1. (8 pts) Rank the following species in order of increasing atomic size (smallest to largest):
   - F$^-$
   - Fe
   - Ne
   - Fe$^{3+}$

2. (8 pts) On the axes below, sketch the speed distributions for Xenon at 300 K, Krypton at 300 K, and Krypton at 500 K. Be primarily concerned with getting the relative shapes of the distributions correct – don't worry about being quantitative.

3. (8 pts) The energy levels of the dication of lithium, Li$^{2+}$, are described by a modified Bohr equation: 
   \[ E_n = \frac{-1.96 \times 10^{-17}}{n^2} \text{ J.} \]
   What is the wavelength (in nm) emitted by a Li$^{2+}$ ion going from the \( n = 5 \) to \( n = 3 \) energy level?
4. (4 pts) All of the following species are isoelectronic except:
(a) F⁻  
(b) Al³⁺  
(c) S²⁻  
(d) Mg²⁺

5. (4 pts) All of the following sets of quantum numbers are allowed except:
(a) n = 1, l = 0, m_l = 0, m_s = +½  
(b) n = 2, l = 1, m_l = 0, m_s = +½  
(c) n = 4, l = 3, m_l = -3, m_s = +½  
(d) n = 3, l = 3, m_l = 2, m_s = -½

6. (4 pts) Which of the following sets of quantum numbers is valid for a 4f electron?
(a) n = 4, l = 3, m_l = 4, m_s = +½  
(b) n = 4, l = 3, m_l = -2, m_s = -½  
(c) n = 4, l = 1, m_l = -2, m_s = +½  
(d) n = 3, l = 2, m_l = 1, m_s = -½

7. (6 pts) An electron in an H atom is excited to an energy of $-5.45 \times 10^{-19}$ J. What is the largest value of $m_l$ possible for this energy level?
(a) 1  
(b) 2  
(c) 3  
(d) 0

8. (15 pts) For the following proposed electronic configurations, write down:
(G) if the configuration is the ground state
(E) if the configuration is an excited state
(I) if the configuration is for an ion
(ND) if the configuration is an example of near-degeneracy (where two orbitals are at essentially the same energy)
and (U) if the configuration is never possible

There may be one or more letters for each configuration listed below.

(a) As: [Ar]4s²3d¹⁰4p³
(b) Cu: [Ar]4s¹3d¹⁰
(c) Cl: [Ne]3s²3p⁵4p¹

9. (6 pts) For the electron configurations given in problem 9, identify each as either paramagnetic or diamagnetic.
10. (10 pts) In an atom such as Kr, electrons in the 3s, 3p, and 3d orbitals have quite different energies. Use the figure given below to explain why this is.

![Diagram showing electron density vs. distance from the nucleus for 3s, 3p, and 3d orbitals]

11. (12 pts) A piston filled with 0.25 moles of carbon dioxide gas is initially at 1 atmosphere and 338 K. This piston is placed in a temperature controlled room at 278 K (still 1 atmosphere) and allowed to reach equilibrium. What is $\Delta E$ for the gas in the piston?
12. (15 pts) Green plants such as corn primarily utilize 670 nm photons from the sun to conduct photosynthesis. On a bright summer day $9.60 \times 10^{20}$ usable photons strike each corn plant each hour. If 100% of the solar energy is used to provide reaction enthalpy, how many grams of glucose ($C_6H_{12}O_6$) can be made in a single corn plant in one hour? Note that the equation given below is NOT balanced.

\[
\text{CO}_2(g) + \text{H}_2\text{O}(l) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(s) + \text{O}_2(g)
\]