1. (24 points) Write the elemental symbols on the blank periodic table attached to this exam, through the first 54 elements.

2. (20 points) Complete and balance each reaction shown below. Use smallest integer values possible for coefficients. Product phases need not be specified.

\[
\text{Na(s) + O}_2(\text{g}) \rightarrow \\
\text{Na(s) + H}_2\text{O(l) \rightarrow} \\
\text{NaHCO}_3(\text{s}) \xrightarrow{\Delta} \\
\text{NaHCO}_3(\text{aq} \ + \ \text{HCl(aq)} \rightarrow \\
\text{CaC}_2(\text{s} \ + \ \text{H}_2\text{O(l)} \rightarrow \\
\text{CaCN}_2(\text{s} \ + \ \text{H}_2\text{O(l)} \rightarrow \\
\text{H}_3\text{BO}_3(\text{s}) \xrightarrow{\Delta} \\
\text{Ba(s) + O}_2(\text{g}) \rightarrow \\
\text{B}_2\text{O}_3(\text{s} \ + \ \text{NH}_3(\text{g}) \xrightarrow{\Delta} \\
\text{B}_2\text{H}_6(\text{g} \ + \ \text{O}_2(\text{g}) \rightarrow }
\]
3. (8 points) For each metal, write its common oxidation states other than zero.

- iron
- copper
- silver
- thallium
- tin
- bismuth
- mercury
- yttrium

4. (6 points) Give the chemical formula of each material.

- milk of magnesia
- salt peter
- limestone
- Epsom salts
- baking soda
- gypsum

5. (4 points) What is the purpose of sodium aluminum sulfate in baking powder?
6. (4 points) Give the chemical formula of each borane.

a) pentaborane(9)  
b) hexaborane(12)

c) decaborane(14)  
d) octaborane(12)

7. (6 points) Write the balanced chemical equations for the three-step Bayer process, by which bauxite is purified in the production of aluminum metal.

8. (4 points) Specify the four point-symmetry elements displayed by a water molecule.
9. (8 points) A particular iron(I) complex has two different ligands: carbonyl and cyclopentadienyl. It also displays two different carbonyl stretching frequencies: 1977 and 1759 cm\(^{-1}\), each with the same intensity. Is the complex a monomer or dimer, i.e., does it have one or two iron cations? Briefly explain your choice.

10. (6 points) Which of the metal complexes shown below is most likely to exist? Briefly give the reason.

\[ \text{[Fe(CO)}_4] \quad \text{[Ni(CO)}_6] \quad \text{[Fe(CO)}_5] \quad \text{[Mn(CO)}_5] \]

11. (6 points) Explain why barium hydroxide and magnesium hydroxide have such different water solubilities.

12. (4 points) What are the components of gunpowder?