Assignment 1 **Properties of Materials**

Question 1

a. Aluminum foil used for storing food weighs about 0.3 g per square inch. How many atoms of aluminum are contained in one square inch of foil?

b. Calculate and compare the number of atoms per cubic centimeter in lead and lithium.

Question 2

Below 24.5 K, Ne is a crystalline solid with an FCC structure. The interatomic interaction energy per atom can be written as

$$E(r) = -2 \in [14.45(\frac{\sigma}{r})^6 - 12.13\left(\frac{\sigma}{r}\right)^{12}] \quad eV/atom$$

Where ε and σ are constants that depend on the polarizability, the mean dipole moment, and the extent of overlap of core electrons. For crystalline Ne,
ε= 3.121×10^{-3} eV and σ = 0.274 nm.

I. Show that the equilibrium separation between the atoms in an inert gas crystal is given by r_o = (1.090) σ. What is the equilibrium interatomic separation in the Ne crystal?
II. Find the bonding energy per atom in solid Ne.
III. Calculate the density of solid Ne (atomic mass = 20.18 g/mol).

Question 3

Explain why the modulus of elasticity of simple thermoplastic polymers, such as polyethylene and polystyrene, is expected to be very low compared with that of metals and ceramics.

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Question 4

A common metal is known to have a cubic unit cell with an edge length of 0.288 nm. If this metal has a density of 7.20 g/cm^3 and an atomic weight of 52.0 g/mole, what is its atomic packing factor? Why?

Question 5

Answer the following three questions about iron.

i. Consider iron below 912°C, where its structure is BCC. Given the density of iron as 7.86 g cm^{-3} and its atomic mass as 55.85 g/mole, calculate the lattice parameter of the unit cell and the radius of the Fe atom.

ii. At 912°C, iron changes from the BCC (α-Fe) to the FCC (γ -Fe) structure. The radius of the Fe atom correspondingly changes from 0.1258 nm to 0.1291 nm. Calculate the density of γ -Fe and explain whether there is a volume expansion or contraction during this phase change.

iii. Identify the most densely packed crystal planes in the BCC and FCC crystal structures.