## Unit 3 Review for Midterms

Intermolecular Forces and properties

You should be able to:

- Identify all types of intermolecular forces present in a molecule
- Explain differences in boiling points and vapor pressures due to IMFs
- Understand the effects of polarizability on strengths of London dispersion forces
- Explain solubility in terms of molecular interactions between different molecules and draw interactions
- Relate properties of solids and liquids to IMFs
- Explain how the properties of ionic compounds, molecular compounds, metallic substances, and covalent network solids are related to their bonding and IMFs
- Perform calculations using the ideal gas law
- Understand partial pressure and how to calculate from moles in a mixture of gases
- Interpret graphical relationships of gases (pressure vs volume, volume vs temp, pressure vs temp) and related calculations
- Understand the Maxwell-Boltzmann distribution of kinetic energies of particles at a given T
- $K E=1 / 2 m v^{2}$, relationship between temperature and average KE
- Understand how real gases deviate from ideal gas behavior and why
- Calculate the molarity of a solution
- Draw and interpret diagrams with particle representations
- Describe how to separate mixtures using filtration, distillation, chromatography
- Relate molecular motion to the types of radiation (microwave, infrared, and ultraviolet/visible)
- Understand that electrons absorb or release energy (photon) and related calculations ( $c=\lambda v$; $E=h v$ ) and perform related calculations
- Understand the Beer-Lambert law $(A=\varepsilon b c)$ and interpret graphs

1. Describe ALL the intermolecular forces that must be overcome to convert these substances from a liquid to a gas:
a. $\mathrm{SO}_{2}$
b. $\mathrm{CH}_{3} \mathrm{CHOOH}$
c. $\mathrm{H}_{2} \mathrm{~S}$
d. $\mathrm{SF}_{6}$
2. Identify and explain which type of IMF accounts for each of these differences:
a. $\mathrm{CH}_{3} \mathrm{OH}$ boils at $65^{\circ} \mathrm{C}$ while $\mathrm{CH}_{3} \mathrm{SH}$ boils at $6^{\circ} \mathrm{C}$
b. Xe is liquid at atmospheric pressure and 120 K , whereas He is a gas under the same conditions.
c. Kr , atomic weight 84 , boils at 120.9 K , whereas $\mathrm{Cl}_{2}$, molecular weight about 71 , boils at 238 K.
d. At 298 K , the vapor pressure of acetaldehyde $\left(\mathrm{CH}_{3} \mathrm{COH}\right)$ is 120 kPa while the vapor pressure of water at the same temperature is 2.4 kPa .
3. Predict which of the following will have the higher boiling point and why:
a. $\mathrm{I}_{2}$ or $\mathrm{Cl}_{2}$
b. $\mathrm{H}_{2} \mathrm{O}$ or $\mathrm{H}_{2} \mathrm{~S}$
c. Hexane $\left(\mathrm{C}_{6} \mathrm{H}_{14}\right)$ or propane, $\mathrm{C}_{3} \mathrm{H}_{8}$
4. Pentane, $\mathrm{C}_{5} \mathrm{H}_{12}$, has two isomers: one is made of a long chain of carbons and the other is not.
a. Draw dot diagrams for each isomer.
b. Based on your diagrams above, thoroughly explain which isomer will have the highest boiling point.
5. Explain the following solubilities using IMFs:
a. NaCl is soluble in $\mathrm{H}_{2} \mathrm{O}$
b. $\mathrm{C}_{2} \mathrm{H}_{5} \mathrm{OH}$ is soluble in $\mathrm{H}_{2} \mathrm{O}$
c. $\mathrm{CCl}_{4}$ is not soluble in $\mathrm{H}_{2} \mathrm{O}$
6. Predict if the following are soluble in $\mathrm{H}_{2} \mathrm{O}$. Explain your reasoning.
a. $\mathrm{CH}_{2} \mathrm{Cl}_{2}$
b. $\mathrm{CH}_{3} \mathrm{OH}$
c. $F_{2}$
7. Draw a particle diagram of HCl as a solid, liquid, and gas. Describe the motion of the particles in each state.
8. Draw two particle diagrams, one containing $1.0 \mathrm{M} \mathrm{CaCl}_{2}$ and the other containing $2.0 \mathrm{M} \mathrm{CaCl}_{2}$. What is the difference?
9. Do the following substances conduct electricity? If so, in what state? Why?
a. $\mathrm{NaNO}_{3}$
b. Iodine
c. C (as a diamond)
d. Copper
10. A rigid 5.00 L cylinder contains 24.5 g of $\mathrm{N}_{2}(\mathrm{~g})$ and 28.0 g of $\mathrm{O}_{2}(\mathrm{~g})$
a. Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K .
b. The temperature of the gas mixture in the cylinder is decreased to 280 K . Calculate each of the following.
i. The mole fraction of $\mathrm{N}_{2}(\mathrm{~g})$ in the cylinder.
ii. The partial pressure, in atm, of $\mathrm{N}_{2}(\mathrm{~g})$ in the cylinder.
c. If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio of moles $\mathrm{N}_{2}$ to moles $\mathrm{O}_{2}$ in the cylinder increase, decrease, or remain the same? Justify your answer.
A different rigid 5.00 L cylinder contains 0.176 mol of $\mathrm{NO}(\mathrm{g})$ at 298 K . A 0.176 mol sample of $\mathrm{O}_{2}(\mathrm{~g})$ is added to the cylinder, when a reaction occurs to produce $\mathrm{NO}_{2}$.
d. Write the balanced equation for the reaction.
e. Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.
11. Two flasks are connected by a stopcock as shown below. The 3.0 L flask contains $\mathrm{CH}_{4}$ at a pressure of 1.5 atm , and the 0.75 L flask contains $\mathrm{C}_{2} \mathrm{H}_{6}$ at a pressure of 4.5 atm . Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant.

