1. (DeGraef, 1st edition, Chapter 2 problem xii) Pair potential: Consider an interatomic pair potential of the form:

\[ V(r) = \left[ \left( \frac{d}{r} \right)^n - \frac{n}{m} \left( \frac{d}{r} \right)^m \right] \]

where \( m \) and \( n \) are exponents with \( m < n \).
(a) Identify the attractive and repulsive terms in the expression.
(b) Differentiate the potential to determine the equilibrium spacing of the atoms. What is the equilibrium spacing for a Lennard-Jones potential?
(c) Determine the value of the minimum of the \( V(r) \) curve for the general potential and for the specific Lennard-Jones potential.

2. Crystalline oxynitrides in the \( \text{SiO}_2\)-\( \text{Si}_3\text{N}_4\)-\( \text{Al}_2\text{O}_3\)-\( \text{AlN} \) system have been commercially developed for structural applications and are commonly referred to as “sialon” ceramics. Si is a metalloid, or ‘semi-metal’ thus treat as a metal for these ceramics.
(a) Classify the bonding type for each of the four binary compounds listed above. Explain how you determined your answers.
(b) In addition to solid solutions in this system, there are also some ternary compounds including \( \text{Si}_2\text{N}_2\text{O} \) and \( \text{Al}_7\text{O}_9\text{N} \). Classify the bonding type in each of these materials. Again, explain how you determined your answers.

3. Two possible configurations for the hypothetical \( \text{Ar}_3 \) molecule are shown below.

(a) For each configuration compute the interatomic distance (separation) to 5 significant digits. Given constants \( A_{12} = 4.0005 \) and \( A_6 = 4.03 \) for the a. molecule and \( A_6 = A_{12} = 6 \) for b. molecule. You can leave your answers in terms of \( \sigma \).
(b) Compute their cohesive energies. You can leave your answers in terms of \( \varepsilon \).
(c) Based on your answers which configuration has the shorter bond length and which is more stable?
(d) Plot/sketch the values you calculated on energy vs. separation curves. Label the axes and the values on the two curves.

4. The melting temperature of \( \text{MgO} \) is 2852°C and \( \text{Al}_2\text{O}_3 \) is 2054°C. What accounts for this trend? Explain to receive full credit.