Key

States of Matter Review

Terms:

- Kinetic molecular theory
- Real vs. Ideal Gases
- Pressure
- Boyle's Law
- Charles' Law
- Gay-Lussac's Law
- Combined Gas Law
- Avogadro's Hypothesis
- Ideal Gas Law
- Graham's Law of Effusion (Honors)
- Diffusion
- Dalton's Law of Partial Pressures
- STP
- Molar Gas Volume
- Stoichiometry
- Polar and Nonpolar Molecules
- Intermolecular Forces
  - Van der Waals (London Dispersion)
  - Dipole-dipole
  - Hydrogen Bonding
- Properties of Solids, Liquids, Gases
- Amorphous Solids
- Crystalline Solids
- Surface Tension
- Capillary Action
- Fluids
- Phase Diagrams
- Phase Changes (fusion, solidification, etc)
- Vapor Pressure
- Boiling Point

Practice Problems:

1) A sample of gas has a volume of 5.0 L at STP. If the temperature was changed to 25°C and the pressure was changed to 75.0 kPa, what would the volume be? Write your answer with significant figures and units.

2) A mixture of gases A, B, and C has a pressure of 800 kPa. If gas A has a partial pressure of 300 kPa and gas B has a partial pressure of 250 kPa, what is the partial pressure of gas C?

3) If water was boiling at a temperature of 70°C, what is the pressure of the surrounding atmosphere? (Use your vapor pressure worksheet.)

4) A) Under what conditions does a gas behave most unlike an ideal gas (in other words, when does a gas deviate from the kinetic molecular theory?)

   B) Under what conditions does a gas would behave most like an ideal gas?

5) A student calculated the boiling point of water ~~at STP~~ to be 102°C in an experiment. What is the percent error in the measurement?

6) A) What is the relationship between pressure and temperature if volume remains constant?

   B) Explain this relationship in terms of molecular movement.

7) State Avogadro's Hypothesis:

8) Define Boiling Point:

9) What is the volume of a 3.00 mole sample of oxygen gas at 70°C and 2.2 atm?

10) Which will diffuse faster, two gases in the same container, or two liquids in the same container? Explain.

11) A) A sample of gas is kept at constant temperature. If the pressure doubles, what will happen to the volume of that gas?

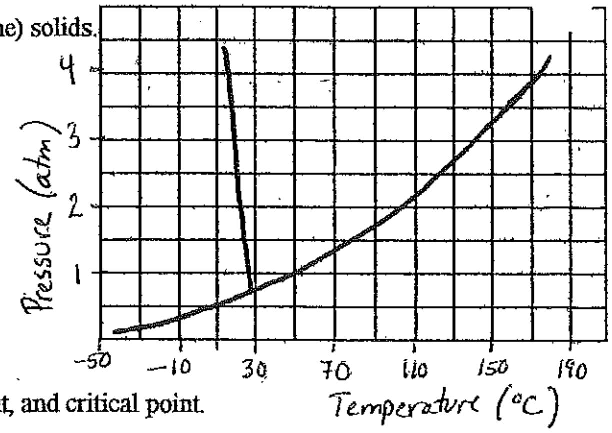
    B) Draw a graph that shows this relationship.

12) Explain how the behavior of gas molecules compares with the behavior of liquid molecules.

13) Compare and contrast boiling and evaporation.

14) Compare and contrast amorphous solids and true (crystalline) solids.

15) Below is a phase diagram.



a) On the diagram, label solid, liquid, gas, triple point, and critical point.

b) If the pressure remains at 2.0 atm, but the temperature increases from -10°C to 120°C, describe all phase changes that occur.

16) For each of the following molecules, draw the dot diagram, identify if the molecule is polar or nonpolar, and then identify the type of intermolecular forces that would exist within a sample of each substance.

a) NH_3

b) CH_4

c) F_2

d) Which of the three substances above would you expect to have the lowest boiling point? Highest boiling point?

17) When an electrical current is passed through liquid water, hydrogen gas and oxygen gas are formed as represented in the equation below.