12. Answer the following questions for the complete combustion of propane.
a. Write a balanced equation for the complete combustion of propane gas $\left(\mathrm{C}_{3} \mathrm{H}_{8}\right)$, which yields $\mathrm{CO}_{2}(\mathrm{~g})$ and $\mathrm{H}_{2} \mathrm{O}(\mathrm{g})$.
b. Calculate the volume of air at $30.0^{\circ} \mathrm{C}$ and 1.00 atmospheres that is needed to completely burn 10.0 g of propane. Assume that air is 21.0 percent $\mathrm{O}_{2}$ by volume.
13. A piece of solid magnesium ribbon was reacted with excess hydrochloric acid solution according to the following reaction:

$$
\mathrm{Mg}(\mathrm{~s})+2 \mathrm{HCl}(\mathrm{aq}) \rightarrow \mathrm{MgCl}_{2}(\mathrm{aq})+\mathrm{H}_{2}(\mathrm{~g})
$$

The following data was collected for the experiment:


| Mass of Mg ribbon reacted | 5.0400 g |
| :--- | :--- |
| Volume of hydrogen gas collected | 405.4 mL |
| Mass of hydrogen gas collected | 0.0907 g |
| Room temperature | $24.1^{\circ} \mathrm{C}$ |
| Vapor pressure of water at $22.1^{\circ} \mathrm{C}$ | 19.8 mmHg |
| Room pressure | 624.2 mmHg |

a. Calculate the experimental molar mass of hydrogen gas in this experiment.
b. Determine the percent error in this experiment.
c. Why would this set up not work for a different experiment if the gas produced was HF?
14. The following graph shows the distribution of speeds of oxygen molecules at 298 K .
a. On the same graph, draw a line showing what the distribution of chlorine molecules would look like at the same temperature.
b. On the same graph, draw a line showing what the distribution of oxygen molecules at 398 K would look like.

