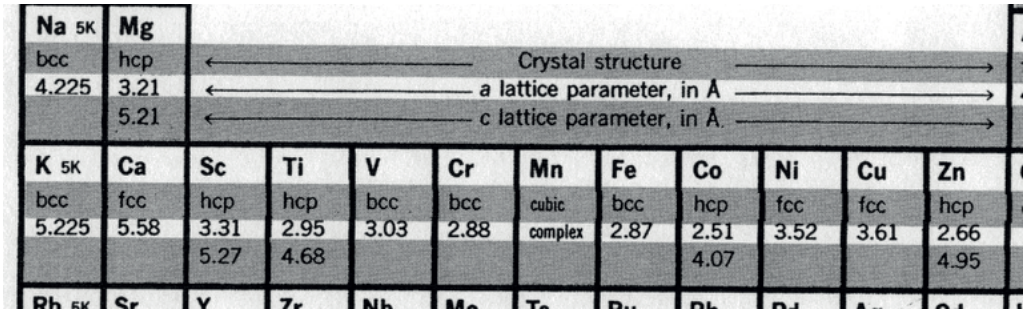
Condensed Matter Physics: Weekly Problem 2

These problems are to be formatively self-assessed by you, the student. Students taking part in the peer-marking pilot scheme will also be required to mark one of their peer's weekly problems. A mark scheme, out of 10, will be provided with each solution to aid your assessment before your timetabled weekly workshop. Information underlined/boxed in red in the model solutions is required for marks to awarded.

Summary: X-ray diffraction measurements from powdered samples give a precise determination of lattice constant and also confirm the crystal structure. Consider the following extract from the periodic table taken from Kittel Chapter 1 Table 3 (page 20).



Na 5K	Mg	← Crystal structure →									
bcc	hcp										
4.225	3.21	← a lattice parameter, in Å →									
	5.21	← c lattice parameter, in Å →									
K 5K	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**
bcc	fcc	hcp	hcp	bcc	bcc	cubic	bcc	hcp	fcc	fcc	hcp
5.225	5.58	3.31	2.95	3.03	2.88	complex	2.87	2.51	3.52	3.61	2.66
		5.27	4.68					4.07			4.95
Rb 5K	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd

a. Starting with the structure factor relationship, given in lectures, and by considering the position of the unique atoms within the unit cell of a lattice having the same structure as calcium (Ca), obtain the structure factor rules for this lattice. **[3 marks]**

b. For an incident x-ray beam of wavelength 0.15 nm, calculate the scattering angles 2θ for the first four observed peaks in an x-ray power diffraction measurement of calcium. Determine the Miller indices of these four peaks. **[4 marks]**

c. Explain why there is no peak observed for diffraction from the (100) planes. **[1 mark]**

d. Without doing any calculations describe qualitatively what the difference would be if calcium were replaced by copper (Cu). Explain your reasoning. **[2 marks]**