$H_2O \qquad\qquad H_2 + O_2$

a) Balance the equation.

b) What type of reaction is this?

c) If 15.0 grams of water are reacted, how many liters of oxygen gas would be formed at STP?

d) If the reaction described in c took place at 50.0°C and 0.300 atm, what is the volume of the oxygen gas formed?

18) A sample of neon gas diffuses at a rate which is 3 times faster than gas Z. What is the molecular mass of gas Z?

19) Determine the relative rate of effusion of ammonia gas, NH_3, as compared to xenon gas, Xe.

States of Matter Review Sheet

1) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{(101.3\,kPa)(5.0\,L)}{273K} = \frac{(75.0\,kPa)(V_2)}{298K}$

combined gas law

$V_2 = 7.4\,L$

2) $P_T = P_A + P_B + P_C$ $800\,kPa = 300\,kPa + 250\,kPa + P_C$

Dalton's law

$P_C = 250\,kPa$

3) Must use vapor pressure curve for this question. (p 344 in textbook)

pressure of atmosphere is ~ 230 torr

4) A) Gases behave UNideally at high pressures and low temps.

B) Gases behave most ideally at low pressures and high temps.

5) Should read "Student calculated the boiling point of water at standard pressure to be 102°C." (not STP!)

$\frac{100-102}{100} \times 100 = 2\%$ error

6) A) Direct relationship or as temperature increases, pressure also increases

B) As temp increases, molecules move faster and hit the walls more often + with greater force. This increase in force on the walls results in an increase in pressure

7) Avogadro's hypothesis is the same as Avogadro's Law: "Equal volumes of gases at the same temp and pressure contain an equal # of molecules."

8) Boiling point: the temperature at which the equilibrium vapor pressure of the liquid equals the atomospheric pressure.

9) $PV = nRT$ $\quad (2.2\,atm)(V) = (3.00\,mol)(0.0821\,\frac{L\,atm}{K\,mol})(343K)$

$V = 38\,L$

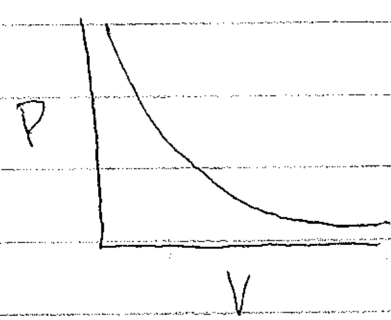
) Two gases diffuse faster than 2 liquids because the gas particles have more space between them therefore they can move through space more quickly because they do not collide with other molecules as often as the liquid molecules collide with each other.

) A) $P_1V_1 = P_2V_2$ $\quad P_1V_1 = (2P_1)V_2$

$V_2 = \frac{1}{2}V_1$

The new volume will be half of the original volume.

B)

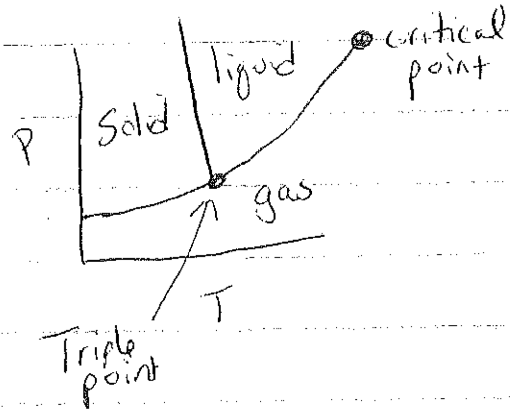


2. Gas molecules have more space between them than liquid molecules. Gas molecules move in straight lines until they collide with another molecule. whereas liquid molecules slide past one another but still stay fairly close to other molecules due to their intermolecular forces.

3. Boiling and evaporation both are when a liquid changes to a gas. However, there are important differences: Boiling occurs only when the atmospheric pressure is equal to (or lower than) the vapor pressure of the liquid. Boiling happens throughout the whole sample of liquid. Evaporation occurs at any temperature (as long as there is liquid present) but only occurs on the surface of the liquid. The molecules on the surface that evaporate are the fastest moving particles in the sample. They have enough energy to overcome the attractive forces of the surrounding molecules.