15. Describe the behaviors of an ideal gas.
16. The following describe properties of real gases that deviate from ideal gas behavior. Explain what causes this deviation.
a. A sample of Xe gas at a high pressure has an even higher pressure than expected.
b. A sample of HCl gas has a lower pressure than expected.
17. Describe how the following radiations affect molecular motion:
a. Microwave
b. Infrared
c. Ultraviolet/visible
18. Explain what you would use to separate the following mixtures and what you would see:
a. Green food coloring (a mix of blue and yellow)
b. A solution of salt and water
c. A mixture of solid calcium carbonate and aqueous sodium nitrate
d. A mixture of methanol and water (both are liquids)
19. A student collected the following absorbance vs concentration data for $\mathrm{CoCl}_{2}$.

a. Give one possible reason for the outlier at 0.050 M .
b. A sample with unknown concentration of $\mathrm{Co}^{2+}$ has an absorbance of 0.35 . What is the concertation of this sample?

## AP Questions

1. 



Represented above are five identical balloons, each filled to the same volume at $25^{\circ} \mathrm{C}$ and 1.0 atmosphere pressure with the pure gas indicated.
(a) Which balloon contains the greatest mass of gas? Explain.
(b) Compare the average kinetic energies of the gas molecules in the balloons. Explain.
(c) Which balloon contains the gas that would be expected to deviate most from the behavior of an ideal gas? Explain.
(d) Twelve hours after being filled, all the balloons have decreased in size. Predict which balloon will be the smallest. Explain your reasoning.
2.

Use the information in the following table to answer parts (c) and (d).

| Name | $\begin{aligned} & \text { Lewis Electron-Dot } \\ & \text { Diagram } \end{aligned}$ | Boiling Point $\left({ }^{\circ} \mathrm{C}\right)$ | $\begin{gathered} \text { Vapor Pressure at } 20^{\circ} \mathrm{C} \\ (\mathrm{~mm} \mathrm{Hg}) \end{gathered}$ |
| :---: | :---: | :---: | :---: |
| Dichloromethane | $: \stackrel{H}{: \ddot{\mathrm{C}}:: \stackrel{\ddot{\mathrm{C}}}{\mu}: \mathrm{H}}$ | 39.6 | 353 |
| Carbon tetrachloride | $\begin{gathered} : \ddot{\mathrm{C} \mid:} \\ : \ddot{\mathrm{C}}: \ddot{\mathrm{C}}: \ddot{\mathrm{C}} \mid: \\ : \ddot{\mathrm{C} \mid}: \end{gathered}$ | 76.7 | 89 |

(c) Dichloromethane has a greater solubility in water than carbon tetrachloride has. Account for this observation in terms of the intermolecular forces between each of the solutes and water.
(d) In terms of intermolecular forces, explain why dichloromethane has a higher vapor pressure than carbon tetrachloride.
3.
(c) $\mathrm{I}_{2}(s)$ and $\mathrm{Br}_{2}(l)$ can react to form the compound $\operatorname{IBr}(l)$. Predict which would have the greater molar enthalpy of vaporization, $\operatorname{IBr}(l)$ or $\operatorname{Br}_{2}(l)$. Justify your prediction.

An experiment is performed to compare the solubilities of $\mathrm{I}_{2}(s)$ in different solvents, water and hexane $\left(\mathrm{C}_{6} \mathrm{H}_{14}\right)$. A student adds 2 mL of $\mathrm{H}_{2} \mathrm{O}$ and 2 mL of $\mathrm{C}_{6} \mathrm{H}_{14}$ to a test tube. Because $\mathrm{H}_{2} \mathrm{O}$ and $\mathrm{C}_{6} \mathrm{H}_{14}$ are immiscible, two layers are observed in the test tube. The student drops a small, purple crystal of $\mathrm{I}_{2}(s)$ into the test tube, which is then corked and inverted several times. The $\mathrm{C}_{6} \mathrm{H}_{14}$ layer becomes light purple, while the $\mathrm{H}_{2} \mathrm{O}$ layer remains virtually colorless.
(d) Explain why the hexane layer is light purple while the water layer is virtually colorless. Your explanation should reference the relative strengths of interactions between molecules of $\mathrm{I}_{2}$ and the solvents $\mathrm{H}_{2} \mathrm{O}$ and $\mathrm{C}_{6} \mathrm{H}_{14}$, and the reasons for the differences.

