at 200 Kelvin.

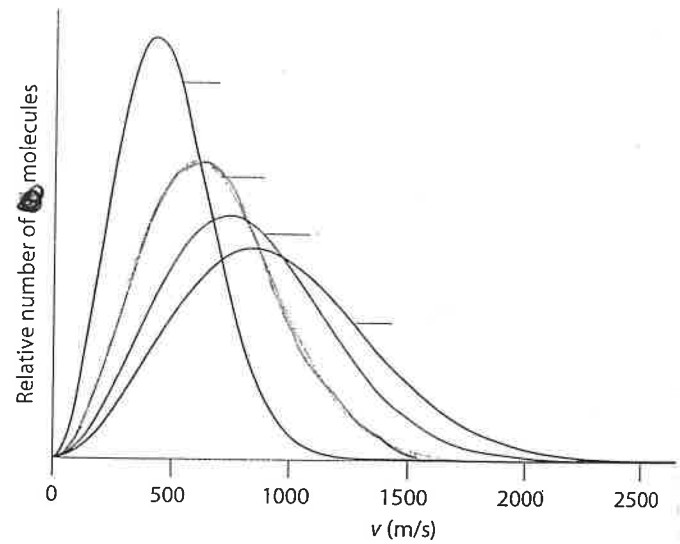
a. Identify which gas corresponds to which curve,
and use the graph to estimate the rms speed of each gas.

b. How does the average kinetic energy of Neon compare to the average kinetic energy of Xenon?



8. Boltzmann distributions for ethane gas (C_2H_6) are shown below/right.
The curves correspond to 400 Kelvin, 800 Kelvin, 600 Kelvin, and 200 Kelvin.

a. How does the average kinetic energy of ethane at 400 K compare to the average kinetic energy of ethane at 200 K?



b. Determine which curve corresponds to which temperature.

c. Calculate the rms speed of ethane at 400.Kelvin.

d. How would the effusion rates of ethane and methane compare, if both are at 400. K? (methane is CH_4)

9. A flask contains 100. g of Xenon and 100. g of Krypton (and no other gases) at room temperature.
The total pressure in the flask is 550. mmHg.

a. Without doing any math yet, which gas should be present at a higher partial pressure? Why?

b. Without doing any math yet, which gas should have a higher average kinetic energy? Why?

c. Calculate the partial pressure of each gas.

d. Another flask contains ethanol gas at a partial pressure of 24 mmHg, diethyl ether at a partial pressure of 400. mmHg, and propane at a partial pressure of 227 mmHg. Calculate the mole fraction of propane in this mixture.

10. $2\ H_2O_{2(aq)}$ ------> $2\ H_2O_{(l)} + O_{2(g)}$

a. If 2.00 grams of hydrogen peroxide decompose, and the oxygen produced is collected by water displacement at ~~33~~ 35 °C and a room pressure of 748 mmHg, what volume of gas will be collected?

b. What was the mole fraction of oxygen in the gas that was collected?

c. Household hydrogen peroxide is typically about 0.88 Molar H_2O_2.
If 250. mL of this peroxide solution decomposed completely (so that all the H_2O_2 solute has reacted), what volume of gas should be collected? Assume the oxygen gas is collected by water displacement at 60. °C at a room pressure of 1.00 atm.

11. A gas with empirical formula CH_2 has an effusion rate that is 71% as high as nitrogen's effusion rate at the same temp. Find the molar mass and molecular formula of the gas.

12. Another gas with the empirical formula CH_2 has a density of 3.02 g/L at 100.°C and 1.1 atm.
Find the molar mass and the molecular formula of the gas.

13. Cerium sulfate dihydrate is a solid with a heat of solution of -80 kJ/mole.
Sodium nitrate is a solid with a heat of solution of 20 kJ/mole.
(Both values are for forming an aqueous solution; the compounds are dissolving into water.)

a. Which substance be more soluble into water as temperature of water increases, and which will be more soluble into water as temperature decreases?

b. If cerium sulfate dihydrate crystals at room temperature are added to water at room temperature, will the water temperature increase or decrease as the crystals dissolve?

c. If sodium nitrate crystals at room temperature are added to water at room temperature, will the water temperature increase or decrease as the crystals dissolve?

d. A substance's $\Delta H_{solution}$ is determined by $\Delta H_{solvent}$, ΔH_{solute}, and ΔH_{mix}.
For each ΔH term, Explain what process is happening on a molecular/atomic level, and whether the term is exothermic or endothermic, and why. Use sodium nitrate as an example.

e. Based on the value of sodium nitrate's $\Delta H_{solution}$ (given above part (a)), how do the $\Delta H_{solvent}$, ΔH_{solute}, and ΔH_{mix} compare in magnitude? (how do they compare to each other?)

14a. Sketch a graph showing gas pressure vs. volume, assuming that the temperature and moles of gas are constant.

b. Is this a direct or inverse relationship?

c. Sketch a graph showing gas pressure vs temperature, assuming that the volume and moles of gas are constant.

d. Is this a direct or inverse relationship?

e. Explain, in terms of kinetic theory, why gas pressure increases/decreases as temperature increases. (when moles and volume are constant).