Practice Test Questions 9
Polarity, Intermolecular Forces, Kinetic Molecular Theory and Gases

1. For each of the following molecules, determine the molecular geometry, and demonstrate whether it is a polar or non-polar molecule. For polar molecules, show the **net molecular dipole moment.**

(a) XeF_2 (b) SO_2

(c) NO_2^+ (d) SO_2Cl_2 *(O is more electronegative than Cl)*

2. *For this question, if the Lewis diagram does not show the correct geometry for a molecule, draw a second diagram to show its geometry.*

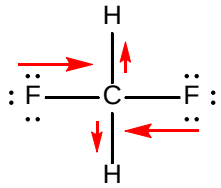
(a) Draw a Lewis diagram for C_2H_4.

(b) Draw a Lewis diagram for C_2H_3Cl. *(Replace one H in your answer to part (a) with a Cl.)*

(c) Draw Lewis diagrams for all three different molecules with the molecular formula $C_2H_2Cl_2$. *(Each will be your answer to part (b) with a different H replaced by Cl.)*

(d) Which of these five molecules are polar? Which of these molecules are nonpolar? Justify your answers.

3. Kevin draws the following Lewis diagram for CH_2F_2:



He argues that CH_2F_2 is nonpolar because the bond dipoles *(shown in red)* all cancel. Identify Kevin's mistake, and explain how to fix it.

4. PF_2Cl_3 is a nonpolar molecule. PF_3Cl_2 is a polar molecule.

(a) Draw PF_2Cl_3. Your diagram must include all lone pairs and show the molecule's shape.

(b) Draw PF_3Cl_2. Your diagram must include all lone pairs and show the molecule's shape.

(c) Do you expect $PFCl_4$ to be polar or nonpolar? Use a diagram to explain.

(d) Do you expect PF_4Cl to be polar or nonpolar? Use a diagram to explain.

5. List the intermolecular forces present in pure samples of each of the following:

(a) NaF (b) H_2S

(c) SF_6 (d) $NaNO_3$

(e) SeF_4 (f) OF_2

6. Which of the following substances are capable of hydrogen bonding with water?

(a) NaF (b) H_2S

(c) SF_6 (d) $NaNO_3$

7. Compare the intermolecular forces present in pure CCl_4 and in pure CI_4. One of these compound is a liquid under standard conditions; the other is a solid. Which is which? Justify your answer.

8.

(a) Draw the Lewis structures for ClF_5 and PF_5.

(b) For each compound, name the strongest intermolecular force present in a liquid sample.

(c) Which of these two compounds would you expect to have a lower boiling point?

9. It is not immediately obvious which boiling point should be higher – that of PCl_3 or PCl_5.

(a) Give one argument for why a student might expect the boiling point of PCl_3 to be higher.

(b) Give one argument for why a student might expect the boiling point of PCl_5 to be higher.

(c) The boiling point of PCl_3 is 76 ˚C, and the boiling point of PCl_5 is 160.5 ˚C. What does this tell us about the intermolecular forces in each substance?

10. Rank each of the following sets of compounds in order of increasing boiling point. ***Briefly***, justify your answers.

(a) CH_2O, CH_3OH, $NaOCH_3$

(b) $Ge(CH_3)_4$, $Si(CH_3)_4$, $Sn(CH_3)_4$

11. Identify whether each of the statements below is correct or incorrect. If incorrect, what's wrong with it?

(a) All gas molecules have the same temperature.

(b) All gas molecules in a sample travel with the same speed.

(c) The temperatures of the gas molecules have a Maxwell-Boltzmann distribution.

(d) The speeds of the gas molecules in a sample have a Maxwell-Boltzmann distribution.

12. For each pair of gases, indicate which has particles with a higher root-mean-square speed <u>at the same temperature</u>?

(a) F_2 and Cl_2

(b) CH_4 (methane) and C_3H_8 (propane)

(c) Ar and O_2

13. Calculate the average kinetic energy of a molecule in an ideal monatomic gas at 25°C.

14. Calculate the root-mean-square speed for a sample of UF_6 gas at a temperature of 298 K.

15. Calculate v_{rms} for oxygen at 0 °C.

16.

(a) What pressure does the ideal gas law predict will develop when 5.00 mol of Ar is placed in a 500. mL container at 300. K?

(b) What pressure does the van der Waals equation predict will develop when 5.00 mol of Ar is placed in a 500. mL container at 300. K?

The van der Waals parameters for Ar are $a = 0.1355 \frac{Pa \cdot m^6}{mol^2}$ and $b = 3.20 \times 10^{-5} \frac{m^3}{mol}$.

(c) Which calculated pressure is expected to better predict the actual pressure, and what is responsible for the difference?

17. When comparing HCl and H_2, which gas would you expect to have a larger value for the van der Waals parameter *a*? Briefly, justify your answer.

18. Compare F_2, Cl_2 and Br_2.

(a) Which of these three compounds has the highest van der Waals constant *a*? Why?

Your answer must address the purpose of van der Waals constant a.

(b) Which of these three compounds has the highest van der Waals constant *b*? Why?

Your answer must address the purpose of van der Waals constant b.

19.

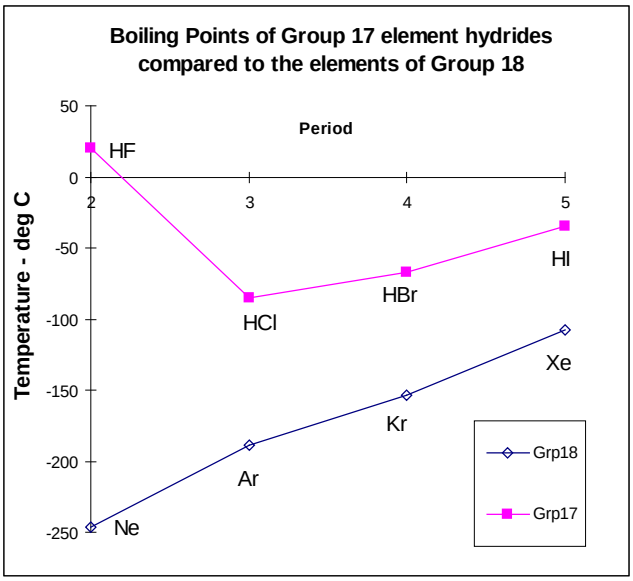
(a) List the intermolecular forces active in solid sodium chloride.

(b) List the intermolecular forces active in liquid water.

(c) Describe what happens when solid sodium chloride is dissolved in liquid water. Which intermolecular forces must be overcome? Which new intermolecular forces become active?

20. The graph at the right presents the normal boiling points of 2nd, 3rd, 4th, and 5th period element hydrides of the Group 17 elements compared to the elements of Group 18.

Explain the trends, differences and anomalies in the graph in terms of the kinds of **intermolecular forces** that operate between the molecules in pure liquids of the given composition. Discuss *all* the intermolecular forces that apply in each system.



21. The table at the right shows physical data for the haloforms (molecules with the general formula CHX_3).

(a) Draw the structure for fluoroform (CHF_3) showing its correct shape as predicted by VSEPR. All of the haloforms shown have the same 3-dimensional structure. *Include all lone pairs.*

(b) Add bond dipoles to your drawing in part (a) and indicate the direction of the net molecular dipole, if any.

(c) Which of the haloforms is the most polar? Explain.

(d) Explain the trend in the physical properties given for this series of molecules.

CHF_3	bp: -82°C
$CHCl_3$	bp: 61°C
$CHBr_3$	bp: 146°C
CHI_3	mp: 118°C