Chapter 3

1. Estimate the density of a neutron star by assuming it consists of a close packed arrangement of neutrons. \( m_n = 1.675 \times 10^{-27} \text{ kg (\approx 1 amu)} \) and \( r_n = 2.0 \text{ fm.} \)

*Fun fact: Large neutron stars can actually exceed this density slightly. It is proposed that the cores of these stars form exotic phases of matter such as a Bose-Einstein condensate or supercritical fluids, but no one knows for sure.*

2. Show that the c/a ratio for an ideal HCP packing (ideal means each atom has 12 nearest neighbors with same bond length to each) is 1.63. *Hint: look for tetrahedra with side length a in the conventional hexagonal unit cell.*

3. Draw the following crystallographic directions in a cubic unit cell

   (a) \([1 1 0]\)
   (b) \([0 2 1]\)
   (c) \([2 \bar{1} 2]\)

4. Draw the following crystallographic planes in a cubic unit cell

   (a) \((1 1 1)\)
   (b) \((0 1 2)\)
   (c) \((2 0 \bar{1})\)

5. Identify the crystallographic directions shown in the unit cell below.
6. Identify the crystallographic planes shown in the unit cells below.

7. An X-ray diffraction peak for the (111) plane in silver (FCC) is found at $2\theta = 38.2^\circ$ when Cu K-\(\alpha\) radiation is used. Given that the Cu K-\(\alpha\) wavelength is 0.154 nm, compute the following for silver:

   (a) Interplanar spacing (d) of the (111) planes (Bragg Law)
   (b) Lattice constant (Equation 3.22)
   (c) Radius of a silver atom
   (d) Mass of a silver atom given that the density of silver is 10.5 g/cm$^3$