

FSK324 Test 1

Solid State Physics

5th September 2012

Time: 120 minutes

Total marks: [80]

Section A - Crystal structure: Answer *all* questions in this section

1. Explain the following terms and give one example or application of each:
 - i.) Amorphous material [2]
 - ii.) Schottky defect [2]
2. With the steps clearly shown, sketch the following Miller indices:
 - i.) $(\bar{2} 1 0)$ [2]
 - ii.) $[\bar{2} 1 0]$ [2]
 - iii.) Hence show that the above indicate perpendicular directions or planes. [4]
3. Alpha-iron (α -Fe) is BCC with lattice parameter 0.286 nm, density 7.9 g/cm³ and atomic mass 56. Determine the lattice parameter of gamma-iron (γ -Fe) that is FCC (see also Figure 1). [6]
4.
 - i.) Distinguish between the “primitive unit cell” and the “conventional unit cell” of a lattice. [2]
 - ii.) Show, using basis vectors, that the volume of the conventional unit cell is one quarter that of the conventional unit cell in the FCC lattice. [4]
5. Consider the orthorhombic lattice: $a=1.25\text{\AA}$, $b=2.4\text{\AA}$ and $c=2.0\text{\AA}$.
 - i.) Draw a labeled diagram of the real lattice [2]
 - ii.) Determine the volume ratio of the unit cell in real space to reciprocal space [6]
 - iii.) Draw a labeled diagram of the reciprocal lattice. [2]
6. A certain two-dimensional lattice has lattice parameter $a=1$. Show that only certain rotation angles θ are permissible if the lattice is to remain invariant. [6]

Section B - Diffraction and the reciprocal lattice

Answer all questions in this section

7. The Bragg angle for the (111) planes of FCC aluminium is 19.2°. Calculate

a.) the inter-(111) plane distance for a x-ray wavelength of 1.54\AA . [4]

b.) Avogadro's number for aluminium of density 2.7 g/cm^3 and atomic mass 27. [4]

8. The symmetry rules for some highly symmetrical structures are shown in Table 1.

Table 1: Some basic rules for some structures.

Lattice type	Rule for reflection
Primitive	None
Body-centered	$h+k+l=2n$
Face-centered	h, k, l either all odd or all even
Side-centered	$h+k=2n$
Rhombohedral	$(-h+k+l)=3n$ or $(h-k+l)=3n$

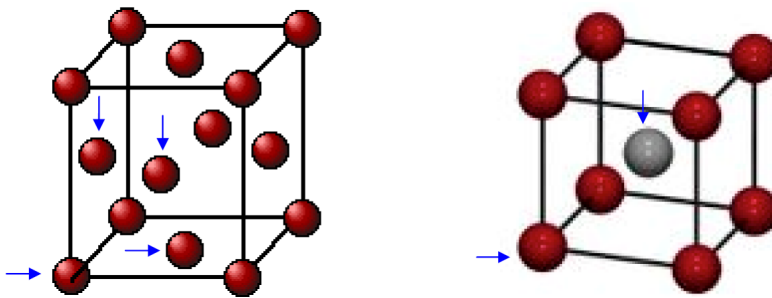


Figure 1: Two different unit cells of iron.

Determine the possible reflections for each iron unit cell shown in Figure 1. *Hint:* Considering only the highlighted (arrows) atoms, first write the fractional coordinates, determine the structure factor and then the possible reflections. [20]

9. The Bragg angle for a certain reflection of a powdered sample of copper is 47.75° at 20°C , and 46.60° at 1000°C . Determine the coefficient of linear expansion of copper. [6]

10. a.) Starting from the fact that for elastic scattering $\Delta\vec{k}=\vec{G}$, derive the Laue equations. [2]

b.) Describe the Ewald construction that helps to visualize scattering in 3-dimensions. [4]

Useful constants

Planck's constant	$h = 6.626 \times 10^{-34}\text{ J.s}$, and $\hbar = h/2\pi$
Avogadro's constant	$6.022 \times 10^{23}\text{ mol}^{-1}$
Electronic charge	$e = 1.6022 \times 10^{-19}\text{ C}$
Electron mass	$m_e = 9.109 \times 10^{-31}\text{ kg}$
Neutron mass	$m_n = 1.675 \times 10^{-27}\text{ kg}$
Boltzmann's constant	$k_B = 1.38 \times 10^{-23}\text{ J/K}$