1. Which of the following is an expanded octet molecule at the central atom?
   A) BeF$_2$  B) CO$_2$  C) NH$_3$  D) PCl$_5$  E) SF$_2$

2. How many unpaired electrons are on a Fe$^{2+}$ ion?
   A) 0  B) 1  C) 2  D) 3  E) 4

3. Which of the following will have a significant resonance structure?
   A) CO  B) CO$_2$  C) H$_2$O  D) NO$_2$  E) PCl$_3$

4. How many nodal planes are present in an s-orbital and π-bond, respectively?
   A) 0, 0  B) 0, 1  C) 1, 0  D) 1, 1  E) none of these

5. How many π* electrons are present in O$_2^{+}$?
   A) 0  B) 1  C) 2  D) 3  E) 4

6. Which of the following is expected to deviate from ideal gas behavior most quickly when temperature or pressure is changed?
   A) Cl$_2$  B) CH$_4$  C) He  D) N$_2$  E) NH$_3$

7. A 0.128 mol sample of N$_2$ occupies 2.44 L at 75 ºC. What is the pressure of this gas?
   A) 0.0514 atm  B) 0.323 atm  C) 0.853 atm  D) 1.01 atm  E) 1.50 atm

8. Which of the following is least dense?
   A) N$_2$(g)  B) H$_2$O(g)  C) Xe(g)  D) O$_2$(g)  E) HBr(g)

Discussion Questions: (You must show your work to receive credit.)

1. For each of the following pairs, indicate which element has the smaller ionization energy and provide the physical basis of your choice: (10 points)
   a) C vs. F
   b) Cl vs. F
2. For each of the following molecules: 1) draw the correct Lewis structure, 2) what is the actual (molecular) shape, 3) what is the hybridization of the underlined atom and 4) write “polar” or “nonpolar” to indicate which is true of the first 2 molecules: $\text{XeF}_4$, $\text{PCl}_5$, and $\text{ClO}_3^-$. (26 points)

3. Describe how a valence bond forms. (8 points)

4. Draw the molecular orbital diagrams for $\text{He}_2$ (A), $\text{He}_2^+$ (B), and $\text{He}_2^{2+}$ (C). Using the A, B, & C labels provided, list them in order of increasing bond length and explain your ordering. (6 points)
5. Explain Avogadro's ($V \propto n$) and Charles’ ($V \propto T$) Laws in terms of the Kinetic-Molecular theory of gases. (10 points)

Avogadro's Law –

Charles’ Law –

6. A balloon filled with nitrogen gas occupies a volume of 6.00 L at 25.0 °C and 1.00 atm. (10 points)
   i) What is the volume at 100 °C and 2.00 atm?
   ii) How many moles of gas are present? (8 points)