1. (36 points) Complete and balance each reaction shown below. Use smallest integer values possible for coefficients. Assume the requisite temperature for those that need it.

\[
\begin{align*}
\text{Li}_3\text{N}(s) + \text{H}_2\text{O}(l) & \rightarrow \\
\text{NaHCO}_3(aq) + \text{HC}_2\text{H}_3\text{O}_2(aq) & \rightarrow \\
\text{CaC}_2(s) + \text{H}_2\text{O}(l) & \rightarrow \\
\text{CaCN}_2(s) + \text{H}_2\text{O}(l) & \rightarrow \\
\text{H}_3\text{BO}_3(s) + \text{heat} & \rightarrow \\
\text{CH}_4(g) + \text{H}_2\text{O}(g) & \rightarrow \\
\text{PbO}(s) + \text{C}(s) & \rightarrow \\
\text{NO}_2(g) + \text{H}_2\text{O}(l) & \rightarrow \\
\text{Li}(s) + \text{N}_2(g) & \rightarrow \\
\text{TiO}_2(s) + \text{C}(s) + \text{Cl}_2(g) & \rightarrow \\
\text{ZrCl}_4(s) + \text{Mg}(s) & \rightarrow \\
\text{Na}_2\text{Cr}_2\text{O}_7(s) + \text{S}(s) & \rightarrow \\
\end{align*}
\]

2. (30 points) Fill in the blank periodic table with the symbols of elements 1-86, exclusive of the f-block elements.

3. (12 points) The O–N–O bond angles in NO$_2^+$, NO$_2$, and NO$_2^-$ are 180º, 134º, and 115º, respectively. Explain why.

4. (12 points) Concentrated nitric acid has a density of 1.44 g/mL and is a 70.0% mixture by weight. What is its molarity?

5. (12 points) Explain the chelate effect.

6. (12 points) Which is the weaker base, NF$_3$ or NH$_3$? Explain why.
7. (12 points) Describe the industrial production of sulfuric acid. Include balanced chemical reactions.

8. (12 points) Hydrofluoric acid is a weak acid in aqueous solutions with a pKₐ of 4.1. What will be the pH of a 1.00 L aqueous solution that contains 10.0 g of the acid?

9. (16 points) Predict the geometries of the following molecules or polyatomic ions.

   a) PCl₃  
   b) XeF₃⁺  
   c) SF₄  
   d) ICl₂⁻

10. (10 points) Give the two half-reactions that occur in your lead-acid storage battery when you start your car.

11. (12 points) Diagram the d orbitals of a transition metal in a square planar complex. Label all the orbitals. Assume the square plane is in the xy-coordinate plane.

12. (12 points) Give the coordination number for a metal atom in the following environments.

   a) cubic closest packing  
   b) body-centered cubic  
   c) simple cubic

13. (12 points) Explain why B(OH)₃ is acidic but Ga(OH)₃ is basic.

Extra Credit (no more than 12 points) Nickel forms an anion [NiCl₄]²⁻ that is square planar while the analogous zinc anion, [ZnCl₄]²⁻ is tetrahedral. Explain the difference.