Condensed Matter Physics: Workshop 1

Summary: This workshop will explore different aspects of crystal structures based on material covered in the first two lectures.

a. In small groups discuss:

- **i.** Why are crystals symmetric structures, what are the physical reasons for this?
- **ii.** What are the implications of this?
- **iii.** What is the difference between a crystal, a lattice and a basis?

b. Consider the following 2-D crystal structure where q, p, d, b represent four different atoms.

On this diagram indicate:

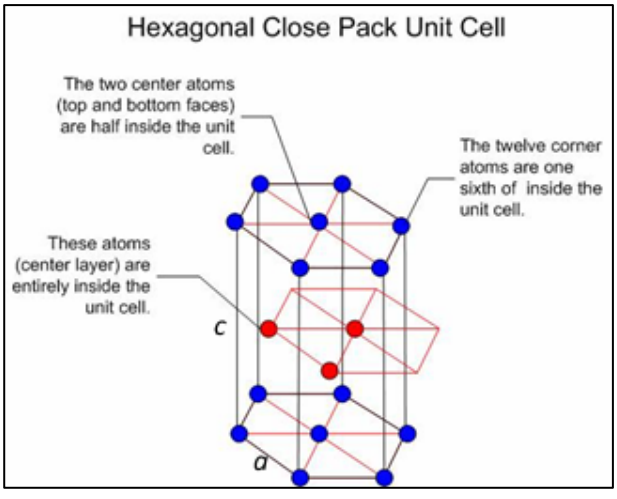
- **i.** a primitive unit cell (called the Wigner-Seitz cell) and a non-primitive unit cell.
- **ii.** the basis associated with the primitive unit cell.

q p d b q p d b q p d b ...
d b q p d b q p d b q p ...
q p d b q p d b q p d b ...
d b q p d b q p d b q p ...
q p d b q p d b q p d b ...
d b q p d b q p d b q p ...
⋮ ⋮ ⋮ ⋮ ⋮ ⋮

c. For a simple cubic lattice draw a sketch illustrating planes with Miller indices (101) and (102). The lattice constant is $a = 0.35$ nm. For the set of planes above, determine the spacing between the planes.

d. A hexagonal lattice is shown in the figure with alternate layers *A*, *B* (blue and red in diagram). Hexagonal close packing is the most efficient method of filling space. The hexagonal lattice is described by two lattice parameters *a* and *c* as illustrated in the diagram (see Handout Lecture 2).

Determine the ratio for *c*/*a* which gives the most efficient use of space. State clearly any assumptions you make.



e. We learned in lectures that metals are generally polycrystalline; the typical dimensions of a grain boundary are 50 μm. Assuming that the metal ions have a radius of 0.15 nm, estimate the number of ions in a grain and the proportion of those that are in contact with the grain boundary. State any assumptions you made. What implications might this have for the physical properties of metals?