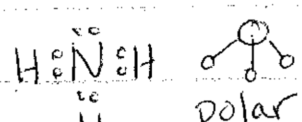
4. Crystalline solids have a very organized repeating pattern of particles called a crystal lattice. Amorphous solids contain particles that are not arranged in regular patterns. Both types of solids contain particles that are held in position and vibrate in place.

15) a)



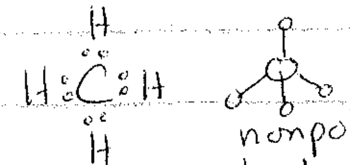
b) begins as a solid, melts at ~20°C, is a liquid, boils at ~100°C, ends as a gas.

16) a)



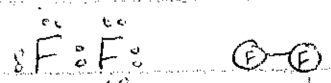
polar
hydrogen bonding

b)



nonpolar
london dispersion forces

c)



nonpolar
London Dispersion forces

d) lowest bp = CH_4 (weakest IMFs because nonpolar and low Molar Mass)
highest bp = NH_3 (strongest IMFs becaus polar and N-H indicates hydrogen bonding)

17) a) $2H_2O \rightarrow 2H_2 + O_2$

b) Decomposition reaction

c) $15.0 g\ H_2O \times \frac{1 mol\ H_2O}{18.0 g\ H_2O} \times \frac{1 mol\ O_2}{2 mol\ H_2O} \times \frac{22.4 L\ O_2}{1 mol\ O_2} = 9.33\ L\ O_2$

d) $15.0 g\ H_2O \times \frac{1 mol\ H_2O}{18.0 g\ H_2O} \times \frac{1 mol\ O_2}{2 mol\ H_2O} = 0.417\ mol\ O_2$

$PV = nRT$ $\quad (0.300\ atm)(V) = (0.417 mol)(0.0821 \frac{L\ atm}{K\ mol})(323 K)$

$V = 36.9\ L$

18) $$\frac{rate_{Ne}}{rate_Z} = \sqrt{\frac{MM_Z}{MM_{Ne}}}$$ $$\frac{3}{1} = \sqrt{\frac{x\ g/mol}{20.2\ g/mol}}$$

Graham's Law

$$9 = \frac{x}{20.2}$$

$$x = 182\ g/mol$$

19) $$\frac{rate_{NH_3}}{rate_{Xe}} = \sqrt{\frac{MM_{Xe}}{MM_{NH_3}}}$$ $$\frac{rate_{NH_3}}{rate_{Xe}} = \sqrt{\frac{131.3\ g/mol}{17.0\ g/mol}}$$

$$\frac{rate_{NH_3}}{rate_{Xe}} = 2.78$$

ammonia gas diffuses at a rate that is 2.78 times the rate of xenon gas.

Key

States of Matter Review – Heat calculations (pay attention to the units!)

1) Given that the heat of vaporization of water is 40.79 kJ/mol, how much energy is required to vaporize 25.0 grams of water at 100°C?

$$25.0\,g\,H_2O \times \frac{1\,mol}{18.0\,g} \times \frac{40.79\,kJ}{1\,mol} = 56.7\,kJ$$

2) How many grams of solid aluminum could be melted at its melting point when 56.0 kJ of energy is added? (ΔH_{fusion} for aluminum = 298 kJ/kg)

$$56.0\,kJ \times \frac{1\,kg}{298\,kJ} \times \frac{1000\,g}{1\,kg} = 188\,g$$

3) The molar enthalpy of fusion of sodium metal is 2.602 kJ/mol. What is the enthalpy of fusion of sodium in J/g?

$$\frac{2.602\,kJ}{1\,mol} \times \frac{1000\,J}{1\,kJ} \times \frac{1\,mol}{23.0\,g} = 113\,J/g$$

4) It requires 5067 kJ of energy to vaporize 1000.g of copper metal at its melting point. Calculate the molar enthalpy of vaporization for copper in kJ/mol.

$$\frac{5067\,kJ}{1000\,g} \times \frac{63.55\,g}{1\,mol} = 322\,kJ/mol$$